Sharing opportunities and understanding challenges: a study of school-university partnerships within Computing Education

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Abstract

The discipline of Computing was introduced to the English National Curriculum in 2014 to equip young people with the skills and knowledge to enact social, political, and economic agency through compulsory education. Three years following its introduction, computing education was beleaguered by poor teacher support and falling levels of pupil engagement, with recommendations that external organisations should work with schools to support the shortcomings of its delivery. Universities are well-positioned to help school communities through improved access to resources, knowledge, and skills, but schools are sceptical of the transactional nature of university engagements. Currently, little guidance exists for schools or universities seeking engagement in equitable partnerships, particularly in computing education. As such, the overarching aim of this research is to develop an understanding of a school-university partnership process for compulsory computing education, with consideration of social and digital structures which occupy this space.

With a focus on lived experience within a community environment through a social constructivist paradigm, the following research adopts the instrumental, exploratory case study methodology combined with an action research approach to understand the experiences of creating and participating in school-university partnerships for computing education. Furthermore, a lens of educational ecology provides this thesis with a framework and terminology to allow for the conceptualisation of the complex and dynamic educational environment, helping one understand how they might affect deliberate and conscious change of computing education as a community.

This thesis presents findings and insights from a series of case studies that explore the creation, maintenance and legacy of school-university partnerships for computing education based in the North-East of England. The first set of case studies documents the experiences of creating and maintaining a school-university partnership between Newcastle University and the computing department at a local secondary school for the development of a Key Stage 3 computing curriculum, pointing towards the importance of re-negotiation of partnership roles, the impact on the engagement of pupils, and methods of support computing teachers in the classroom. The second set of case studies outlines the end of the partnership process and explores school-university partnerships' legacy. Findings from these case studies demonstrate how the framing of risk and school technology policies can constrain school engagement in such partnerships while developed processes and materials can continue to exert a positive pedagogical impact on the school environment.

Drawing upon the empirical findings from these case studies, I then present a conceptual model of operational processes involved in creating and sustaining equitable school-university partnerships for computing education. I also explore the role of technologies in supporting such processes from a human-computer interaction perspective. The thesis contributes to computing education research, educational partnership research involving universities and communities and HCI research into technologies to support educational partnerships. Firstly, in drawing these case studies together and discussing lessons learned from the research, I contribute and critique the implications of the partnership approach in support of compulsory computing education in England. Secondly, my research presents a framework to define the practice of school-university partnerships for computing. Future researchers can develop their process and use of technology when supporting the development of computing education in schools, focusing on developing meaningful and equitable partnerships between stakeholders.

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Chapter 1. Introduction

Over the course of the last few decades, computing technologies have been in rapid development, with the proliferation of personal computing devices, smartphones and the internet influencing the digitalisation of public services (Dunleavy and Margetts 2010; Margetts and Dunleavy 2013), daily social activities, employment, education, healthcare, and civic participation (Wing 2010a; UK Department for Digital Culture Media and Sport 2017; Ofsted 2022).

Concerns for digital literacy (Department for Business Innovation & Skills 2014), economic agency (Livingstone and Hope 2013) and social exclusion (Helsper and Reisdorf 2017; Bacon and Mackinnon 2016) positioned the development of computing skills as a key focus for governments around the world (Wing 2016). These concerns prompted the UK government to respond with a reform of computing education, introducing a new National Curriculum for Computing in 2013 (Department for Education 2013a; 2013c; Ofsted 2022).

However, in the past decade, there has been increasing concern that this educational reform of computing in the curriculum has only caused further challenges to the educational wellbeing of young people in the UK (Berry and Kemp 2019; Berry, Kemp, and Wong 2018; The Royal Society 2017). In response, there have been several recommendations for the continuous improvement of computing education (The Royal Society 2017), including support for improved professional development for teachers, increased access to computing education, the development of educational research capacity in the UK, and developing methods to share knowledge between researchers and schools (Pye Tait Consulting 2017).

Conducted in the educational context of Northern England, the following research (structurally outlined overleaf in Figure 1) explores how partnerships between schools and universities can begin to support the improvement of computing education. It considers the opportunities, barriers and challenges inherent to educational partnerships between universities and schools, and proposes a conceptual framework that can be used to develop these future partnerships.

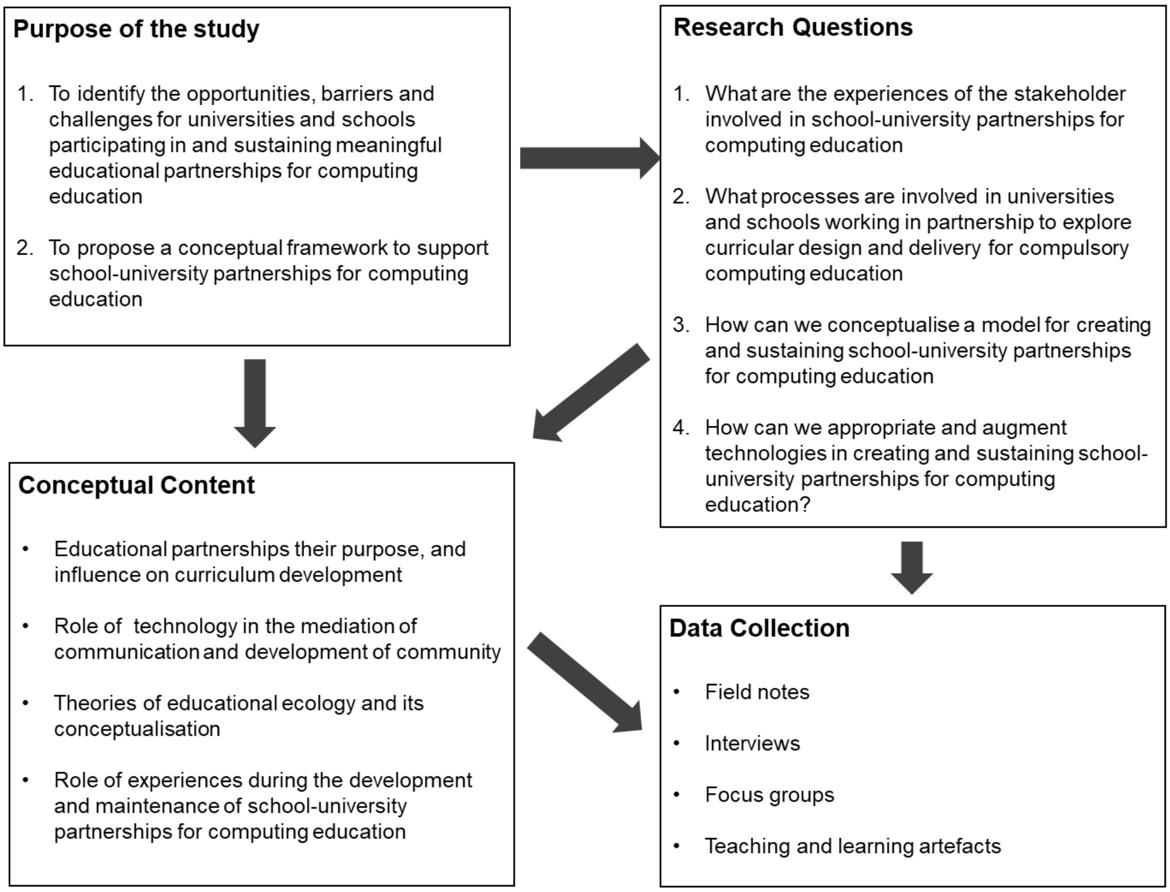


Figure 1. Diagrammatic representation of the research presented in this thesis

1.1. Context for research

The research in this thesis explores how school-university partnerships can be leveraged to support the development of computing education in the UK. Specifically, this research looks to explore how such partnerships can address the identified shortcomings of computing education in the classroom. Therefore, the following section provides an overview of 1) the current deficits of computing education in the UK, 2) configuring the role of universities and 3) exploring school-university partnerships in addressing these identified challenges.

1.1.1. Current deficits of the computing education in the UK

Compulsory computer science education was introduced to prepare young people in the UK with digital skills for modern citizenship (Department for Education 2013a; 2013c). However, this may have caused further problems than solutions, ranging from identifying poor teacher support (Royal Society 2018a; The Royal Society 2017; Larke 2019) to falling levels of pupil engagement where learners *fail* to be active participants in the teaching and learning process (Royal Society 2017; Wohl 2017; Cellan-Jones 2017; Haigh 2016).

In a comprehensive review of the impact of computing education policy changes conducted in the UK between 2012 and 2017 by the Royal Society, there were a series of recommendations put forth to address these identified challenges.

One recommendation was for government and industry to develop and provide continuous professional development (CPD) for computing teachers, which once developed, could lead to increased pupil engagement in computing (Royal Society 2017). Teachers involved in the Royal Society review welcomed collaboration opportunities with subject specialists, industry experts and computer science graduates to improve their subject knowledge. However, teacher noted that they lacked a method by which to engage with this expertise (The Royal Society 2017). As of the writing, there are no official, available guidelines to support external partners in initiating or maintaining engagement with schools that are focused on CPD for computing teachers.

A further recommendation is an ongoing programme for the development of content, qualifications, pedagogy, and assessment methods for computing to provide content that helps engage young people in their learning and gain interest in computing technologies**.** This includes the participation of with computing, education and pedagogical knowledge to advise the development of the curriculum, with a recommendation that these experts should be willing to spend time in the classroom context to support teaching and understand the physical, cultural and curricular constraints of developing and delivering educational improvement in schools. However, there is currently little guidance on what it *means* for these experts to spend time in the classroom context.

Furthermore, there is a need to develop the capacity to conduct computing education research and sharing of best practice. The UK's research community for computing education is negligible. In a systematic review of over 2,000 research papers on computing education between 2005 and 2014, the USA produced 1,231 papers on computing education while the UK only conducted 128 within the same period. The number of published, school-led research between 2005-2014 dropped to 170 in the USA and 24 in the UK (Waite 2017). These figures were attributed to computing education research lacking the social science methods and educational theory needed to explore the context of computing in the classroom and social science researchers lacking an understanding of the technical elements of the computing curriculum. Higher education was encouraged to undertake more research with schools around the development of computing education in the UK. However, computing education is a developing field of research, with little foundational research to help structure meaningful engagements between universities and schools. There is a need to develop a framework by which HE researchers can engage with schools to conduct mutually beneficial research and engage teachers through infrastructuring long-term research projects.

This includes a need to consider outputting research outcomes that are accessible and meaningful for the broader field of computing education. Published papers are often locked behind paywalls or otherwise inaccessible to the teaching community who encounter difficulties engaging with academic research and implementing findings from research evidence (Judkins et al. 2014). There is a clear need to develop methods of sharing research more effectively within the teaching community. This process involves disseminating research outcomes in an understandable format, with learning artefacts that teachers can utilise in their classrooms.

Whilst these are not the comprehensive list of recommendations proposed by the Royal Society report, these four areas are highlighted as motivation for the development of this thesis. This list of recommendations do not focus on pupil outcomes in computing directly, and instead focus on providing foundations for improved pupil outcomes to take place. Therefore, this work focuses on configuring the environment to provide these learning opportunities to young people, through the provision of teacher CPD, content and capacity for educational research.

1.1.2. Configuring the role of universities

Higher Education Institutions can be ideally placed to address these identified challenges and their proposed recommendations. However, these are not without their challenges.

Firstly, looking at how a university can be places to provide continuous professional development (CPD) for computing teachers. An issue is that the predominant approach for teacher CPD is a deficit model. The deficit model has been criticised for its ‘sink or swim’ attitude towards professional development (Lo Bianco and Freebody 2001; Comber and Kamler 2004), where individual teacher performance is addressed through *remedial* training (Sentance et al. 2016). Teachers who attend CPD sessions also report that the theory is difficult to implement in their local context (Neutens and Wyffels 2018). This lack of contextually-aware CPD prevents teachers from improving computing education in their schools (Pye Tait Consulting 2017), negatively impacting pupil engagement and future opportunities for their work and study (The Royal Society 2017). Therefore, a university will need to engage with schools while ensuring that efforts to provide specialist computing CPD values teacher experience, and is engaged in the context of educational delivery.

A further consideration for universities is how to structure ongoing programme for the development of content, qualifications, pedagogy, and assessment methods for computing, In their book ‘Academic Capitalism and the new economy’, Slaughter and Rhoades (2009) propose that university engagement falls under one of two opposing *regimes*. The first is a purpose centred around the *public good*, focusing on citizenship, where the university produces knowledge for the benefit of the community. The other is known as *academic capitalism*, defined as the commodification of the production of knowledge for more insular benefits. In valuing privatization and profit-taking ‘*above all else, knowledge is seen as a product by which to “generate profit… through the global market’* (ibid, p. 29). Schools can be sceptical of the transactional nature of university engagements and work must be done to explore how long-term, ongoing programmes can fit within university research and engagement lifecycles.

Finally, focusing on the challenge of conducting and sharing computing education research in the UK, universities are among the most strongly positioned institutions for the development and sharing of research. However, teaching communities report difficulties engaging with academic research and encounter difficulties with implementing new practices from their outputs (Judkins et al. 2014). Research demonstrates how embedded researchers can work towards developing relationships with educators, and ‘translating’ specialist knowledge for use by educators (Bouwma-Gearhart, Perry, and Presley 2014). However, care must be taken to avoid inconsiderate and exploitative research practices in these situations (Radinsky et al. 2001).

1.1.3. Exploring school-university partnerships

In *Pedagogy of the Oppressed*, Freire (1970) discusses the role of Higher Education Institutions as cultural invaders when conducting research. He also notes how highlighting this perspective can be met with hostility as it threatens the foundation of Higher Education institutions and individuals who have constructed identities around the deliverance of public good. To address this embodiment of oppression through unidirectional approaches to community working, Freire encourages a necessary shift in perspective - from universities creating invasive change to a community to working *with* a community in a partnership that crosses these socio-cultural boundaries.

Technologies may begin to address this challenging, helping to provide structure of the aims and responsibilities of school-university relationships and as a form of expectation management and workflow amongst a geographically and temporally distributed group of people (Wenger, McDermott, and Snyder 2002b; Venn-Wycherley and Kharrufa 2019).

While models of collaboration between universities and schools have yielded positive learning outcomes (Goode 2007; Ryoo, Goode, and Margolis 2015; Weston 2016), universities can struggle to authentically engage in boundary-crossing activities with schools (Gu 2016). There are currently few guidelines that exist to support universities to best engage with schools while avoiding the hierarchical relationships that may be encountered during this process.

Research has demonstrated the benefit of implementing communication technologies, in which digital services and systems can support the development of shared sensemaking (Fulk 2017) between entities. These communication technologies reported to structure an improved deliberation process between communities with differing power dynamics (Johnson, Al-Shahrabi, and Vines 2020), allowing for the creation of space and capacity to discuss issues and concerns (Olivier and Wright 2015). This improvement could be attributed to the freedom from physical barriers that may restrict in-person communication (Spears et al. 2002) or the obfuscation of social markers which attribute power or status to a group or individual (Bierema and Merriam 2002). However, further research points to how the nature of the digital medium of communication influences the emergence and replication of existing power dynamics, with text-based communication ranking among the most equitable initial forms of discussion between group members (Yamaguchi, Bos, and Olson 2002)

Therefore, one must acknowledge the identified challenges of university working, so this research looks to identify the experience of those involved in the process of a school-university partnership for the development of computing curricula, and use this to propose a framework for other universities and schools to adopt to engage in further development of the computing curriculum. Technology can provide useful infrastructuring for the development and maintenance of educational partnerships, but consideration must be taken as to its design, and consider the practicalities of function within a resource limited school environment (Royal Society 2017).

The work in this thesis is an opportunity to explore how school-university partnerships for computing education can be developed for long-term support of computing education in the UK. My role within the partnership acts as the proxy for university involvement, with my motivations being the design, enactment and sharing of research and its associated outcomes while working to understand the experiences of my partner teachers during this process. These findings then culminate in a proposal of a conceptual framework for others to engage in similar partnerships for the development of future materials, resources and assessments in computing education.

1.2. Research Questions

This research aims to develop an understanding of a school-university partnership process for compulsory computing education. As such, there are both empirical and conceptual contributions to this study. Research aims and their sub-research questions are as follows:

A. ***To identify the opportunities, barriers and challenges for universities and schools participating in and sustaining meaningful educational partnerships for computing education***

A1) What are the experiences of the stakeholders involved in school-university partnerships for computing education?

Through participating in school-university partnerships for compulsory computing education, I explore the perceptions of those involved in creating, running and maintaining these relationships

A2) What processes are involved in universities and schools working in partnership to explore curricular design and delivery for compulsory computing education?

The School-University partnership processes will be explored through the following research from curriculum design and delivery perspectives as I seek to identify the processes that influence participation and sustainability in school-university partnerships.

B. ***To propose a conceptual framework to support school-university partnerships for computing education***

B1) How can we conceptualise a model for creating and sustaining school-university partnerships for computing education?

Drawing upon empirical findings from Aim A and the body of literature on partnerships between schools and universities supporting educational outcomes, I seek to contribute an early conceptualisation of the operational processes involved in creating and sustaining school-university partnerships for computing education.

B2) How can we appropriate and augment technologies in creating and sustaining school-university partnerships for computing education?

While the use of technology is increasingly familiar in the educational context, the following research will examine how school-appropriate technologies can be used to address identified challenges in school-university partnerships.

The second aim of this thesis is to integrate the empirical findings from the previous set of questions and to underpin theoretical constructs to present a conceptual framework to support school-university partnerships for computing education.

This relationship is represented diagrammatically as the following in Figure 2, below:

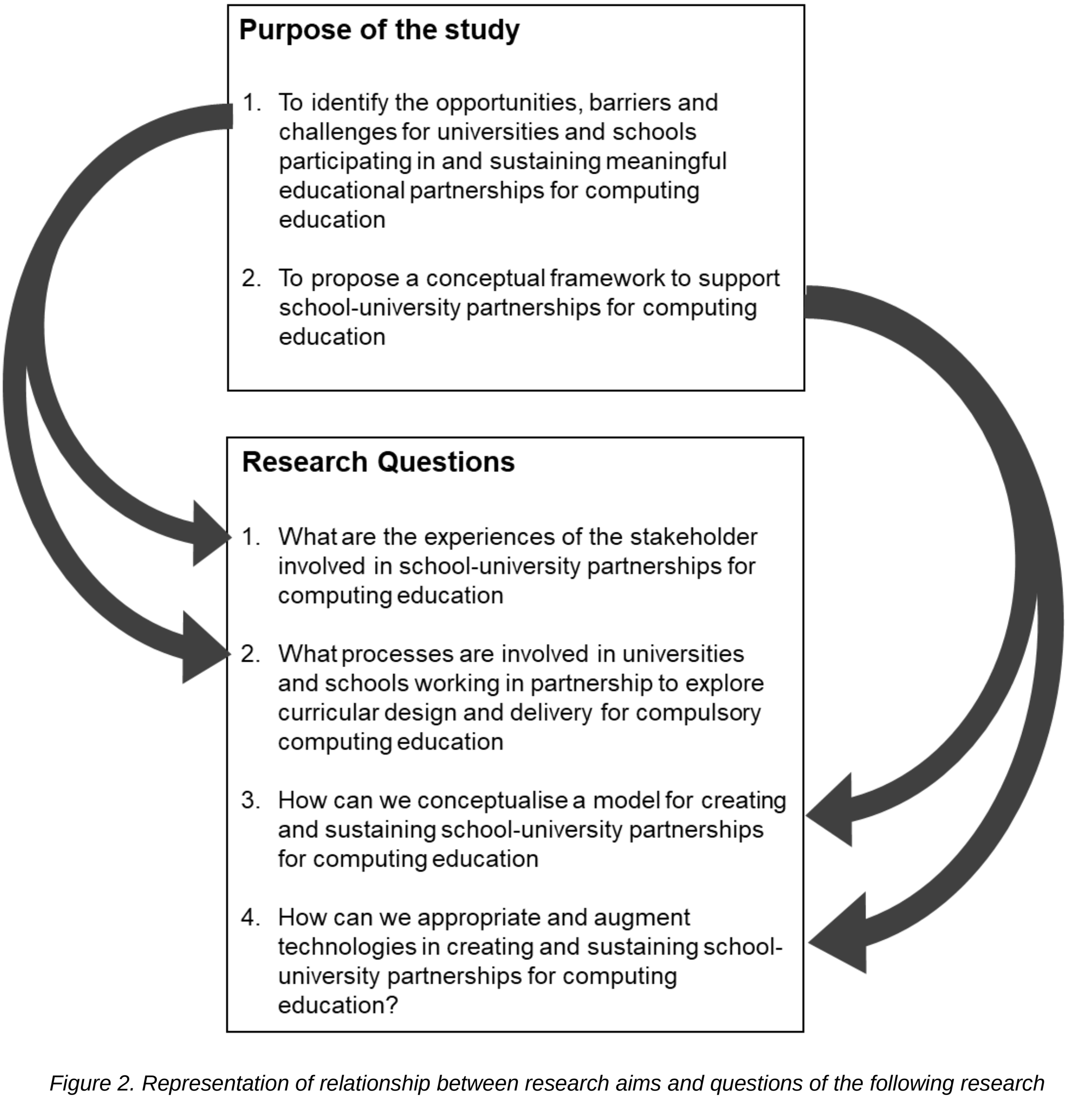


Figure 2. Representation of relationship between research aims and questions of the following research

1.3. Research Approach

As this research aims to investigate school-university relationships, I adopt a qualitative approach to the following research, focusing on methods that capture pupil, teacher, and researcher experience. These reflective experiences and impressions are recorded through observational field notes, interviews, self-assessment surveys and focus groups, to be analysed through thematic analysis to identify critical areas of development.

Traditionally, a researcher is in a position of power in the design and conduct of a study, which passive participants undertake. The nature of a PhD dissertation means that I must independently report the study. However, the design, delivery, evaluation and analysis can be conducted with stakeholders in the educational partnership process. However, as highlighted in the previous sections there is an inherent power dynamic when framing a collaborative investigation in terms of ‘researcher and participants’ and as such, my role within such a study cannot simply be ‘researcher’ but *partner*.

With my role as a partner in designing, maintaining, and investigating the school-university partnerships, this made Action Research (AR) an ideal approach when exploring the development of school-university relationships with pupils, teachers and researchers. This approach is then paired with action research (Hayes 2012, 2011). Historically employed in classroom-based research to uncover the complexities of the teaching process and improve the learning experience for pupils (Altrichter, Posch, and Somekh 2005), AR promotes systematic and collaborative research towards the practical resolution of community concerns, mindful of the social relations inherent to the research environment (Hayes 2012). With this focus on democracy, collaboration and acknowledgement of co-constructed meaning, AR can consider the interactions of these varying stakeholders in the school-university partnership while still retaining the practical concerns of the individuals, reflecting the nature of the entangled educational ecology. AR will be used in conjunction with a case study methodology, as it allows for in-depth explorations of complex issues in their natural environment (Hayes 2012).

The research approach and methodology for the overall project is discussed in more detail in my methodology overview in Chapter 3, with methodological detail of each case study provided in the relevant case study Chapters 4 through 5.

1.4. Thesis Structure

Having introduced the core motivations of the thesis, I have provided the contextual framing of this research in Chapter 1. This overview included the development of computing in the 21st Century, the introduction of the computing curriculum and the challenges and opportunities this presented to the UK educational system. I explored the reported deficits of the UK curriculum and identified areas of improvement, including the need to support teachers, the development of engaging learning materials for young people and the need to develop capacity in computing education research in the UK. I proposed that universities are ideally placed to address these challenges but suffer from unidirectional knowledge development goals in the form of academic capitalism. Through this positioning, I suggested two central research aims for this thesis:

A. *To identify the opportunities, barriers and challenges for universities and schools participating in and sustaining meaningful educational partnerships for computing education*
B. *To propose a conceptual framework to support school-university partnerships for computing education*

Chapter 2 begins by synthesising current literature on educational partnerships, curriculum and computing, demonstrating their viability in support of content, pedagogy and assessment method development. Ultimately, the literature highlights the challenge of power dynamics in educational partnership relationships, the importance of transparency of communication and contribution processes, and the need to engage in the notion of community to achieve meaningful partnership outcomes for schools. Human-Computer Interaction research can be positioned to bridge the current gaps in educational partnership research, particularly how partners engage in sharing practice and resources. Finally, drawing upon the work by Bronfenbrenner (2000), Hodgson and Spours (2013), and Mueller and Toutain (2015), I provided a review of key literature in the framing of educational ecologies to develop an early understanding of the factors influencing educational development, delivery and learning.

In Chapter 3, I present the methodological approach of the following research, opening with a discussion of my chosen approach to research design within the framing of school-university partnerships for computing education. With a focus on lived experience within a community environment, I outline the use of case studies (Lazar, Feng, and Hochheiser 2017) through an ecological approach to action research (Hayes 2012) and provide an overview of the role of data collection and analysis in my research study. I conclude the chapter by discussing ethical considerations of my research, with a particular focus on the role of power when undertaking work between universities and schools and working with young people.

Chapter 4 describes the first two case studies involved in creating and maintaining school-university partnerships. Case Study One presents the experience of creating an educational partnership between the computing department at a local secondary school and myself in the role of a researcher from Newcastle University. This configuration of the partnership process explored how university research groups could commission problem-based challenges, to which pupils had to design, code and present a response as part of their compulsory computing classes, and what this meant to the stakeholders in the partnership process. Key findings of this case study include the challenge of disconnect between schools and universities, the digital infrastructure of schools, and the barrier posed by accountability structures upon the novelty of partnership activities and engagements. Case Study Two explores the maintenance of an existing educational partnership as a continuation of Case Study One with new pupils and partnered staff members. This case study outlines the changes undertaken to the partnership process to maintain viability in the school setting, including how educational materials were created and delivered and my position as a researcher in the classroom. The case study also includes the decision to terminate one of the iterations prematurely due to a series of behavioural challenges across the school.

The subsequent Chapter 5 describes the case studies involved in the ending and legacy of a school-university partnership. Case Study Three marked the adoption of the design studio approach to computing curriculum delivery and the end of the direct partnership process. In this case study, I report my findings on partnerships' ability to diversify a failing computing curriculum through appreciative approaches to computing concepts and practice, the constraints of communication and the importance of flexible schemes of work when developing curricula. Case Study Four presents the legacy of the school-university partnership work detailed in the previous case studies by reporting upon two further secondary schools in the North East that used the scheme of work developed in Case Studies One through Three. These legacy case studies provide a perspective on a loosely coupled relationship between the schools and the university and demonstrate how these relationships can still support non-specialist teachers in computing delivery and promote positive pedagogical impact.

The overall findings are discussed more fully in Chapter 6. This opens with a discussion of identified opportunities, barriers, and challenges for universities and schools to create, maintain, and sustain school-university partnerships for computing education. This section is followed by a response to Research Aim B, in which I provide a critical examination of the processes and technologies involved in supporting the proposed conceptual framework to support the creation and sustainability of school-university partnerships for computing education, encapsulated as a a conceptual framework to support school-university partnerships for computing education. I present the five key stages in the conceptual framework: create, design, deliver, sustain and legacy. I conclude this chapter with a reflection upon the limitations of my research and potential for future research in the domain of partnerships for computing education.

1.5. Thesis Contributions

The following research has both empirical and conceptual contributions to both the fields of Human-Computer Interaction (HCI) and Computer Science Education (CSEd). The empirical contribution of this research lies in the exploration of school-university partnerships for computing education, including the opportunities, barriers and challenges inherent to the partnership process. The conceptual contribution takes the form of a conceptual model of operational processes to support future researchers to engage in the creation, maintenance and legacy of school-university partnerships. Underpinning this framework is a focus on technologies and their role in supporting the partnership process.

In short, this thesis contributes findings such that future researchers can develop the process and use of technology when supporting the development of school-university partnerships in support computing education in schools. It focuses on developing meaningful, equitable partnerships between stakeholders and exploring the role of technologies in supporting such processes from a Human-Computer Interaction perspective.

Chapter 2. Literature Review

2.1. Introduction

In Chapter 1, I provided an overview of the motivations and direction of my research study on the development of educational partnerships for computing education. In Chapter 2, I build upon these notions by synthesizing previous literature to further frame my research.

I begin the chapter investigating computer science education in the UK, providing an analysis of the strengths and limitations of computing curricula in the UK. I also delve into the topic of pedagogy in computing education, including different approaches to teaching and their effectiveness in the context of computer science education in the UK. I then move to examine the role that educational partnerships can play in supporting computer science education, examples of successful partnerships, and challenges and best practices for establishing and maintaining educational partnerships.

Finally, I explore the use of conceptual and theoretical frameworks in understanding and addressing the challenges of current approaches to computer science education through educational partnership, including educational ecology theory as a framework for addressing challenges in computing education, its key components and its application in informing educational partnerships.

This literature review was conducted through the ACM Digital Library, JSTOR, Scopus, the digital collection at Newcastle University, and the exploration of peer-reviewed journals, books, and online articles. Keywords implemented in the search strategy included UK computing curriculum, computing curricula, computer science education pedagogy, pedagogical approach for computing education, educational partnerships, curricular partnerships, partnerships for computing education, school-university partnerships, community relationships in education, design of participation, community, knowledge sharing, equitable communication, and educational ecology.

2.2. Computing Education, Curriculum and Pedagogy

In Chapter 1, I outlined the importance of computing education, where computer science education plays a crucial role in preparing young people for the rapidly-evolving digital world. However, current provision of computing education in the UK

In the following subsections, I will review the arguments for the importance of computing education, then examine how this influences the current approach to the computing curriculum in the UK, including the strengths and limitations of the curriculum in practice. I will then explore the most popular pedagogical approaches to the delivery of this curriculum, providing a critical analysis of these approaches in the context of computing education in the UK and how this influences the direction of the overall research of this thesis.

2.2.1. The importance of computing education

From a commercial perspective, computing education has been framed as a method of plugging the UK's current lack of domestic computing professionals (Livingstone and Hope 2013) in preference to international candidates. This industrial motivation is evident in the increased popularity of informal short-term coding boot camps (Eggleston 2019; Gallagher 2020), aiming to provide retraining or upskilling to those interested in a career in computing, specifically in software development. This is typically paired with the popular narrative that a career in computing is a position of improved quality, to encourage job retraining, as demonstrated in Figure 3 (Helsper and Reisdorf 2017; Cebr 2015; 2018; Tamatea and Pramitasari 2018).

Figure 3. Cyber First advertisement 2020. Photograph: HM Government

Compared to the cost of study of Higher Education, boot camps appear to be eminently more affordable and appear to promote socio-economic inclusion in marginalised communities and minority groups such as refugees (Francis 2019) and women (Lyon and Green 2018). However, Bootcamp participants note a series of barriers upon attempting to enter the software industry, including the stigma faced in job interviews, the importance of pre-existing social capital and a sense of imposter syndrome, or are not always aware of the financial implications of withdrawal or rejection from their course of study (Wilson 2018; Thayer and Ko 2017). These challenges lead to the critique of the opportunistic and exploitative nature of the Bootcamp model of computing education, where market-driven behaviours sustain an unrealistic narrative of a career in computing being a straightforward approach to financial stability (Wilson 2017). The economically driven approach to computing education is particularly noticeable in coronavirus pandemic-response policy, such as the £21m allocated to digital bootcamps aimed at "those who are unemployed, seeking a change in the career, and employees looking to gain the required digital skills to secure a promotion in their current job," (WMCA 2021). Computing education, driven from the perspective of the economy, is underpinned by a focus on meeting current economic supply and demand, leading to the potential to further entrench the power imbalance between those with knowledge and those without.

From a political perspective, the importance of computing involves the digital inclusion of all citizens through digital literacy skills (Ofsted 2022). In 2016, the Science and Technology Committee of the House of Commons of the UK predicted that 12.6 million adults were currently suffering from some form of digital exclusion due to personal, social or economic circumstances that affect their digital literacy skills (Cebr 2015; Science and Technology Committee 2016). It was proposed that most people would naturally acquire these skills through everyday interaction with computing technologies. However, this approach would likely leave large communities of people digitally excluded for the foreseeable future, leading to further entrenching existing social exclusion (DiMaggio and Garip 2012; Robinson et al. 2015). In juxtaposition, articles such as 'Please don't learn to code' propose that while coding is an important skill, it is only essential in the proper context for a particular subset of people (Farag 2016). The author of this article goes on to say that he would "no more urge everyone to learn programming than I would urge everyone to learn plumbing," (ibid. para. 11), adopting the ideological stance that there is no room for programming to exist beyond meeting an urgent financial, economic or political need. The epistemological stance behind computing education is driven by a perception of instrumental knowledge, as it can be used to achieve a different, valued purpose (Zimmerman and Bradley 2019). This positions computing as a form of knowledge that only has value when considering the potential value of something else (e.g. serving an economic purpose), which impacts how computing is taught in formal education (Brown et al. 2014; Hubwieser et al. 2015; Department for Education 2013b; 2013c; Royal Society 2017).

However, this stance wilfully ignores the fact that there is more to learning programming than profit or socio-political activism. It dismisses that learning to code can help people to improve their cognitive skills (Scherer, Siddiq, and Sánchez Viveros 2019), express ideas and enable creativity (Kafai and Vasudevan 2015; Roque, Rusk, and Resnick 2016), build relationships with others (Roque, Rusk, and Resnick 2016; Butler, Flood, and Power 2018), as well as develop their understanding of personal identity (Roque and Rusk 2019) and self-confidence (Denner, Bean, and Martinez 2009) and community (Lombana-Bermudez 2017). This thesis adopts the belief that learning to code should not only be a response to extrinsic financial, economic or political needs but a skill worth developing for intrinsic wants, needs and applications. When our society is rapidly more dependent on computing technologies, it becomes logical that we ensure that learners can use and understand these digital tools for their own sustained political, civil and social citizenship (Royal Society 2017). Computing education helps us analyse the power afforded by humans and computers and points towards the subsequent improvements to be achieved by a combined interaction of technology, engineering and organic computing (Denning and Tedre 2019).

2.2.2. The computing curriculum in the UK

While there is no singular definition of curriculum, respected academics within the field of curricular theory, such as Kelly, consider that curriculum is a set of courses or educational content designed to prepare learners in responses to the needs and development of society (2009). However, this perspective of curriculum could mean that it often failed to take into account the broad perspective of the educational curriculum as an interplay of political, economic, moral and ethical factors to promote freedom and independence of thought, political empowerment, mutual respect and improved quality of life.

In England and Wales, the curriculum is determined centrally by the Department for Education and is known as the National Curriculum (Department for Education 2013f;). Working groups determine the essential knowledge young people should achieve through their compulsory academic careers, with a focus on content that has been identified in response to societal need (Kelly 2009, Department for Education 2013f; Apple 2018). Kelly (2009) is a key critic of the political selection of curriculum content, where the justification for chosen content is vague and overly utilitarian (pg. 64), and can fail to consider the importance of personal development beyond achievement of identified knowledge. Furthermore, in a 2022, an Ofsted research report notes that the ability to navigate modern society is crucial if *'business, industry and individuals are to exploit the opportunities offered by this revolution'* (Ofsted 2022, para 1)

As outlined in the previous subsection, the development of the computing curriculum in 2013 was driven largely by concerns for economic and political development of citizens in response to the widening proliferation of technological systems. There is some focus on "computational thinking" and the wider personal benefits available to young people studying computing – for example, the curriculum outline published by the Department for Education highlights that the study of computing "*equips pupils to use computational thinking and creativity to understand and change the world"* (Department for Education 2013f, pg. 1) but provides no concrete channel for how this 'world-changing' is to be achieved. Kelly (2009) identifies this approach to curriculum as a 'cash-in' on moral and ethical curricula, obfuscating the utilitarian curricula driven by political intervention through a philosophical argument. At no point is creativity mentioned again in the curriculum documents for computing.

This becomes a practical issue in the delivery of computing, as an increase in pressure to assess pupil retention of identified curriculum content has led to a focus on test preparation and a narrowing of the curriculum (Royal Society 2017). This results in a lack of attention to important areas such as critical thinking, creativity, and social-emotional skills, which are not adequately measured by standardized tests (Pellegrino, Chudowsky, and Glaser, 2001).

The nature of assessment and evaluation is typical of politically-driven curriculum development (Kelly 2009), providing opportunities for data generation for use in decision-making, yet criticised for concentrating on the effectiveness of delivery rather than on the value to learners and their development. In the computing curriculum, this demonstrates a need to focus on the intrinsic importance of computing, such as the development of cognitive skills, communication, personal development, self-confidence and community (Scherer, Siddiq, and Sánchez Viveros 2019; Kafai and Vasudevan 2015; Roque, Rusk, and Resnick 2016; Denner, Bean, and Martinez 2009).In implementing the computing curriculum assessments, teachers in England, Wales and Norther Ireland highlighted challenges with the focus on assessment, expressing concern that assessment methodologies were "*onerous*" (Royal Society 2017, pg. 33), resulting in a heavy workload that would drive many new computing teachers from the profession. In a further survey, the assessments required of GCSE and A-Level computing were criticised for their lack of guidance on performance benchmarks and grade boundaries, as well as controlled assessments for taking up too much time. Teachers described these assessment approaches as demoralising and difficult, squeezing out any of the ICT elements that might focus on communication, personal development or community development (Pye Tait Consulting 2017). This has been partly attributed to the fact that current approaches and methods of assessment are routed in in Higher Education (Kallia 2017), meaning that teachers must spend time to modify assessment with few examples of what this looks like in practice.

A further challenge regarding the politically-driven, curriculum-as-content approach to curriculum development is the misalignment between the curricular outline and the needs and interests of the learner (Reiss and Edwards, 2003). Where this "curriculum as content" paradigm is adopted, with a focus on pupil acquisition of identified knowledge (Kelly, 2009), it can result in a lack of engagement and motivation on the part of the students, and exclusion of important knowledge and perspectives that are not reflected in the curriculum (Leat 2015). rather than focusing on the intrinsic importance of computing to a learner.

This has meant that students who typically choose to study computing at GCSE and beyond are largely identified as academically strong, mathematically able, from economically stable families and overwhelmingly likely to be male (Berry and Kemp 2017). These statistics have drawn criticism that the computing curriculum is not accessible for young people from disadvantaged backgrounds who are most at risk from social-digital exclusion (Robinson et al. 2015; The Royal Society 2017; Matheson 2017; Berry and Kemp 2017b). In a survey of 4,000 young people (aged 14-18) in England, the top reason cited for not choosing to study computing was due to a lack of interest in the topic (Wellcome Trust 2017), denoting a gap between the political needs of learning and the needs of young learners, where the value and importance of computing has not been adequately communicated.

According to the curriculum theorist William Pinar (2004), one of the primary drivers of curriculum development should be the cultural and societal context in which it is being developed. This includes factors such as the values, beliefs, and priorities of the community of a learner, with consideration of the wider historical, political, and economic conditions that shape educational policy and practice. A particular challenge of this approach to curriculum development is in ensuring that the curriculum is inclusive and representative of the diversity of experiences and perspectives of the learners (Archer, de Gayardon, and Khattab, 2015). This includes issues of equity and access, as well as the need to provide a curriculum that is culturally responsive and respectful of the diverse backgrounds of students, as a way to engage a wider range of young people in their education. Kelly (2009) notes that, where the curriculum is intended to address issues of poverty, unemployment and social disorder, such as a computing curriculum to address digital exclusion *and* economic stability, a monocultural curriculum is unlikely to be effective for learners.

Literature points towards the possible subversion in the form of the community curriculum (Alexander 2010). Statutory guidance remains to determine the description and rationale for each subject, with nationally determined (yet non-statutory) programmes of study allowing for the joint construction of curriculum content and assessment. Underpinning these are locally determined community curricula, which can adapt programmes of study and content to meet local needs and opportunities (Leat and Thomas 2016; Leat 2015; Cummins, Chow, and Schecter 2006). Local authorities and schools are ideally placed to recognise local needs and educational opportunities (Hodgson and Spours 2013), connecting learning institutions with local employment opportunities and further education. Teachers are experts in their classrooms and pupils (Leat 2015). Parents, carers, and children should also be considered knowledgeable partners in creating a curriculum that meets local needs and opportunities (Bronfenbrenner 1986; Epstein 2014). Developing this further and engaging local businesses, organisations, and educational institutions can introduce expert knowledge into the curriculum, providing improved levels of engagement and potential future pathways into education, employment or training (Hodgson and Spours 2009; 2013; Carlsen 2021; Leat and Reid 2012; Leat and Thomas 2017).

This could be introduced through a differing structure of curricular implementations. For example, in Wales Crick et al. (2018) demonstrated how practitioner-led support networks focus on sustaining local communities of practice to address to learner perceptions and interest, while enabling the delivery of digital competency education. The “Technocamps” model involved universities working in collaboration with teachers, pupils, schools, parents and wider educational and political bodies to address the wider ecosystem of activities and engagement available to implement the computing curriculum. However, the research does not explore the challenges of partnership working between universities and communities, which I initially noted in Subsection 1.1.3 that noted while models of collaboration between universities and schools can yield positive learning outcomes for participants (Ryoo, Goode, and Margolis 2015; Weston 2016), universities struggle to authentically engage in boundary-crossing activities with schools (Gu 2016), resulting in unintentional oppression through unidirectional approaches to community working (Slaughter and Rhoades 2009).

Finally, is the impact of the introduction of the computing curriculum on teachers. One computing education advisory group noted that the policymakers had “*naïve assumptions and unrealistic expectations*” about how existing ICT teachers could transition to computing education without training or support (Phillips 2016, para. 16). One approach to addressing this problem, through the Computing at School community, was funded by the Department for Education. The programme involved the development of the Master Teachers programme between 2014-16, providing in-depth training for a small number of teachers (Smith et al. 2015) who would then be encouraged to share this knowledge with their own teaching communities in peer-to-peer CPD, addressing some of the challenges of deficit-based CPD and their poor applicability in the classroom context (Haden et al. 2016; Brown et al. 2014). A further £84m of funding was made available through the National Centre of

Computing Education in 2018, providing nationally recognised certification in computing subject knowledge and online communities for UK-based computing teachers (Sentance 2019). However, as of 2022, there are still concerns about the number of qualified teachers who are able to deliver the curriculum-as-written (Ofsted 2022).

Considering these range of challenges facing the computing curriculum, a key element becomes clear – there is a need to balance the needs and goals of the learner with the needs and goals of the broader educational community, including educational institutions, policy makers, and learners themselves (Fullan, 2002). Balance can be achieved through the use of educational partnerships, in which different stakeholders come together to collaborate on the development and implementation of the curriculum. Educational partnerships can take a variety of forms, such as teacher-led initiatives, community-based projects, or government-funded programs, and can be a useful way to bring a diversity of perspectives and expertise to the curriculum development process (Cuban, 2001).

However, the partnership approach is not without its challenges. In the development of the computing curriculum, a wide range of stakeholders, including teachers, policy makers, and industry experts were cited to have worked together to outline curriculum components (Department for Education, 2014). Kelly (2009) stressed the importance of including teachers in curricular development, placing them as a central figure in the effectiveness of an implemented change. However, the introduction of the computing curriculum appeared to have been undertaken without consideration of many teachers who lacked specialist knowledge, with no clear steps for training or support from central policy-makers (Phillips 2016, para. 16, Royal Society 2017). While there was some consultation of teachers undertaken in partnership towards the development of the new computing curriculum it did not place *all* teachers at the centre of the curricular change, ultimately affecting the effectiveness of the implementation, as outlined by Kelly (2009) in his chapter covering the challenges of curriculum as content.

This approach has meant that neither the practicalities of teaching an entirely new curriculum, teacher knowledge, experiences, nor student interests were considered in the development of the computing curriculum, largely related to the driving political influence of the curricular introduction. This not only influences the curriculum-as-designed, but also the practicalities of the computing curriculum-as-delivered.

2.2.3. The practicalities of the computing curriculum

Despite the curriculum requiring teachers to deliver the specified content, there was initially very little direction as to how the curriculum should be delivered, nor was there much consideration of the practicalities of the delivery (Pye Tait Consulting 2017). In the following subsection, I outline the most common approaches to the delivery of the computing curriculum, and the challenges that surround the practicalities of their delivery.

In her systematic literature review of the common pedagogies for the delivery of computing education, Waite (2017) outlined the importance of learning models, curricula framework, context, programming language and student engagement. In the following thesis, with a focus on the practical implementation of the curriculum, I focus on her findings that discuss the practicalities of varying pedagogical approaches, This also includes the opportunities and challenges they present for student engagement, such as programming work produced, peer instruction and student contributions such as problem-solving.

Physical Computing, rooted in Papert's constructionist framework (1980), focuses on learners controlling devices such as motors, speakers, LEDs and more. While the combination of these devices could externalise some of the abstract, internal workings of computing devices to learners, Falkner and Vivian (2015) highlighted that there was a lack of appropriate pedagogy for its implementation, and while this pedagogical approach could support learners, further research would need to be conducted to evaluate teaching strategies (Waite 2017).

However, further research by the Royal Society noted that disadvantaged pupils were disproportionately impacted, as they would have lower probability of access to equipment (2017). A further challenge was considered to be the digital infrastructure of schools, in which security policies restricted the use of technologies in the classroom to support computing education (Pye Tait Consulting 2017, Ofsted 2022).

Waite (2017) also notes that game-making pedagogies appear to improve student motivation, but can be adopted differently by gender, often being seen as more appealing to male students (Royal Society 2017). Pair programming was noted to improve collaborative engagement, but resulted in less work and did not increase overall learning (Denner et al. 2014). This is similar to findings of unplugged pedagogies, that while one of the most common pedagogical approaches (Sentence and Csizmadia 2017), have been noted to provide mixed evidence as to their effectiveness (Thies and Vahrenhold 2016), often resulting is disengaged pupils and reduction of interest in studying computing further (Taub et al. 2012).

Proposed as a pedagogical approach to encourage learners to engage in their computing education, Waite (2017) outlines the promise of project-based learning, demonstrated to improve engagement and improve skills beyond programming, encouraged to help pupils learn about the common uses of technology beyond the school environment (Ofsted 2022). Project-based learning (PBL) is practice-based and experiential, engaging students in their learning through extended engagements centred on a response to a complex, well defined task (Leat 2017). This pedagogical approach often works towards a ‘community of practice’ (Wenger 1998), in which students, teachers and people outside of the school environment work together to develop expertise, share knowledge and solve problems (Maida 2011).

However, these partnerships in support of curriculum are not without challenge. These challenges include concerns of sustainability, legacy and the realities of long-term teacher development (Leat and Thomas 2018b), the brokering of relationships and the negotiation of personal and public lives (Restad 2021), the concern regarding the potential for the exploitative practice of students or teachers (Radinsky et al. 2001) ensuring mutual respect of the cultural values of partners involved in curriculum development (Lewis et al. 2016; San Martín-Rodríguez et al. 2005). Furthermore, the divergence from centralised, statutory guidance means that the assessable products of such a curriculum (as a product of an educational partnership) can include such variety as to include ’reports, displays, films, cartoons, events, plans, food, gadgets, webpages, guides and menus’ (Leat 2015). These outputs become more difficult to standardise and assess within the statutory requirements of the National Curriculum, denoting how the balance of novelty should be carefully considered when engaging in curricular development with partners. This presents this pedagogical approach, despite its benefits for learners, as a particular challenge for a system where teachers can lack knowledge, confidence, training and adequate resources (Royal Society 2017, Ofsted 2022).

Furthermore, in exploring of pedagogical development, is the call for the development of a semantic wave approach to design and delivery (Ofsted 2022; Maton 2013). This includes the introduction of abstract computing concepts by introducing it within a wider context and introducing pedagogical examples such as metaphors, examples and unplugged activities to construct meaning. This pedagogical approach has been used in individual lessons, with Ofsted (2022) calling for its use across longer programmes of study, to encourage pupil engagement and learning.

However, underpinning these approaches to pedagogical content knowledge is the lack of suitably qualified teachers to deliver these approaches to curriculum. In 2017, only 36% of secondary school teachers held a computing degree (Pye Tait Consulting 2017). Teachers involved in the Royal Society review welcomed collaboration opportunities with computing subject specialists, industry experts and computer science graduates to improve their subject knowledge and develop curricula. However, they lacked the time and knowledge to be able to engage with this expertise (The Royal Society 2017, Ofsted 2022).

Throughout this synthesis of approaches to current pedagogical delivery in the classroom, they are impacted by a lack of expertise, technological resource and people. While curricular approach is beyond the scope of this research, the exploration of infrastructuring relationships with the purpose of developing curricular and pedagogical understanding within computing education is not. The following sections explore how these relationships might be developed to provide access to expertise, resource and people through the development of educational partnerships for computing education.

2.3. Partnerships for Education

The proposition that computing curricula in schools can be supported through the development of educational partnerships warrants a conceptual exploration of their definition, purpose, motivations, challenges and best practices of partnerships focused on educational development and delivery, particularly where these concepts have been explored within the sphere of computing education. This section will then situate the need for establishing and maintaining educational partnerships for computing education, and the challenges for doing so, providing the conceptual space that this research will look to explore.

Educational partnerships are often portrayed as a superior method of educational organisation due to the positive characteristics they are supposed to portray (Cardini 2006). They are also perceived as maintaining inclusivity and accountability to the broader community (Cox-Petersen 2011). In the following thesis, the term ‘educational partnership’ denotes the relationship between a school and one or more external partners.

One of the reported purposes of an educational partnership is to prepare young people for employment and citizenship in modern society in an age of unprecedented uncertainty (Cox-Petersen 2011). Educational partnerships can provide a mutual exchange of knowledge, skills or resources (Cox-Petersen 2011; Hora 2011; Nardi and O’Day 1999), address the shortage of teacher capacity while increasing academic success (Cox-Petersen 2011), and develop an educational culture able to weather continuous or turbulent change (Nardi and O’Day 1999). Additionally, they can improve social and economic development (Cardini 2006, improve community relationships and provide access to training at a decreased cost (Glenn 2017).

Following the formation of the New Labour government in the mid-1990s, the use of partnership as a term to denote support for the delivery of national objectives expanded dramatically within UK government policymaking, particularly in the provision of social services such as education (Glendinning and Powell 2002). Examining this phenomenon from a political perspective, educational partnerships were considered a pragmatic form of empowering local people and communities to develop and deliver educational policy, particularly in the New Labour government of the 1990s (explored further in Blunkett 1999). However, this approach to educational provision shifted the accountability and governance of educational design and delivery from the state to the citizens (Cardini 2006).

Moving beyond the social and political constructions of educational partnerships, Cardini (2006) highlights a key series of tensions and contradictions inherent to partnerships in theory and partnerships in practice. Firstly, there is no single method of approaching the definition and process of engaging in an educational partnership – the political fixation on partnerships under New Labour (Glendinning and Powell 2002) meant that many non-reciprocal, unidirectional relationships were considered a partnership. Furthermore, developing partnerships were reported to demonstrate a poor understanding of preconceived social hierarchies, diverse motives, organisational structures, culture and access to resources, often leading to their eventual breakdown (Newman et al. 2000; Cox-Petersen 2011).

Therefore, it is necessary to understand the perceived purpose and motivations of educational partnerships, to begin to address how to navigate and address the challenges of educational partnerships, and explore their role in improving the provision of computing education in schools. In the following subsections, I review the stance of literature on purpose and motivations of educational partnerships, and how this influences the process and outcome of the partnership. I then move to explore the challenges and best practice of educational partnerships, and round off the subsection with a review of these findings in light of partnerships in support of computing education.

2.3.1. Purpose and motivations of educational partnerships

The role of educational partner can be played by anybody with an interest in supporting education provision, from families to businesses, communities, and education providers, where each partner is a valued part of the process of education design and delivery (Epstein et al. 2009; Miller and Hafner 2008; Carlsen 2021). While there may be a central goal to a partnership, each of these partners may have a differing purpose or motivation for entering into a partnership agreement, which can influence the way in which a partnership is created, maintained and ultimately terminated. These can include: providing access to physical resources; access to expertise; undertaking evaluation; or encouraging progress (Cox-Petersen 2011, Epstein et al. 2009, Cardini 2006

Epstein (2009) positions the importance of partnerships as central to educational development, able to provide resources beyond the scope of schools – particularly where schools are unable to provide the resources needed to succeed in society. In the UK, schools are adversely affected by economic recession and associated austerity measures and are often unable to provide consistent access to resource

(Busby 2019; Boden, Kenway, and James 2020), which is particularly notable in computing (Royal Society 2017). Therefore, schools will often enter into partnerships in order to gain access to material resource, and provide improved access to resource for their learners.

While universities were not intended to be hubs of physical resource, the natural by-product of academic capitalism (Slaughter and Rhoades 2009) tends toward the accumulation of physical resources and equipment. These are resources that can be mobilised for use by the educational community surrounding the university and beyond should there be a shift in consideration for the outputs and process of research with schools that go beyond limited outreach (Atherton 2012; Rivera, Gardner-McCune, and McCune II 2017).

However, the resources required to provide successful educational experiences to young people go beyond the material, and also include *people* within communities (Epstein et al. 2009). People within a partnership have much to share, a fact noted by the recommendation of the Royal Society (2017) that more needed to be done by partners to support the computing curriculum, such as the provision of industry-aligned continuous professional developed (CPD) for teachers. Educational partnerships can provide a mutual exchange of knowledge, skills or resources (Cox-Petersen 2011; Hora 2011;) addressing the shortage of teacher capacity while increasing academic success (Cox-Petersen 2011). Universities are ideally placed to provide specialist content knowledge required by schools (Bouwma-Gearhart, Perry, and Presley 2014), and as outlined in Section 1.1.3, are institutions driven by research and education. They are able to provide access to resources, access to social capital and expertise, as well as provide evaluation through research.

The production of knowledge and its evaluation is often core to the purpose of a university and its engagements with community partners, such as schools. This production of knowledge can often be shaped by the Research Excellence Framework (REF). The REF is a national research impact evaluation of British Higher Education institutions in which research outputs are assessed to provide accountability for public investment in research. However, the nature of the REF means there are few extrinsic motivators for researchers to ensure their community work goes beyond publishing (Lopez Turley and Stevens 2015). This may mean that school partners may be sceptical of working with academics (Gu 2016) due to their approach of ‘impact mercantilism’ (Watermeyer and Hedgecoe 2016), in which researcher and research community performance is measured primarily through output rather than community benefit.

Furthermore, there is not often the requirement that researchers engage in training for long-term, mutual research partnership activities (Lopez Turley and Stevens 2015), acquiescing to the development of inconsiderate and exploitative partnership practice (Radinsky et al. 2001). While turning to considerations of governance for schools, university partners must consider mandatory curricular needs and the role of local authorities and administrators when developing these relationships (Severance, Leary, and Johnson 2014). To address the issue of relationship dynamics within the educational ecology, it is worth exploring the role of mutually beneficial partnerships which focus on trust, deliberation and the parity participation between researchers and teachers (Schaik et al. 2018).

An alternative purpose of partnership for universities, briefly popular for computing curriculum delivery in Higher Education, is found in the form of service-learning for university students. With theoretical roots in Dewey (1997), service-learning gained popularity in the 1990s as a form of reciprocal experiential learning. It was characterised by learners applying course concepts through the development of a service or product to meet an authentic community need (Corporation for National and Community Service 1990). The service-learning approach to educational partnerships supports the learner in the improvement of their academic performance, interpersonal skills and professional development Coyle, Jamieson, and Oakes 2005; Pollock et al. 2018) with a focus on the potential for social justice outcomes (Mayhew and Fernández 2007). In computing, academics work with community project partners to identify their digital needs and work to develop a project in which a digital system or service is delivered and maintained to amplify a given service to the community (Hoxmeier and Lenk 2020). Examples of projects undertaken as part of a computing-community partnership include the development of e-commerce platforms for local businesses, software support for public libraries and the provision of community IT support (Tan and Phillips 2005; Pollock et al. 2018; Hoxmeier and Lenk 2020).

However, research calls our attention to the fact that there is often little consideration of the community impacts of service-learning partnerships (Cronley, Madden, and Davis 2015). Unlike industry partnerships, the locus of control sits firmly with the university as the organisation with access to the resource (i.e. computing students and their technical skills), driving unilateral community engagement.

Drawing from the above literature, the perception of power is the core foundation for making or breaking an educational partnership. A partner with better access to financial capital, fewer performance targets and a perceived position of social power is more likely to hold an upper hand in the partnership relationship. This perception is particularly problematic in partnerships with state schools in the UK, who are adversely affected by austerity policies (Busby 2019; Boden, Kenway, and James 2020) that limit their financial capacity. This environment can position them as the subordinate partner in this typical form of partnership, reducing the importance placed on the contribution of schools, teachers and students (Slaughter and Rhodes 2009, Cox-Petersen 2011).

Overall, the purposes and motivations between partners may not be identical in an educational partnership, with both partners seeking to access the same resources, expertise, evaluation or progress. However, they do impact the internal workings and outcomes of a partnership. In the next section, I outline the challenges and best practices of educational partnerships – identifying key elements that can help begin to provide structure as to how schools and universities can work together to address the identified challenges of the computing curriculum.

2.3.2. Challenges and best practices in educational partnerships

As outlined in the section above, the tension of motivations and purpose in an educational partnership can lead to a range of challenges such as power, hierarchy and control regarding access to resource. This is particularly challenging when UK schools, disproportionately impacted by austerity measures (Boden, Kenway and James 2020), are placed almost immediately in the position of *lesser*, in this traditional perspective. In the following section, I provide a review of current research into the range of challenges and best practices for educational partnerships in the UK context, moving to focus on to particular examples of challenges regarding school-university partnerships. This can begin to support the identification of opportunities, barriers and challenges for universities and schools discussed in Research Aim A.

First, and perhaps most importantly, is the discussion of power in educational partnerships. In Section 2.2.1, I briefly outlined how the perception of power is foundational in the creation and maintenance of educational partnerships, with partners who have better access to financial and social capital more likely to be positioned as the dominant partner. This draws into question the prevalent power dynamics of an educational partnership, which can be loosely categorised as either a top-down or bottom-up approach.

A top-down approach is reminiscent of the rhetoric employed by the New Labour partnership boom (Glendenning et al. 2002) and is more likely to reinforce a unilateral power relationship in a partnership, encouraging ‘the stronger’ partners to avoid distribution of power altogether by ensuring leadership is placed with a single individual or organisation (Cox-Petersen 2011), with little consideration of how this strength is measured or who decides the criteria of strength. Top-down approaches to educational partnerships are most likely politically driven, historically with an interest in educational reform and restructuring (Goodlad 1993, Glendenning et al. 2002). The top-down approach also has the tendency to discount of ignore the experiences of the *lesser* partners engaged in an educational partnership – their outlooks, motivation, skill, know-how and commitment. However, Bros and Schetchter (2022) demonstrated how the lack of consideration of this experience can lead to difficulties in implementing educational change.

In Cardini’s (2006) study on the analysis of rhetoric and practice of educational partnerships in the UK looked to explore an understanding of theory and practice of educational partnerships. In this work, Cardini discusses particular challenges for collaborative educational partnerships, including structural and functional barriers, and cultural barriers.

Structural barriers include elements such as the fragmentation of organisations involved in a partnership, or where partners are organised around the services delivered rather than their beneficiaries. The organisational realities of educational systems, where schools have complex organisational needs and wider organisational accountabilities mean that coordination, formation of trust and mutual understanding are key challenges to educational partnerships (Coburn and Penual 2016).

Research in HCI, particularly those related to computer-mediated communication systems, has played an undeniable role in the development of communication between systems and people separated by geographic distance and time for such purposes as diplomacy, economy, finance, education and personal communications on a global scale (Downey 2002). Through communication technologies, one can develop connections that help link these separate entities in a way that mediates shared sensemaking (Fulk 2017). These are known as computer-mediated communication systems and underpin the creation and maintenance of interpersonal relationships in a variety of relational contexts (Walther 2011). Individuals can make use of CMCS to portray positive impressions and seek out new relationships (Tong and Walther 2011), engage in community development (Corbett and le Dantec 2018), and support learning (Mazer, Murphy, and Simonds 2007).

As previously highlighted, educational partnerships between schools and universities are likely to experience challenges of social dynamics between individuals and organisations, which can ultimately place the success of such a partnership at risk. Instead, partners should consider technologies that structure equitable communication in conveying the partners' meaning, roles, and responsibilities. The following section explores how computer-mediated communication systems can foster trust-based relationships in distance-working conditions (Khawaji et al. 2013), improve deliberation between communities with differing power dynamics (Johnson, Al-Shahrabi, and Vines 2020) and promote equitable methods of communication within a group environment (Yamaguchi, Bos, and Olson 2002).

Where meaning is communicated cooperatively through a digital system, one can begin to foster more positive, trust-based relationships (Khawaji et al. 2013). However, trust starts at a much lower level in groups of people engaging in group-based working through CMCS. However, it can slowly increase to similar levels of trust as those reported in face-to-face teams if these working relationships are sustained over an extended (Wilson, Straus, and McEvily 2006).

Cultural barriers reflect the challenges inherent to the differing ways of working within partner organisations, as well as perceptions of external partner organisations. For example, communications internal to school-university partnerships are susceptible to preconceived notions of power (Slaughter and Rhoades 2009). When knowledge production is seen as a product of process between the university and consumer schools, this can allow for the dismissal of practical and personal knowledge of teachers (Wieser 2016) in preference for the perception of objective, codified, generalised, impersonal and theoretical knowledge (Cain 2016). This approach is further exacerbated by the perception that teachers lack the skill to apply findings to their own educational environments (Cain 2016; Schaik et al. 2018; Ion and Iucu 2014), despite evidence demonstrating that academic research is unlikely to be used by teachers as they note difficulties in finding research which applies to their own teaching experiences, written using accessible language, and is adaptable to their organisational environment (Cain 2016; Hemsley-Brown and Sharp 2003; Schaik et al. 2018; Ion and Iucu 2014; Levin 2013).

The challenge of cultural barriers and their navigation was discussed in a study of school-industry partnership for STEM education in New Zealand (Pattison 2021), in which the authors conducted a study of a partnership between a junior school (Year 7 – 10) and a technology company. Students undertook a design sprint to investigate a tree-scanning technology to monitor forest diseases. Pattison noted the importance of a "boundary broker" who was "*was most crucial during the development of a relationship and trust between the school and industry"* (Pattison 2021, pg. 23), who worked to navigate the complexities of management structure, funding, working schedules and organisational priorities and interests.

Brokerage, discussed prominently in Elliot's seminal work (1991), notes how the alignment of purpose is to be achieved through cultural and social brokerage, where an individual takes on a role in understanding the needs, desires, and politics of disparate groups within an ecology to foster a mutual understanding. Current literature demonstrates how brokers' role in school-university partnerships provides improved opportunities for the translation of specialist knowledge for use by educators (Bouwma-Gearhart, Perry, and Presley 2014). They can also address the challenge of school partners who may be wary of working with academics (Gu 2016) and negotiate the cultural, structural, and logistical barriers that inhibit mutual trust and respect in school-university collaborations (Mclaughlin and Black-Hawkins 2007; 2004). While the role of the broker is not insignificant in time, resources and effort

(Venn-Wycherley and Kharrufa 2019), this approach to school-university partnerships has the potential to begin to negate transactional approaches to educational partnerships.

Adapting brokerage as a foundational concept, I then draw upon the idea of 3rd Space from Hora (2011) to identify concepts to support the creation of a neutral space in which to negotiate the varying needs, interests and aims of each partner. Through this 3rd Space, brokers can be positioned as a central proponent of educational change, acting as an intermediary to communicate academic research findings (Malin and Brown 2018) and navigate logistical, cultural and communicative boundaries (Leat and Thomas 2018a) between universities and schools (Gu 2016).

In partnerships with a focus on research and the improvement of educational practice (known as *research-practice partnerships)*, long term partnerships between educational practitioners and researchers are developed to investigate solutions for improving school practice. These interventions have demonstrated positive outcomes, but demonstrate a challenge of communication with a lack of shared language to discuss issues, atypical interactions and unclear responsibilities (Coburn and Penuel 2016). There is an evident need to position researchers, teachers and other stakeholders as equal partners in the research process, such that structural collaborations can shift the dissemination of knowledge from the hierarchical ‘dissemination by knowledge producers model’ towards a collaborative approach to the generation of knowledge (Schaik et al. 2018). However, this does not consider how the educational partnership research outcomes can benefit all partners and what this means for schools not currently able to engage in an educational partnership with a school or university. Work by Hendriks (2021) noted that teachers who were not involved in the process were more likely to accept research outcomes when the research team contained individuals perceived to understand and appreciate their environmental challenges of education and had similar professional backgrounds.

School-university partnerships support wider-scale changes by publishing research (in both formal and informal venues). Still, they can also help generate a variety of new learning materials to be introduced as part of a school curriculum for pupils. They can also build upon wider educational partnership research that notes this as a method to engage young people in their learning and develop and develop an interest in the topic at hand (Thomas 2011; Leat 2015). However, the suitability of developed resources for the given context must be considered. For example, school-university partnerships for curricular development can lead to curricular mismatch and interruption, where the ‘new ideas’ introduced by academia can interrupt the flow of the previously planned educational curriculum (Ledoux and McHenry 2008). Ledoux (2008) notes that these mismatches are likely to occur within under-resourced school organisations seeking to support novelty and exploration within the curriculum. Therefore, there must be consideration of how resources and power may provoke tension in School-University partnerships.

2.3.3. Partnerships for computing education

In Section 1.1.1, I outlined the deficits of the computing curriculum, which included the challenges of poor teacher support (Royal Society 2018a; The Royal Society 2017) to falling levels of pupil engagement (Wohl 2017; Cellan-Jones 2017; Haigh 2016).

The design of the computing curriculum was the responsibility of central government, as advised by working groups, yet the implementation was the responsibility of teachers and schools. Employers and experts moved to fill the gaps. However, regional differences meant that computing education was largely dependent on the requirements of examination boards, teacher skills, school resources and access to support networks with little support from official bodies (The Royal Society 2017; Pye Tait Consulting 2017). In adopting this top-down approach, experience was omitted, leading to “naïve assumptions and unrealistic expectations” about how ICT teachers could transition to computing education without training or support (Phillips 2016, para. 16).

Exploring the body of research that focuses on teacher-led professional development through educational partnership initiatives, Goode et al. (2014) note how groups of teachers could be introduced to computing practice, pedagogy and institutional support through the structure of peer-supported professional development. Whereas Brennan et al. (2016) outline how teachers can develop participatory networks across schools, regions, and countries to develop their in-school curriculum.

However, current studies did not explore how external institutions could be positioned in support of professional development practices.

Research-based partnerships focused on teacher development demonstrate the challenge of curricular support being developed by non-practitioners, with workshop or training content developed challenging to transfer to the classroom in practice (Haden et al. 2016; Brown et al. 2014). Research also demonstrated how individual practice might be improved as a product of a partnership with a specific school, but improvements tended to remain within the school community in which they were developed (Tondeur et al. 2016; Leary and Severance 2018). Therefore, rather than diffusing knowledge to the wider community, partnerships can have a limited effect on their educational ecology. Furthermore, these approaches to partnerships can suffer from problems of poor long-term sustainability (Portnoff 2020; Leary and Severance 2018) and be difficult for teachers and schools to access due to issues of capacity, flexibility and administrative support (Pollock et al. 2017; The Royal Society 2017).

Organisational attempts to support the development of computing curricula also must balance their benefits and disadvantages. For example, the Computing at School community was funded by the Department for Education to develop a Master Teachers programme between 2014-16, providing in-depth training for a small number of teachers (Smith et al. 2015) who would then be encouraged to share this knowledge with their own teaching communities in peer-to-peer CPD, addressing some of the challenges of deficit-based CPD and their poor applicability in the classroom context. A further £84m of funding was made available through the National Centre of Computing Education in 2018, providing nationally recognised certification in computing subject knowledge and online communities for UK-based computing teachers (Sentance 2019). This approach has the potential to mark a return to the more traditional delivery of CPD and its inherent problems of access and applicability. However, more research is required in this area before a conclusion can be drawn with confidence.

Moving away from curriculum and teachers in schools, approaches to computing education partnerships in Higher Education allow for more freedom without meeting external accountability such as Ofsted. This freedom allows for a more novel approach to content development, pedagogy and assessment methods. The computing curricula can allow for increased opportunities for applied education by working in partnership with industry (Dini and Mahdavy 2019; Steghöfer et al. 2018), allowing for access to professionals in the computing sector to share their skills and knowledge (Dini and Mahdavy 2019), and support transition to roles in industry (Dagnino 2014). However, this approach to educational development with external industry partners typically focuses on developing the practical programming skills of learners, as an industry partner has a vested interest in securing a talented pipeline of future employees (Carlsen 2021).

An alternative form of partnership for computing curriculum development in Higher Education is found in the form of service-learning. With theoretical roots in Dewey (Dewey 1997), service-learning gained popularity in the 1990s as a form of reciprocal experiential learning. It was characterised by learners applying course concepts through the development of a service or product to meet an authentic community need (Corporation for National and Community Service 1990). The service-learning approach to educational partnerships supports the learner in the improvement of their academic performance, interpersonal skills and professional development (Coyle, Jamieson, and Oakes 2005; Pollock et al. 2018) with a focus on the potential for social justice outcomes (Mayhew and Fernández 2007). In computing, academics work with community project partners to identify their digital needs and work to develop a project in which a digital system or service is delivered and maintained to amplify a given service to the community (Taylor 2014). Examples of projects undertaken as part of a computing-community partnership include the development of e-commerce platforms for local businesses, software support for public libraries and the provision of community IT support (Pollock et al. 2018; Hoxmeier and Lenk 2020).

However, research calls our attention to the fact that there is often little consideration of the community impacts of service-learning partnerships (Chupp and Joseph 2010; Cronley, Madden, and Davis 2015; Kimball and Thomas 2012; Ringstad et al. 2012). Unlike industry partnerships, the locus of control sits firmly with the university as the organisation with access to the resource (i.e., computing students and their technical skills), driving unilateral community engagement.

A way to include the community, is through community curriculum (Alexander 2010). The National Curriculum, with its statutory guidance, remains to determine the description and rationale for each subject, with nationally determined (yet non-statutory) programmes of study allowing for the joint construction of curriculum content and assessment. Underpinning these are locally determined community curricula, which can adapt programmes of study to meet local needs and opportunities (Leat and Thomas 2016; Leat 2015. Local authorities and schools are ideally placed to recognise local needs and educational opportunities (Hodgson and Spours 2013) teachers are experts in their classrooms and pupils (Leat 2015). Parents, carers, and children should also be considered knowledgeable partners in creating a curriculum that meets local needs and opportunities (Bronfenbrenner 1986; Epstein 2014). Developing this further and engaging local businesses, organisations, and educational institutions can introduce expert knowledge into the curriculum, providing improved levels of engagement and potential future pathways into education, employment or training (Hodgson and Spours 2009; 2013; Carlsen 2021; Leat and Reid 2012; Leat and Thomas 2017). Previous research has demonstrated how the community curriculum, when developed with a range of such partners, demonstrates an improvement in student engagement with their learning (Thomas 2011), supports young people to develop personal and professional identities (Leat 2015) and supports teacher professional development (Voogt et al. 2011) through a focus on cultural relevance (Scott et al. 2015).

Culturally relevant pedagogy, such as community curriculum, move away from a deficit focus and instead allow students an opportunity to reflect on their learning in the context of their own identities, cultures and needs of their communities (Chinaka et al., 2021). In computing, such approaches have demonstrated an improvement of minorities typically excluded from the computing curriculum, particularly minority ethnic groups (Scott and White 2013).

Considering these prominent approaches to partnerships for computing education, one can begin to understand the importance of acknowledging the role of power in these partnerships and how this influences both the process and the outcomes for those involved. Firstly, how disparate power dynamics between partners can prevent meaningful impact on the given situation, failing to provide practical, implementable outputs in the community. Secondly, a lack of respectful communication and mutual working, exemplified by work between schools, communities and higher education, demonstrates a lack of reflection on the privilege afforded by access to computing skills, knowledge and resources. Thirdly, the nature of the partner involved in the educational partnership impacts the focus of the partnership, with industry placing greater importance on the development of applicable skills rather than the wider range of civic and self-expressionist skills gained through the study of computing.

2.4. Conceptual Framing of Educational Partnerships for Computing Education

The metaphor of an ecology has often been used to frame the discussion of the influence of actors and environment on the development of knowledge of a given locality (Hodgson and Spours 2013; Leonard 2011; Bronfenbrenner 1994;). In recognising the complex, dynamic and multifaceted nature of our social systems, we can begin to understand how knowledge is discovered, synthesised and disseminated for the benefit of its participants. Attempting to conceptualise the myriad of relationships between educational organisations, groups, and individuals can be a difficult task. This is particularly challenging when needing to consider the varying cultures, resources and space which then inhabit (Mueller and Toutain 2015; McNall et al. 2009; Leat and Thomas 2018a) and the technologies which underpin these experiences (Nardi and O'Day 1999). Thus, through a symbolic comparison with naturally occurring biological ecologies, we can begin to meaningfully conceptualise our environment, being aware of the systematic and diverse nature of relationships, resources and culture, and the opportunities and constraints these provide.

Notably, a fundamental difference between biological ecologies and social ecologies is the potential for deliberate and conscious change to the relationships and practices contained within. Freire (1970) notes that human beings are capable of direct action and reflection, which helps them objectify and transform the world about them, transcending the typical conceptualisation of a biological ecology. Nardi and O'Day (1999) propose that the use of 'ecology' may be a better way to refer to 'community', as an ecology has a more holistic view of relationships, resources and the impact of change brought about by deliberate action. I use the two terms in combination and often interchangeably in this thesis. However, underpinning theory is drawn mainly from ecological research due to the focus on a more holistic perspective of a community and the interplay of values, actors, influences and resources. The following section explores this in more detail, outlining the conceptualisation of educational ecologies adopted throughout this thesis.

2.4.1. Ecology theory as a framework for addressing challenges in education

In the literature above, I have outlined the challenges facing the delivery of the current form of the computing curriculum, including a lack of consideration of the practicalities and pedagogies of delivery, and positioned educational partnerships between universities and schools as a potential method to address these challenges. However, school-university partnerships are not without their own intrinsic issues, and care must be taken to pay due consideration to the actors and environment in which learning takes place.

Ecological approaches to the conceptualisation of education, developed from work by Urie Bronfenbrenner (1986), posit that human development is influenced by a series of concentric layers of actors and processes. The model, known as the bio-ecological model, consists of the microsystem, which represents the direct interactions and relationships an individual has with those in their immediate environment (Bronfenbrenner, Morris, and Lerner 1998). The mesosystem, which represents the lateral relationships between actors in the actors who interact directly with the child at the inner *microsystem* layer; the exosystem, which represents actors who have an indirect influence on the individual (Tudge et al. 2009); the macrosystem, which represents the community's ideological, political, and economic organization; and the chronosystem, which represents how an individual's development changes over time (Bronfenbrenner 1986).

While the broad scope of Bronfenbrenner’s ecological conceptualisation of environment and relationships permits appropriation of the model in a wide range of disciplines (e.g., health, learning, employment), this is both a strength and a weakness. However, Bronfenbrenner’s bio-ecological model was intended to help conceptualise the influence of processes, people, context and time on human development and was not intentionally developed as educational theory. These limitations are recognised in work conducted by Hodgson and Spours, who aim to provide a framework for analysing the wider ecological system of a community and its educational impact on young people (Hodgson and Spours 2013). The Local Learning Ecology model (LLE) conceptualises collaborative relationships between educational entities and their impact on learners (Dillabough and Kennelly 2010) and provides a revised series of layers to better conceptualise the context and relationships of the educational environment of the young person. It provides a common language for discussing the layers that impact the development of an individual and highlighting the actors (and their actions) who populate these layers.

- The *microsystem* is focused on a learner's interaction with families, the classroom and the immediate environment
- The *mesosystem* explores learner interaction with a range of education professionals in the learning environment and also considers institutional policies such as curriculum development
- The *exosystem* from Bronfenbrenner's 1979 model is split into two sublayers:
    - The *Exo 1* is defined as learners interacting beyond their immediate learning environment, such as their local area, geography and history, a configuration of educational institutions, or a network of professionals and employers. Defining this new level of the exosystem provides the ability to differentiate the relationships between educational institutions and local organisations, which are likely to have similar cultural underpinnings which a potential for shared values, symbols, and language.
    - The *Exo 2* examines the movement between the locality and the wider region, the impact of the labour market, travel to learn patterns and further/higher education providers. Here, one must understand that those cultural similarities between acting organisations might be limited due to their geographical, historical and economic differentiation.
- The *macro* layer has substantial overlaps with Bronfenbrenner's *macrosystem*. However, Hodgson and Spours highlight the influence of national economic, political and social factors on the educational context, highlighting *Meso-level* performance measures, poor curricular cohesion, educational expenditure cuts, poor recognition of the *exo-layer* organisation and a limited environment for policy development.

To provide young people with a successful transition to further learning or employment, Hodgson and Spurs recommend that each layer of an LLE is configured to prepare young people for academic and social opportunities (Dillabough and Kennelly 2010). For example, one such recommendation is the development of partnerships between multiple educational institutions at the Exo 1 layer to provide young people with pathways between educational provision. However, there is more to an educational ecology than considering the hierarchical categories of actors and their influences. (Orphan and O'Meara 2016) provided an earlier critique of the dangers of adopting a unidirectional approach to knowledge production and instead paint a picture of a complex, messy, multi-*dimensional* ecological system of knowledge expansion.

The dimensional approach to educational ecologies differs from that of Bronfenbrenner's layers. Instead, it focuses on the interplay of living components, material means, and relationships between these dimensions (Mueller and Toutain 2015). The key dimensions arising from the literature on educational ecologies result in the following: 1) bounding frameworks (Mueller and Toutain 2015); 2) relationships between people and place (Hodgson and Spours 2013; 2009; Cardno 2012); 3) culture (Foster et al. 2013; Isenberg 2010); 4) pedagogy (Gruenewald 2003); 5) physical space (Mueller and Toutain 2015) and access to resource (Luckin 2008) and 7) technology (Nardi and O'Day 1999, Ofsted 2022).

Bounding Frameworks: While the REF and KEF act as bounding frameworks for research interactions and engagements in Higher Education, the curriculum is a common bounding framework for schools enforced by government quality standardisation. The bounding structure of a legally mandated curriculum is not just an independent factor on the educational ecology but is also equally impacted by environmental factors which dictate policy, access to funding and skills, and organisational standards (Moore 2013; Null 2011). This often translates to teachers being concerned about working within mandated syllabuses, which meet policy requirements of their educational system (Lynch and Smith 2011), where the curricular framework acts in a supervisory capacity – ensuring there is accountability for the learning outcomes the system produced. Tied to this need for accountability are Ofsted Inspections carried out by the Office for Standards in Education, Children's Services and Skills. These inspections aim to ensure that educational services, such as those provided in schools, are held to a consistently high standard of quality and provide clearly signposted opportunities for ongoing development of educational delivery.

Relationships: In considering the relationships of different members of the educational ecology, it is important to consider the nature of *dominance* in natural ecological settings, where an individual, group or species has more power or control than others within their environment. The same must be considered in ecological models of education, where individuals, groups or organisations have disparate amounts of power, resource or control of their environment and act as a coordinator of societal functions (Hermann 2016). Certain members of the educational ecology will exert greater power in creating, maintaining or breaking relationships due to social, cultural or financial capital. For example, senior leadership in schools will often control how teachers are supported to engage with external educational organisations, budgets and access to professional development (Schaik et al. 2018; Daly, Liou, and Brown 2016). A further example would be examining the power held by universities engaging in community engagement and outreach, which can determine the remit or shape of the engagements due to their access to resources, and influence at the political and global levels of their ecology (Mallory 2005). While leadership is essential to action within the educational ecology, an effort should be made to challenge these traditional power dynamics toward collaborative and cooperative relationships.

In reframing these relationships, there needs to be consideration of the *experience* of those within the educational ecology. In this context, experience is considered the intrinsic knowledge each person holds of their environment and their understanding of the frameworks, culture, pedagogy, space and technological constraints within which they live and work (Mueller and Toutain 2015; Nardi and O’Day 1999) For example, when undertaking work with teachers in a teaching environment, they are the people best placed to understand the young people within their classroom and the wider school community. Furthermore, teachers are aware of pedagogical and accountability structures within which they must conduct their work and are keenly aware of school structure, culture and policy. In acknowledging and *valuing* the experience of the members of an ecology, these mutually respectful relationships allow researchers to become better resourced to plan and enact ecological change.

Culture: There is a need to consider the ethical ideals and values of those involved in an ecology and how those fit within the constraints of the frameworks within which actors must work. It is essential to consider how schools and external actors create and sustain shared meanings, behaviours, and practices for engagements within their ecology (Mueller and Toutain 2015). This can be achieved through the implementation of brokerage, where an individual can take on the role of a cultural and social broker to help better understand the needs of partnered groups (McNall et al. 2009; Leat and Thomas 2018a;).

There must also be a need to consider relationships: their power and influence over social structures. Freire (1970) outlines this in his antidialogical theory of cultural invasion – where *invaders* (those with more power and influence in a given situation) penetrate a cultural community and impose their own world values. Instead, research shows that school-level teachers were more likely to engage in educational innovation and research when part of a school culture valued experimentation, new ideas and broader interactions within teaching and learning (Daly, Liou, and Brown 2016).

Pedagogy: It is crucial to consider the development of pedagogical approaches within an educational ecosystem, including the approach within the school, the school and the wider community and the nature of educational relationships within this space. This approach to pedagogical development is primarily fostered by school leadership, which determines access to funding, training and incentives (Ion and Iucu 2014; Levin 2013; Ostinelli 2016; Cain 2016). Learning anchored in the broader community can provide teachers and pupils with personal and academic development opportunities with access to further cultural and social resources (Ryoo, Goode, and Margolis 2015; Leat and Thomas 2018a; Epstein et al. 2009; Leonard 2011). However, the quality of these engagements can be limited by bounding frameworks such as curriculum and accountability policies (Moore 2013; Null 2011; Lynch and Smith 2011).

Space and access to resource: A further factor in consideration of educational ecologies is the physical and virtual spaces available for education to occur and the barriers that might impede access. Mueller and Tutain's (2015) propose that space includes such concepts as classroom capacity and design, but does not consider *space* as access to learning materials, training resources and equipment. In the following thesis, I also include these latter considerations as a factor of *space*, in so much as *space* signifies an element of physical freedom and opportunity.

An equally important consideration is who designs the space in which educational activities take place within the ecology. Typically, these will be moulded by the culture, bounding frameworks and existing relationships of a given institution. However, it is rarely the individual (teacher, researcher, practitioner, even less so *pupil*) who designs the spaces in which they work, learn and develop educational relationships (Ryoo, Goode, and Margolis 2015; Alsubaie 2016; Lopez Turley and Stevens 2015).

Technology: In conceptualising our environment as a series of interdependent relationships, the role of technology can be considered in the growth, restriction and equilibrium of an ecology (Nardi and O'Day 1999). The connectivity afforded by technology is essential when considering the complex and dynamic nature of educational ecosystems, allowing for the development of ideas, connection, knowledge and practice (Clayton 2016) across contexts of organisational boundaries, space and time. While the highlighted ecological models dismiss or subsume the role of technology in the *layered* approach to ecology, it is vitally important to consider the role of technology as its own influencing factor. As mentioned previously, technology is capable of engraining or exacerbating existing power relations.

Overall, these dimensions can help isolate an aspect of an educational ecology for inspection and analysis, or provide a nuanced lens to explore the practicalities of delivering the computing educational curriculum in schools and the impact this might have on actors. For example, in using the dimensional approach to educational ecologies and examining the interplay of *technology, space* and *relationships*, Nardi and O'Day (1999) reported on an academic case study where personal computers were introduced to low-income households to study how they engaged with these technologies. However, when the access to technology was rescinded at the end of the project, researchers (and the university) were accused of being *dope dealers* by participants. Here, researchers had not considered the participant's relationship to technology, nor the space in which these learning interactions took place.

In utilising educational ecology theory as a lens to surface these complex, and often dynamic environments of delivery, one may begin to acknowledge the tensions, miscommunications and control that have negatively impacted previous educational partnerships between schools and universities, and the impact this would have if utilised in a computing education context.

2.4.2. Applying educational ecology theory to computing education partnerships

The vast and complex nature of educational ecologies fall victim to the critique that adopting a holistic view of the system can lead to further feelings of powerlessness on the part of participants considering change (Freire 1970). After all, the system is far too large, comprised of local, national and international actors (should you look far enough) and begs the question of how researchers are supposed to engage and action change when they are such a small part of a dynamic system.

In response, Winner proposes that these individuals can position themselves as firefighters and concentrate their efforts for improvement on a small and well-defined section of our ecology (Winner 1977). This can be done in collaboration with others who are interested in developing the practices and understanding of a particular community, beginning to organise collective and collaborative action that spans beyond the sphere of our expertise toward a community of practice (Wenger, McDermott, and Snyder 2002c;). Furthermore, in understanding the wider sphere of the educational ecology, researchers or community organisers can support engagement in educational partnerships for innovation concerning computer science education while still allowing flexibility for ecological differences from community to community.

In educational partnerships, ecology has been used as a model for family-school partnerships (Epstein et al. 2009) to provide interventions on a young person's learning and socio-emotional development, for community-school partnerships to develop systems of care for young people living in underserved rural areas (Shamblin et al. 2016), and exploring school-university partnerships for school improvement (Larson and Nelms 2021). Through these examples, educational ecology was applied to understand complexity between partners, the impact of cultural, the exploration of dialogic exchange, the development of trusting relationships and examining shifting power relations (Epstein et al. 2009, Shamblin et al. 2016, Larson and Nelms 2021). When outlining the challenges of school-university partnerships, educational ecology can be applied as a lens to interrogate issues with power dynamics, control and communication highlighted during this literature review.

Furthermore, educational ecology is a conceptual framing that is not novel in computing education (and its' predecessor, ICT) at an international scale, with a number of studies adapting educational ecology models to investigate the development of computing education. For example, Rana et. al (2019) used educational ecology as a framing to explore Nepal's implementation of ICT educational policy, reporting the symbiotic relationship of NGOs and government in rural areas that developed to respond to the needs of policy and the impact of ongoing implementation of ICT education in Nepal. Stornaiouolo and Nichols (2018) make use of educational ecology theory when exploring the introduction of "Maker Movement"-style tinkering to the practice of teaching in a US urban high school centred around the principles of making, and the importance of mobilising audience to ensure educational success – but highlighting how historical, cultural, social and political factors could prevent engagement from learners and teachers.

Van den Beemt and Diepstraten (2016) adopted an education ecology approach to explore the impact of socio-cultural factors (such as places, activities and relationships) on teachers' professional development in ICT, with findings demonstrate that learning was impacted beyond the classroom by relationships with siblings and friends, the importance of informal learning, and development of social capital, culminating in pedagogical contributions for the training of ICT teachers. It can also be used in exploring the instructional design process for computing education delivery, with Fragou et al. (2017) demonstrating the development of an instructional design process for the teaching of ubiquitous computing in Higher Education. Their research also demonstrated the importance of considering space, actors, participation, reflection, processes, relationships and knowledge when undertaking instructional design, particularly when designing learning activities and developing practice and support activities for learners.

Regarding resources in UK schools to facilitate computing, the Royal Society report (2017) noted the barriers imposed by the digital ecology of schools regarding the improvement computing education, where network security and performance policies in schools could inhibit access to specialist software and hardware to support education.

Of educational ecology models in computing education, they can *"illuminate interactions… (and) emergent gains"* (Rana et al. 2019, pg. 4), demonstrate "*how people make use of learning resources*" and develop competences (Van den Beemt and Diepstraten 2016, pg. 3), and support "*tracing tensions*" (Stornaiuolo and Nichols 2018) within the computing ecology. Fragou et al. (2017) note that educational ecology models are "*well suited to human interactions between people and environment, their process to learning, doing and achieving and for developing new knowledge in ill-structured contexts"* (ibid, pg. 1818).

However, there are currently limited works that explore educational ecology models for exploring partnerships between universities and schools for the improvement of computing education regarding foundational aspects such as CPD, content and capacity for educational research that will begin to allow for improved pupil outcomes.

In the previous sections, I have noted the tensions and possibilities provided by school-university partnerships regarding place, space, culture, resource (and more) for computing education in the UK, and no clear structure or guidance as to how mutual, reciprocal relationships between such partners could be created and maintained. Therefore, in the following research, I demonstrate how educational ecology theory can be utilised as a lens for exploring tensions, interactions, use of resource, processes of learning and developing of knowledge in an ill-structure context, towards the infrastructuring of a school-university partnership for computing education.

Chapter 3. Methodology

3.1. Introduction

In previous chapters, I have explored the role of computing in 21st-century society and examined how computing education has supported political, social, and economic mobility in the UK and internationally. I discussed the position and purpose of universities within their communities and their ability to work in partnership with schools to achieve educational improvements before highlighting the key issues of communication, collaboration, and community. Exploring the current body of research within the HCI community, I outlined how technology has been designed, created, or repurposed to address the challenges of fostering and supporting school-university partnerships for the benefit of compulsory computing education. Finally, I explored how an ecological perspective might be used to frame research on these partnerships between schools and universities, and how the experiences of the people involved, their environment, and their access to resources could influence the process of the partnership.

The approaches concerning educational research rest upon how a researcher perceives the construction of reality, knowledge, and human nature. Research does not exist in a hermetically sealed environment, nor are researchers free from external biases and assumptions. With this in mind, the following chapter explores the epistemological and methodological perspectives on the study of school-university partnerships for computing education undertaken in this thesis.

I begin with a reflection on my own research journey, and how this has affected the shape of my research. I then go onto outlining the methodological approach that I have adopted in my thesis research design and the role of interdisciplinary research methods drawn from education and HCI, with solid roots in qualitative inquiry for technical, social and educational research. I then address my methods for data collection in line with my chosen approach, criteria for data quality, and methods used for the analysis and sense-making of this collected data. This chapter then closes with a review of the ethical considerations undertaken in the planning, conducting and analysis of my research, as well as highlighting the delimitations and limitations of my research in terms of broader factors such as the impact of COVID-19.

3.2. My Research Journey

My Master's research involved coordinating an extended educational engagement in collaboration with local secondary schools, undergraduate students from the Science, Agriculture and Engineering faculty of Newcastle University and the BBC. Through this project, I identify design considerations towards developing educational ecologies for computing education partnerships between universities, schools and external organisations – including processes and the role of technology in infrastructuring support for university-school partnerships. While this project helped formulate the basis of my PhD research, it also helped me understand the university's role in its educational environment and what it meant to represent the institution within the community. This experience became most evident when meeting with teachers and staff from the BBC, where I was perceived to possess power and authority simply because I was attached to my university.

It is essential to mention that the EPSRC Digital Civics grant funded my work. Digital Civics aims to support cross-disciplinary research into the role of technologies on community involvement in the design, delivery and critique of government services for the benefit of representative and sustainable forms of local democracy, public health, social care and education. The civic focus of the awarding grant meant that I did not have to focus on a commercial approach and was able to choose an area of research where little support or funding was available while also encouraging a criticality of power structures in social and digital spaces. This financial support meant that I was able to help share a version of computing that I loved – introducing an entirely different aspect of HCI to the school curriculum) – without the need to reiterate the narrative of the software development career. Through such a project, I might begin to help young people engage critically with the technology surrounding them, supporting them to explore digital equality and justice opportunities. Newcastle University would be my vehicle to achieve such an aim - by learning how to challenge our perceived unapproachability and becoming partners with schools in our community instead.

3.2.1. Defining Experience

Throughout this thesis, emphasis is placed on exploring the experiences of those engaged in educational partnerships, involved in curricular innovation and those who work in computing education. Therefore, in this section, I outline my intentions in using the word *experience* and potential alternate uses throughout this work.

The definition of experience is manifold and, throughout this thesis, is used to refer to three different occurrences: 1) a process of an individual perceiving and deriving meaning from an environment, 2) an event with a lasting impression on an individual, and 3) the development of skills and knowledge.

Concerning the first point, experience can be considered contact with an environment, ranging from a realist recognition of an individual's sensory perceptions of their environment to an interpretivist reporting of an individual's social (Buttimer and Seamon 2015). I adopt a social constructivist paradigm within my work, which is outlined in further detail in Chapter 3. My interpretation of experience lies in individuals' interactions with their environment and its actors (Buttimer and Seamon 2015).

Secondly, the idea that experience is a form of impression left upon an individual in response to an event (or indeed, a protracted engagement with an environment and its actor) is of particular importance to this thesis in its exploration of school-university partnerships for computing education. If an individual or organisation has a positive experience of such an engagement, a partnership may be more likely to continue. Where this partnership experience is negative, it is more likely that this partnership will fail to achieve its aims or be dissolved before aims can be met (Cox-Petersen 2011; Cardini 2006; Handscomb, Gu, and Varley 2014). Therefore, experience also relates to the judgement of those involved in partnerships activities designed as part of this research and the first-hand reflections of these participants in relation to their participation in such an 'event'. Sharing these impressions can help create and maintain the relationships underpinning school-university partnerships for computing education, allowing for more positive experiences for those involved.

Finally, experience can be defined as developing capabilities, knowledge and skill in response to an event. As previously outlined above, the 'event' is the school-university partnership itself, designed to respond to the deficits of current computing education in the UK. All three definitions of experienced can be found in this report of my research. However, the focus is only on the perceptions and impressions of those engaged in school-university partnerships for computing education.

3.3. Approach to Research Design

Taking my research journey and focus on experience into account, the following section documents my approach to research design. The design of any research is heavily influenced by an author's ontological and epistemological standpoint. Therefore, it is vital to outline critical philosophical stances available to the research community when considering research design. Following the structure outlined in Figure 4 (below), I begin with an exploration of my chosen research paradigm and how this links to my choice of community-embedded, ecological research.

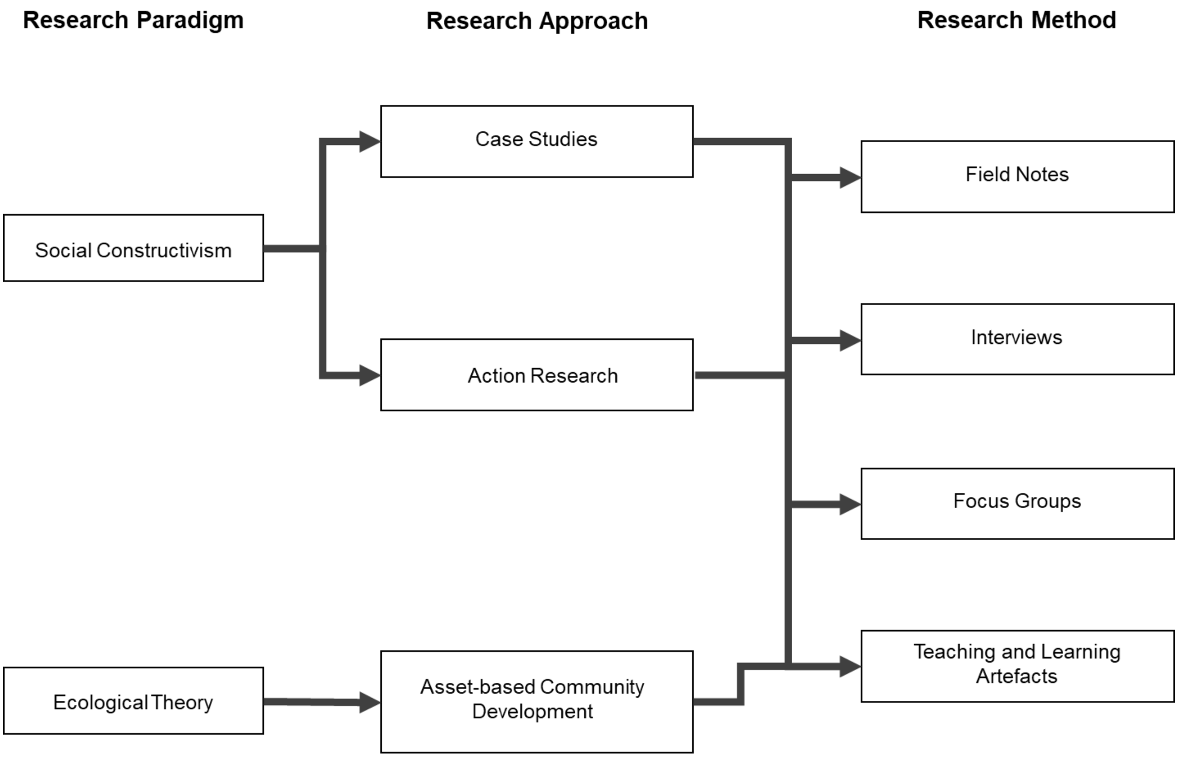


Figure 4. Diagrammatic representation of the relationship between chosen research paradigm, approach and methods

An action research approach paired with a case study methodology will help answer my chosen research questions.

3.4. Research paradigms

First, I must outline possible approaches to ontology and epistemology within research in general terms. Central to these ideas is the perception of reality and the nature of knowledge, which may be narrowed down to two possible approaches – objectivism and subjectivism. The objectivist paradigm is founded on the concept that only one true reality exists independently of consciousness (Rand, Binswanger, and Peikoff 1990), with the dismissal of the impact of social actors upon an environment (Bryman 2012). In objectivist research, there is a focus on quantitative research methodologies in which objective measures can be used to explain phenomena and thus relies on quantitative methods such as sampling, statistical analysis, and questionnaires (Feast and Melles 2010).

However, this approach is under heavy critique from researchers in the social sciences who call out the limitation and partiality of a paradigm that chooses to ignore experience and socio-cultural activities (Pascale 2010). From this limitation, subjectivist research claims that all knowledge is socially constructed and indivisible from the culture and history in which the knowledge is created (Pascale 2010).

Within these two paradigms, my work is firmly situated within the realm of subjectivism with a strong focus on the environment, social construction of relationships and resources, and the lived experiences of a given locale. The educational nature of my research, and the goal of implementing social change, do not align with the objectivist paradigm of positivist research methodologies. The next step is to narrow down the appropriate subjectivist theoretical perspective. Symbolic interactionalism theorises that humans interact with their environment dependent on their ascribed meanings, which the person individually interprets in a specific circumstance (Bruce and Blumer 1988). However, this theory is focused on meaning under certain conditions rather than a broader view of social reality (Aksan et al. 2009) necessary to answer my research questions outlined in Section 1.2. Phenomenology resides in the study of conscious experience from the individual's perspective, focusing on perception, memory, and emotion in a given situation (Smith 2018). However, a critique of phenomenology arises from the poststructuralist movement in that experience represents an absolute precondition that does not consider the history that underpins the experience at a given historical moment (Butler and Scott 2013).

Responding to these theories and addressing their shortcomings, I finally turn to social constructivism. The social constructivist view of knowledge determines that reality is an active and collaborative construction, emphasising the social and physical context under study (McKinley 2015; Andrews 2012). This focus on constructing multiple realities favours qualitative inquiry (Lincoln, Guba, and Pilotta 1985). The researcher plays the role of a *negotiator* to convey the interpretation of these lived experiences (*ibid, p. 41).* With this in consideration, in terms of its methodological assumptions, the social constructivist paradigm encourages the study of the phenomenon in the field, to recognise and understand the social and cultural practices of the people with whom they work (Denzin and Lincoln 2005). With the acknowledgement of lived experience and the focus of my research questions on ecology and community, the following subsections outline research perspectives within the social constructivist paradigm.

3.4.1. Ecological research

An ecological perspective to research can trace its roots to Durkheim's structural functionalism (Schneider 2007), which is understood as a positivist phenomenon in which reality is external to the element under study (Cohen, Manion, and Morrison 2017). Typically, structural functionalism only concerns results that can be scientifically measured and verified with Durkheim positing that viewing society as a biological cell could determine how external influences impact a functioning whole (Durkheim 1973). However, critiquing Durkheim's structural functionalism, one must note the dangers of adopting biological determinism as a lens for society.

An approach that adopts biological characteristics as a method to explore the relationship between a citizen and their community arguably does not consider the autonomy of these citizens nor the exertion of dynamic social, cultural and political influences on citizens and society (Berger and Luckmann 2016). Therefore, as a singular approach to understanding educational partnerships between multiple partners, structural functionalism is superficial and dismissive of rich social data and the wider dynamics of society. However, this approach is not without its strengths – it can provide '*common denominators for comparison among outwardly very different* *polities'* (Groth 1970), which can be used to challenge oppressive hierarchical social structures (Tokar 2010). This is the point at which structural functionalism, as a foundation of ecological approaches to research, can help researchers understand how the localised nature of partnerships for computing education between schools and universities may be generalised to locales beyond that of the original research.

There is a need to explore working with people within an ecological framing while critiquing power dynamics of an ecology. This means including the people searching for meaning as co-investigators, rather than between myself as a researcher and my research partners, therefore understanding and explaining how to design research that is respectful of diverse and varied experience. Freire (1970) is once again significant in the discourse, noting that intruders will negatively influence the *objectivity* of research. As such, my role within such a study cannot simply be 'researcher', as there is an inherent power dynamic when framing a collaborative investigation in terms of 'researcher and participants'. Traditionally, a researcher is in a position of power in the design and conduct of a study, which passive participants undertake. The nature of a PhD dissertation means that I must independently report the study. However, the design, delivery, evaluation and analysis can be conducted with stakeholders in the educational partnership process. As such, within the collaborative elements of the research study, I adopt brokerage to address the concerns of power. In brokerage, I can act as a broker to mobilise knowledge and physical assets of my institution to connect these resources to schools while navigating the familiar political, social and cultural structures of my university as an educational ecology (Leary and Severance 2018; Malin and Brown 2018; Leat and Thomas 2018a). When working with collaborators who are brokers for their own institutions (e.g. schools, businesses, organisations), one is provided with the opportunity to understand the mutual needs, desires and politics of these disparate groups within an ecology and foster mutual understanding and relationships (Ryoo, Goode, and Margolis 2015; Gu 2016).

In examining the benefit and challenges of an ecological approach to the design of research exploring the development of educational partnerships between schools and universities for the benefit of compulsory computing education, the following section explores the Asset-Based Community Development approach to help address some of the shortcomings of ecological-based research.

3.4.2. Asset-based community development

An Asset-Based Community Development approach (ABCD), largely considered to have developed from the field of urban planning, intends to identify and mobilise existing but unrecognised assets within a community (Nurture Development 2020) to deliver improved processes and services. Offering principles and practices that aim to strengthen the sustainable development of a community, with consideration of social capital, social psychology of capacity and agency as citizens, the ABCD approach considers the role of multiple stakeholders with a critical emphasis on *control* within the development process (Mathie and Cunningham 2005). In particular, ABCD challenges the '*well intentioned effort of a number of actors [such as] - universities – which have focused on the needs, problems and deficiencies of low income communities…'* (Mathie and Cunningham 2005, p.2) who have contributed to the rhetoric that communities must rely upon external institutions to solve their problems. The focus on social community relationships offsets the criticism of Durkheim's structural functionalism approach, such that one might instead centre the autonomy of citizens and the social, cultural, and political exertions that impact citizens within a given ecology.

Linking this back to the ecological approach to school-university partnerships for computing education, ABCD can support researchers to find points of leverage within an ecology (Nardi and O'Day 1999). Furthermore, integrating this approach can help identify and mobilise resources (Mathie and Cunningham 2005). In adopting this post-structural, ecological understanding as the basis for constructing, understanding and evaluating educational partnerships throughout the following research, one can design research that aims to identify opportunities, barriers and challenges for universities and schools that participate in educational partnerships. This can contribute an understanding of the sustainability of the process and the meaning perceived by those involved in such a partnership.

3.4.3. A consideration of methodology: action research

Considering these approaches opens up a series of potential methodological perspectives, which focus on the social construction of meaning with consideration of the researcher, including design-based research, ethnography and action research.

While each of these methodologies can be carried out within a variety of possible frameworks, here they are explored from a social constructivist perspective:

Design-based research studies an environment through a series of iterations in which changes are introduced systematically and their impacts recorded and analysed (Scott, Wenderoth, and Doherty 2020). Key critique on design-based research, relevant to the context of the study detailed below, centres on the long-term requirements of undertaking such work, including participant retention and maintenance of partnership processes (Anderson and Shattuck 2012) due to the iterative nature requiring a well-resourced environment.

Further critique is also attributed to resource intensity, such as costs, logistical needs and time (Scott, Wenderoth, and Doherty 2020), and a lack of direction in adopting, rejecting, or re-iterating design-based research (Dede 2004). In short, the choice of design-based research is not simply a methodological consideration but also one of a practical nature. The open-ended nature of design-based research is difficult to balance against the inherent time constraints of this research being part of a limited PhD study and resource constraints of the school research environment (Scott, Wenderoth, and Doherty 2020). Therefore, design-based research is one of the more challenging methodological perspectives to adopt in this particular investigation of school-university partnerships for computing education.

A different perspective is that of ethnography. Rooted in anthropology, postmodern ethnography is a methodology valued for its ability to allow participants to present their perspectives on their given, everyday realities. Through participating in ethnography in a definite setting, researchers can capture participant reports on their experiences of a given phenomenon (Klobas 2001). Critique of ethnographic methodology is limited to the moments a researcher can observe and may miss crucial elements from the wider community that contribute to patterns of actions within the research context, particularly within school environments (Hammersley 2006). This presents ethnography as a challenge of understanding and deciding the scope of this ‘wider context’ and the researchers' inherent power in being the locus of control in ethnographic research (Jacobs-Huey 2002). Furthermore, the application of ethnographic research serves largely to provide an in-depth description of participant perspectives on a given phenomenon (Reeves et al. 2013), rather than driving an improvement in practice or construction of new forms of knowledge.

A "*study of a social situation with a view to improving quality of action within it*" (Elliott 1991, p. 69), the action research (AR) approach focuses on iterative and participatory research, inclusive of researcher, participants and broader context (Kemmis 2009). Within the realm of social constructivism, AR considers the influence of oppressive social and historical infrastructure on the local community, and aims to provide practical knowledge through collaborative work while challenging the relationship between researcher and researched (Reason and Bradbury 2001). This need for a methodology focused on exploring multiple experiences through egalitarian, social-justice-oriented lens reasons the choice of AR as the key methodological approach within the design of my research.

> *"*How can you make a real difference in the world? To some, science and research are divorced from this inherent human need to make positive changes in the world – if not divorced, at least distanced… We can, in fact, create positive social change and simultaneously do good research. It's just a matter of slightly changing the way we think about scholarship and participation in research*."* (Hayes 2012)

As a methodology, AR has been highlighted as an appropriate approach when adopting a critical focus on knowledge generation to address critical social issues within a community (Post et al. 2016) since intepretivist AR is focused on addressing the practical concerns of people in a problematic situation through collaboration. This allows research to reflect the social and educational practices, and the partnerships between schools and universities in context, in which the action research studies are carried out, such that people can reflect upon the conditions in which a given action is taken (Kemmis 2009) and the outcomes. This means that AR can be considerate to the interactions of those participating in computing while still retaining the practical concerns of these individuals, reflecting the nature of the entangled educational ecology. In fact, Arendt posited that through engaging in action, "*no matter what its specific content, always establishes relationships and therefore has an inherent tendency to force open all limitations and cut across all boundaries" (*Arendt 1958, p. 190).

People can be truly agentic concerning the conditions in which a given action is taken (Kemmis 2009). For these reasons, AR has been highlighted as an appropriate methodology when taking a critical focus on knowledge generation to address critical social issues (Post et al. 2016) since AR focuses on addressing people's practical concerns in a problematic situation through collaboration (Hayes 2012). This allows AR research to reflect the social and educational practices and the context in which a given study is carried out.

However, AR is not without criticism. A key critique of AR is centred on the lack of objectivity in the relationship between the researcher and the community and the impact on the perceived validity, reliability and transferability of research outcomes and applicable process improvements. Critics note that closely-coupled research relationships can severely limit critical discussion of inefficient or damaging practices within an environment (Biesta 2007). Research also criticises the lack of generalisability of highly contextualised research that cannot be transferred to a new context (Hayes 2012) and the impact of positionality on the exclusion of those involved and affected by practices within the environment of study (Kemmis 2006).

In response to these challenges, Hayes encourages researchers to act "*not as researchers, nor even advisors, but as friendly outsiders*" (Hayes 2011, p. 1) to a community, in which we consider how to communicate and design with partners towards the development of a cohesive understanding. AR provides scientific rigour through the transparent collection and analysis of data (Lincoln, Guba, and Pilotta 1985; Hayes 2011; 2012) to allow others to transfer findings to their own context.

Further considering these complex communicative relations between academic and practitioner partners, there must be a mutual alignment of purpose to ensure interactions are purposeful and effective (Elliott 1991b). This alignment of purpose can be achieved through brokerage, which is considered a role undertaken by an individual who works within the space to understand disparate groups' needs, desires, and politics and bring about mutual understanding. Brokers can be positioned as a central proponent in educational change, acting as an intermediary to communicate academic research findings (Malin and Brown 2018) and navigate logistical, cultural and communicative boundaries (Leat and Thomas 2018a). Typically, brokerage research centres on the idea that a researcher must act as a community broker to generate benefit of academically produced work (Malin and Brown 2018; Venn-Wycherley and Kharrufa 2019; Bouwma-Gearhart, Perry, and Presley 2014). This approach to bridging existing communities strongly lends itself to AR integration. Therefore, I adopt a brokerage role support school-university partnerships for computing education, in order to explore how aligning the purposes of disparate stakeholders within such a partnership can impact communicative practices.

Furthermore, in response to the challenge of voice within AR research, there is a need to understand the view of those involved in computing education – namely, young people. This can only be addressed by the involvement of these young people in the production of research (Hadfield and Haw 2001), so clear consideration must be given to the ethical design of AR research, including safeguarding procedure, data collection, negotiation of power relations, consent, privacy and anonymity (Schäfer and Yarwood 2008; Cullen and Walsh 2019). These ethical concerns are addressed further in Section 3.7.

With these challenges in consideration, AR then provides a framework to adopt and adapt in this research design, focusing on iterative and collaborative experience. As this work explores the role of technology in supporting the communication, collaboration and community-building processes of those involved in school-university partnerships, Hayes (2012) proposes a model of AR which has been adopted in my research design process. This model includes a series of seven steps:

1. Establish a relationship with a community partner who has expertise in the applied area of research, and take the time to understand the goals, limitations and resources of those involved
2. Develop research questions in collaboration with the partners
3. Plan and execute your action, focusing on outcomes over success
4. Evaluate the action you have undertaken, and use your findings to plan a subsequent iteration. This step can be repeated as often as deemed necessary until research questions have been answered.
5. Share what you have learned from your research with the inclusion of community partners – these outputs can be scholarly and practical, such that

they contribute towards the improvement of practice through a contribution of knowledge

6. Enjoy the process and recognise moments of success
7. Step back and trust in sustainable change. As researchers, we are limited in the length of our research by a variety of factors. Therefore, our AR research iterations must come to a close and communities continue to maintain the changes made.

This framework was used to guide the design the execution of the case study iterations and can be found in the structuring of case study chapters within this thesis. From an interpretivist epistemological perspective, the AR approach highlights the importance of partner involvement in the design, delivery, and dissemination of the following research. There is also a strong focus on lived experiences and the social and material impacts upon the environment.

3.4.4. Case studies

Considering the longitudinal nature inherent to studying an educational ecology and the underlying social nature of such research adopts a case study approach. This particular approach was chosen as it allows for in-depth explorations of complex issues in their natural environment through inductive reasoning (Denscombe 2014).

The nature of a case study is that it is undertaken to learn more about a distinct phenomenon, to understand the dynamic influences upon a given, scoped setting (Eisenhardt 1989) and the impact of context (Yin 2017) through an explorative account and comparison of the intricacies of a situation. This approach lends itself to the study of educational ecologies and the partnership process as a naturally occurring phenomena (Yin 2017; Lazar, Feng, and Hochheiser 2017; Locke and Strunk 2019).

However, dependent on the aims of the research, case studies can be implemented in a variety of ways (Yin 2003; Lazar, Feng, and Hochheiser 2017):

- Exploratory case studies are chosen for a preliminary understanding of the area and are typically implemented when there is no pre-defined set of outcomes. They are used when a researcher wishes to gain an extensive understanding of social factors impacting a phenomenon.

- Explanatory case studies describe a phenomenon within a given environment and its causal factors, typically underpinned by a pre-existing theory (Yin 2003; Shankardass et al. 2015).
- Descriptive case studies seek to provide a description or definition of the phenomena under study

Further to the typology of case studies, there are also variations in the design of case studies:

- Intrinsic case studies are used to better a particular environment and phenomena (Stake 2005).
- Instrumental case studies are used to provide insight or refine a theory and are used to better understand atypical cases (Lazar, Feng, and Hochheiser 2017; Yin 2017).
- Comparative case studies are used to compare two or more case studies to understand similarities and differences between cases. These are particularly useful when addressing challenges of transferability or generalisability in qualitative-focused research (Yin 2017).

It is essential to recognise that there is no single way of adopting case studies in research. It is likely to be a combination of the above approaches to help understand experiences and technologies used in creating and sustaining school-university partnerships for computing education. To understand which is most appropriate for the scope of this research, I turn to critique the limitations of case study research and how these sit within the framing of ecological action research.

Central to the case study methodology critique is the perception that case studies are limited in their generalisability beyond their immediate context (Denscombe 2014). In response, researchers must question the need to generalise the findings of a case study to the broader world. Instead, researchers should consider case studies to be a distinct and standalone foray into analytic generalisation as part of a process that can be used to define and redefine theoretical concepts through empirical evidence (Eisenhardt and Graebner 2007).

This perspective then questions the *transferability* of reported research, similar to the issues highlighted in AR. To respond to this challenge, it becomes vital that my research reports necessary contextual information about the chosen case, including geographical, historical and social elements so that future readers can make an informed decision about the relevance of my case study findings to that of their own context. Eisenhardt (1989) responds to this criticism by contributing a synthesised roadmap for building theory from case study research. Her work suggests using theoretically practical cases, which replicate or extend current understanding while using multiple data collection methods for the triangulation of evidence. Through cross-case study analysis, researchers can analyse a phenomenon through multiple lenses to construct definitions, validity and measurability for wider theoretical contribution (see more (Yin 2017))

With this in mind, the study adopts an instrumental, exploratory case study approach (Lazar, Feng, and Hochheiser 2017). The instrumental case study approach hopes to generate broader, novel insights for the development of educational partnerships for computing education and the development of a conceptual framework to support such a process. The participants and findings are particular to their context.

The following research reports on four case studies developed in iteration with one school partner, which can be found in Chapter 4 and Chapter 5 of this thesis. These case studies focus the experiences of participants' involved in creating, maintaining, and legacy a school-university partnership for computing education.

With this structure in consideration, the subsequent section explores the impact of the chosen case study approach on data collection methods.

3.5. Methods of Data Collection

Neither AR nor case studies should be considered a method in themselves but should be considered instead as research approaches that shape the natures of the methods chosen (Hayes 2012) and encourage the incorporation of methods based on qualitative or quantitative nature of the enquiry. In the framing of this research, methods will primarily be qualitative. I explore the *subjective and personal* experiences of those involved in differing forms of computing education partnerships and understand how these digital technologies can support the development and maintenance of these partnerships.

In the following section, I outline the series of data collection methods used in the course of my case studies, including a formal explanation, reasoning for their inclusion in this work, and information about the data collection process such as sampling. These include field notes taken by myself and teachers throughout the design and delivery of computing sessions, the collection of teaching and learning artefacts produced over the course of the partnership, and interviews and focus groups used to consolidate the meaning of collected data.

3.5.1. Field notes

Originating from ethnographic anthropology, field notes are considered a form of data collection that helps capture specific moments from the perspective of those involved in note-taking (Phillippi and Lauderdale 2017) and provide rich descriptions of the social and physical characteristics of the learning environments, as well as the interactions and activities that took place within them (Lofland et al. 2022).

By providing these *thick descriptions* of the context of a study, field notes can capture personal thoughts, feelings and actions in response to a given phenomenon (Creswell and Clark 2011; O'Brien et al. 2014). The focus on multiple perspectives, and the capture of temporally persistent information, allow for the sharing of meaning and understanding within various members of a partnership, making it an ideal method of prolonged data capture. It can also prevent the chance of hindsight bias in long-term educational research (Coburn and Penuel 2016), where retrospective analysis may not allow researchers to explore the tensions and challenges that resulted in the recorded experiences, but ongoing records such as field notes can provide time-based, relevant detail during the analysis process – explored further in Section 3.7.

In their work on "Introduction to Qualitative Research Methods", Taylor et al. (2016) noted the importance of field notes during the process of obtaining access to a research setting, including identification and obtaining entry as it can be useful both as a reflection on process, hierarchy and organisation, but also "*lends insight into how people relate to one another and how they process others"* (ibid, pg 51).

Therefore, this method was chosen to primarily contribute towards the answering of Research Question A1) *What are the experiences of the stakeholders involved in school-university partnerships for computing education?* through its focus on recording lived experience in a social, cultural and temporal context of a study. However, it also has implications in the recording of process, contributing towards Research Question A2) *What processes are involved in universities and schools working in partnership to explore curricular design and delivery for compulsory computing education?*

Following the guidance criteria proposed in (Phillippi and Lauderdale 2017), I began the process of data collection through field notes with planning the note-taking process. Firstly, field note workbooks would be made available to myself and to participating teachers in the form of Year Planners. At the initial stages of the case study we would discuss what needed to be recorded – reflections of the session content, its ease of use, perceived engagement and enjoyment of pupils and any notable challenges, observations or experiences of the author of the field notes (Taylor et al. 2016). By making use of a diary, with reflections written on each date of the research, entries made on similar dates to be compared to one another and used for discussion topics later in the process, embracing the temporality of the study. Furthermore, these field notes would be private to the owner until the end of the iteration. At that point, the owner could choose to add or remove further information upon reflection, with additions being made clear through labelling and different colour of pen.

Following recommendations by Taylor et al. (2016), field notes would be recorded after every classroom session or planning meeting. They would include brief elements about the context of the recording – including the setting, purpose of the session (if in the classroom or meeting), and any particular influences that had impacted the partnership process from the author's perspective.

The nature of AR research means that I often took notes while “in the field” and notes on meetings and personal reflections. These fieldwork books, multiple across the varying case studies, recorded my observations and feelings when encountering challenges, obstacles and opportunities when participating in educational partnership activities as a representative of my institution. Later, these notes would be captured digitally as photos, such that they could be better recorded for posterity while reducing the time taken to type these up manually. I would lightly code notes, ensuring initial thoughts were not lost, and I could present these initial thoughts to partner teachers through semi-structured interviews.

Participating teachers were able to use their field note workbooks to record their thoughts and feelings on the process – while a physical notebook was supplied, teachers were free to make their own decisions of where to record these notes for their ease of access. At the end of the project, these were then made available on a 1:1 basis between the teacher and myself for a given case study for transparency, reciprocity, discussion and verification through *member checking* –a process allowing for discussion of observations in the field notes and promoting internal validity between myself and partner teachers - explored in more detail in Section 3.6.1.

3.5.2. Interviews

Interviews are one of the most common forms of data collection used in qualitative research as a tool for exploring peoples experiences, perceptions and attitudes towards their lived reality in their own words (Taylor et al. 2016. They involve a questioner and a respondent, who work through a verbal exchange in the form of a series of questions related to the research topic to interpret, validate, and communicate respondents' views. Interviews are typically presented in three formats, dependent on the purpose of the data collection (Zhang and Wildemuth 2009):

- Structured interviews are typically a set of close-ended questions which are asked according to schedule (Zhang and Wildemuth 2009). This standardisation means that interviews are easy to repeat, allowing for the collection of large data samples with generalisability and comparability for validation purposes. However, the structured nature of these types of interviews does not allow for flexible exploration or elaboration upon responses (DiCicco-Bloom and Crabtree 2006).
- Semi-structured interviews use an interview guide but allow for deviation, unlike the more formal structured interview. This allows researchers to pursue ideas or responses beyond the scope of their interview guide while providing a level of guidance on discussion topics (Gill et al. 2008).
- Unstructured interviews are closer to a conversation, allowing for flexibility and deviation in response to answers from respondents (Zhang and

Wildemuth 2009), without the imposition of limiting pre-existing categorisation. However, these can be expensive to run due to the time involved in collecting and analysing this form of data.

Some researchers believe that the personal nature of the interview process renders their subsequent data to be *'unreliable, impressionistic, and not objective*' (Denzin and Lincoln 2005, p. 9). However, interviewing must not be perceived as a neutral form of data collection but instead an active sense-making process between participants (Fontana and Frey 2005).

A further challenge is in the power structures inherent to the interviewing process, in which the interviewer is in charge of the questioning process (Ebbs 1996). Much work has been done to address this ethical challenge (Wolf 2018; Lincoln, Guba, and Pilotta 1985), with Taylor et al. (2016) contributing the framing that the interview process can be modelled after a conversation between equals, rather than formal question-and answer exchanges in traditional participant-based research, particularly in less structured interview. This is corroborated in current literature that points to the importance of the relationship between researcher and respondent. AR already situates the researcher within the research context, in a co-development relationship with those within the context of the study, which can encourage reflection and transparency between participants (Kemmis, McTaggart, and Nixon 2013; Kemmis 2006).

Semi-structured interviews are a particularly relevant choice when looking to respond to Research Aim A of this research - *To identify the opportunities, barriers and challenges for universities and schools participating in and sustaining meaningful educational partnerships for computing education,* particularly with focus on experience and perceptions of process, in a much more direct way than field notes alone, while also beginning to address the concerns of unidirectional power dynamics in school-university research relationships. Furthermore, these interviews adopted a back-talk approach, as a mutual discussion of findings during and after the completion of my research (Frisina 2006).

Within the project, 1-to-1 semi-interviews were conducted with teachers at the end of each case studies to create a collaborative reflection on our individual and shared experiences as part of the project. The questions were developed as part of the reflection on the field notes and early themes recorded and analysed by myself and contributed by the interviewed teacher, to allow for a “back-talk” approach (Frisina 2006) By presenting teachers with an opportunity to discuss, refute or explore some of the early themes I had generated from our field notes, this would allow for further opportunities to disrupt the typical unidirectional style of school-university approach, promote a mutual approach to the research while remaining within the requirements of PhD research, and allow for validation and verification from participating teachers in the early stages of data analysis.

The questions of the semi-structured interview were piloted with colleagues in the Educational Research Group within Open Lab to review and refine questions as part of a process of *peer debriefing (*explored in further detail in Section 3.6.1). The piloting process took place approximately two weeks in advance of each ‘end-of-case-study interview’ and would allow for testing and feedback of the structured elements of the semi-structured interview).

Interviews were audio-recorded, transcribed and then shared with the partner teacher for their reflection and prompting further discussion. These were then analysed using thematic analysis (explored in more detail in Section 3.7) to provide groupings for discussion and the development of the proposed conceptual framework.

3.5.3. Focus groups

Where interviews are typically (but not exclusively) intended to explore experiences of an individual, focus groups are intended to explore the plurality of experience in response to a defined topic (Hennink 2014). They are used to gain insights from a group of people with some form of question schedule to guide discussion but a greater reliance on the interaction within the group of respondents to allow for the sensitivity to social and cultural variables (Taylor et al. 2016), making it an appropriate choice for the scope of this research.

Furthermore, focus groups encourage further criticality than interviews and help generate potential solutions (Kitzinger 1995). This focus on active and constructive communication positions focus groups as an ideal method for data collection within an action research project (Chiu 2003).

Focus groups were planned in response to the findings of Case Study One, following an improved understanding of the partner school environment and the development of rapport with partner teachers and other staff. These were intended to take place with pupils in Case Study Two, Three and Four after the curricular development had finished. I would use De Bono's Six Thinking Hats (de Bono 2017) to provide structure to the focus group, aiming to scaffold creative thinking in a group-based environment by asking questions based on feelings, potential changes, elements they liked and disliked, to gain an understanding of their experience as the beneficiaries of this research. This focus group approach was piloted with colleagues from the Educational Research Group within Open Lab to review and refine the question structure of the focus group, as part of my *member checking* process to provide credible research outcomes. The final focus group questions can be found in Appendix C3.

The focus group sessions that were able to take place were audio-recorded (ethical considerations are discussed further in Section 3.8) and transcribed. The transcriptions of these focus groups were then analysed using the process of thematic analysis.

3.5.4. Teaching and learning artefacts

Artefacts are a tangible representation of knowledge, skill and attitude (Douglas et al. 2015), where product and environment cannot be separated. Artefacts may evoke stories, histories, or explanations for their purpose or production and suggest emotional connections between participants and their environment from an empirical perspective (Corbin and Strauss 2014). While my research is focused on experiences and process, teaching and learning artefacts are undoubtedly part of the outcomes of processes to support computing education, making this a factor of consideration in my research.

Typically, artefact analysis is used as a method of triangulation alongside other qualitative methodologies in the study of a given phenomenon (Denzin and Lincoln 2005), which addresses the challenges of generalisability (Patton and Ralph Erskine Conrad Memorial Fund 2002) and credibility (Eisner and Noddings 2017) within qualitative research. For this reason, teaching and learning artefacts were examined as a source of data in combination with field notes, interviews and focus groups to provide a clear and holistic view of the research context.

In this research's first three case studies, teaching artefacts were produced in collaboration with teachers to create a computing curriculum. These included teacher guides, lesson plans, lesson slides, and homework activities that would be used in a typical computing class, with the idea that these could be made available to further schools as part of the project's legacy. Therefore, a shallow analysis of content was undertaken during the subsequent redesign of produced teaching artefacts, at the start of each Case Study. The analysis could then help to demonstrate the processes involved in universities and schools working in partnership to explore curricular design and delivery for compulsory computing education. Learning artefacts are considered the outcome of the designed teaching activities and are produced by pupils as part of the outlined case studies. These artefacts are also data, both through their production and their connection to the stakeholders as part of the partnership process. These artefacts included elements such as lesson slides, schemes of work, completed worksheets and produced digital prototypes.

Exploring these artefacts could then be used in the subsequent informal and audio recorded discussions with stakeholders to understand their experiences of their involvement in school-university partnerships for compulsory computing education. Furthermore, in adopting a perspective that these artefacts are also considered deliverables of a partnership process, they can aid in developing a conceptual framework to support school-university relationships for computing education.

3.6. Data and Trustworthiness in interpretivist research

Historically, qualitative methods of research have been criticised for their lack of scientific rigour due to their subjective, anecdotal nature, coupled with researcher bias and a lack of generalisability to the wider context (Locke and Strunk 2019, Silverman 2010. Underlying these criticisms is a central challenge – qualitative researchers must work towards the highest possible standard of trustworthiness of data regarding the report of experiences of a given phenomenon (Cope 2014; Chowdhury 2015). As such, the literature notes that several criteria must be addressed to demonstrate the trustworthiness of interpretivist research: credibility, transferability, dependability and confirmability. (Collingridge and Gantt 2008;

Lincoln, Guba, and Pilotta 1985; Guba and Lincoln 1994; Guba 1981). These are expanded upon in the following sub-sections.

3.6.1. Credibility

> *How can one establish confidence in the truth of the findings of a particular inquiry for the subjects (respondents) with which and the context in which the inquiry was carried out?* (Guba 1981)

Within positivist research, the truth value is determined by demonstrating that there is a direct and consistent relationship between research data and the phenomena recorded, which results from the perspective that there is a single, objective reality in which these phenomena take place (Peikoff 1993). The interpretivist perspective acknowledges that participants are likely to possess multiple models of their reality yet establishing a truth value holds a great position of importance within the research process (Guba and Lincoln 1994). Therefore, there is a need to consider the *credibility* of research findings and their interpretation from which data is drawn (Guba 1981; Cope 2014).

To assure credibility, literature provides a series of criteria, such as prolonged engagement, persistent observation, peer debriefing, triangulation, referential adequacy materials and member checks.

Prolonged engagement aims to overcome distortion of the presence of research at the site of investigation, particularly when working in collaboration with participants in situ (Barusch, Gringeri, and George 2011; Cope 2014). In this research, AR paired with a case study methodology focuses on developing long-term, embedded research, which encourages the prolonged engagement required to address the credibility criteria of interpretivist research. To address my potential biases, I used the field note diaries discussed in Section 3.4.1 to reflect on my understanding and characterisation of the phenomena I experienced as part of my research and the consistencies and changes throughout these accounts.

This also underpins *persistent observation,* through which extended interaction helps a researcher identify key characteristics of their research environment. Importantly, Guba (1981) notes this criterion can be achieved by demonstrating that researchers have spent sufficient time in the research environment and again suggests that keeping a research journal can aid in the reflection of changes in observed behaviours, phenomena, and related experience throughout the research. In my research, to ensure a credibility I engaged in persistent observation across an entire academic year.

In *peer debriefing*, interpretivist researchers work through their research with professionals who are not directly involved in collecting data and provide the opportunity for these professionals to question and critique the ongoing research process (Hadi and Closs 2016). In the case of my research, debriefing took place firstly with my dissertation committee, who have a range of expertise in computing and education, who were able to provide advice, critique and questions in response to the insights and experiences produced during my research process. Additionally, I made use of the Educational Research Group within Open Lab to provide feedback on my research design, through piloting sessions to explore the design of my planned interviews and focus groups.

Triangulation uses a variety of researchers, data sources, theories, and methods to cross-examine data, findings, and interpretation. Data is considered valid from multiple perspectives, ensuring no internal conflict or contradiction in interpretations or findings of this research. The nature of this research is that there is only a single researcher, rather than a team as might be expected of triangulation. However, the peer debriefing method outlined above helps provide a level of triangulation through discussion and critical examination by my dissertation committee. Using a wide range of data collection techniques also helps to triangulate the research reported in the following thesis.

The c*ollection of referential adequacy materials* requires the recording, storage and accessibility of primary data resulting from research, such that future researchers can compare their findings and interpretations (Borgman 2012). Therefore, as part of this research, all anonymised research data will be documented, archived and published as part of Newcastle University's open data repository to ensure that reference materials are freely available for comparison

Member checks are a method by which data and interpretations are verified and validated by participants of the research (Guba 1981; Ritchie et al. 2013), with alterations documented in response to member feedback. The collaborative nature of my research allows for critical working with participants, particularly through the critical exploration of our differing perspectives of a phenomenon through field notes, an opportunity to consolidate our experience through interviews and focus groups, and the use of the 'back-talk' approach, a mutual discussion of findings during and after the completion of initial data analysis (Frisina 2006).

3.6.2. Transferability

How can one determine the degree to which the findings of a particular inquiry may have applicability in other contexts or with other subjects (respondents)? (Guba 1981)

In research, applicability considers how the research findings can be applied to a new population, intervention or setting (Burchett et al. 2013). In an objectivist paradigm, findings must apply to these new framings without regard to the chronological or situational relevance of the originating context of the research. However, within an interpretivist paradigm, the probability of transfer between research contexts is pre-empted by *thick descriptions* (Geertz 1973).

A thick description describes a context that involves the understanding and absorption of the context of a given situation, behaviour, emotionality, history and intentionality of action (Ponterotto 2006). The thick description then provides a context under which researcher interpretations are constructed. A thick description of the contextual factors impinging upon my reported research is provided in Chapter 4, providing a socio-cultural, economic, political, and education account of the North East for the benefit of future researchers who are gauging the transferability of this interpretivist research to their own domains. Furthermore, throughout the development and report of this research, thick descriptions were developed to highlight the characteristics of the research context, such that researchers are provided with the necessary information to test the fittingness of interpretations and findings represented by this research to their own contexts.

A further technique for assuring the transferability of research is *purposive sampling*. Guba (1981) notes that purposive sampling involves maximising the range of data uncovered, ensuring that a range of perspectives is considered from a range of participants. Within my research, purposive sampling is provided by engaging with various teachers from three schools with a range of experience and academic backgrounds, young people from the first three iterations of the case studies, and stakeholders involved in the provision of education of young people. However, the sampling was limited to the North East, to available computing department staff and a select year group of young people. Where sampling was limited, this is made clear in each case study section, alongside a detailed description of participants, such that researchers can judge the transferability of these findings and interpretations to their own context.

3.6.3. Dependability

How can one determine whether the findings of an inquiry would be consistently repeated if the inquiry were replicated with the same (or similar) subjects (respondents) in the same (or similar) context? (Guba 1981)

Within objectivist research, stable research instruments are believed to provide stable research results, providing a consistency between replications of a research study. In interpretivist research, the validation and verification of results is a more complex concept related to the acknowledgement of multiple personal realities experienced by participants – instability of results from replicated research may arise from variability in a variety of contextual factors (Guest, MacQueen, and Namey 2012; Mason 2017; Corbin and Strauss 2014). Dependability accepts the potential for instability in the replication of studies. Guba (1981) provides a series of techniques to address the dependability of qualitative research: overlap methods, stepwise rotation, and a dependability audit.

Overlap methods involve using a variety of research methods in tandem and are considered to address invalidities that arise through the weaknesses of single, independent research methods. From a qualitative perspective, the following research involves using field notes, interviews, focus groups and teaching and learning artefacts to understand an experience from multiple perspectives through multiple methods that are focused on beginning to answer Research Aim A – understanding the experiences and processes of school-university partnerships for computing education.

Stepwise rotation requires multiple, separate research teams to deal with separate data sources and cross-check findings at key milestones to corroborate findings (Onwuegbuzie and Daniel 2003). However, the nature of this research being conducted independently in fulfilment of PhD requirements and the limited access to resources means that the stepwise rotation technique was not adopted in the following study.

Addressing research dependability through *audit* assesses the process of the inquiry itself to establish the decision trail within qualitative research studies, including the confirmability of data and associated conclusions (Lincoln and Guba 1982). To support researchers in determining the dependability of research, the following are suggested categories for the presentation of research data (Lincoln, Guba, and Pilotta 1985):

1. Materials related to intentions and dispositions: outline of inquiry, reflection on motivations, and intentions
2. Process notes: e.g. methodological details, including procedures, designs and strategies related to the inquiry
3. Preliminary development of instruments: e.g. preliminary interview schedules, observation formats
4. Raw Data: e.g. research notes, audio-recorded interviews and focus groups in response to research design
5. Data reduction and synthesis products: e.g. condensed summaries, themes, definitions and conclusions of raw data

These categories reflect how the following research is structured. I began this thesis by providing my material related to intentions and dispositions, outlining the context and purpose of my research, my underlying motivations for my involvement in such research, and what I aimed to explore as part of this research. This is followed by the methodological details of my research and the design of research instruments to collect raw data, captured in this very chapter. This *raw data* is discussed in further detail in my case studies contained within Chapters 4 and 5, which is then reduced and synthesised through the process of Thematic Analysis (discussed in further detail in the subsequent subsection of this chapter). The outcomes of the analysis are then discussed in Chapter 6. In following this structure, I present sufficient detail of the research design and methodology, including events, influences and actions of participants, that a reader can audit research decisions, such as choice of methodology, data collection, analysis and discussion, and reach their conclusion on the dependability and validity of the data presented (Koch 1994).

3.6.4. Confirmability

How can one establish the degree to which the findings of an inquiry are a function solely of subjects (respondents) and conditions of the inquiry and not of the biases, motivations, interests, perspectives, and so on of the inquirer? (Guba 1981)

Typically, neutrality is within the purview of objectivist research, in which neutrality of data is guaranteed by adopting a methodology independent of research influence. In interpretivist research, researchers are aware of their influence on the research process and their inability to be objective when interpreting. Instead, interpretivist researchers focus on interpretational confirmability.

Firstly, this can be achieved by *triangulating* data from various perspectives and methods. This approach has already been discussed in Section 3.2.1 regarding the credibility of interpretivist research data. However, in the framing of confirmability, this encourages researchers to provide documentation of each interpreted claim from two or more sources (Guba 1981). This encourages the researcher to test their own biases, motivations, interests and perspectives regarding the interpretation provided. In this research, thematic analysis is used to generate critical themes built upon multiple sources throughout the data collected during the research process (Braun and Clarke 2012) to address the criteria of confirmability. This approach to analysis is discussed in further detail in the subsequent section.

A second method for addressing confirmability is that of *practising reflexivity*. A researcher reveals the epistemological assumptions of their reality and its impact on interpreting the researcher's findings (Taylor 2006). This is recommended to involve a research diary to record personal introspections on perceived phenomena and make use of these during *peer debriefings* mentioned above. A further element in practising reflexivity is to ensure that the discussion of research also documents shifts in researcher perspectives (Taylor et al. 2016), demonstrating how researcher assumptions changed throughout the research. In the following research, field notes were kept to document these shifts in the researcher's perspective and the teacher involved in each case study. Results were used to prompt informal discussions about the project and the basis of research interviews later in the process, and ensure an internal validity and external verification of collected data.

3.7. Data Analysis

The nature of my research means that the data collected is largely qualitative, involving the analysis of field notes, interviews, focus groups and teaching and learning artefacts that centre on subjective meaning and interpretation. This approach requires a rigorous and systematic method of data analysis to provide credibility, dependability and confirmability of my findings and interpretations. Within a social constructivist paradigm, and the variety of data collection points, the following theories were available for use.

Grounded theory typically begins with a research question, reviewed as concepts emerge towards the development of theory divorced from initial preconceptions and notions (Walker 2006). Therefore, this was not the most appropriate form of analysis, as coming into this research I already had pre-existing notions towards this area of research, that would prevent analysis being truly grounded.

Discourse analysis focuses on how a situation is described and the conflicts that reside within this situation (Johnstone 2017), while narrative inquiry analysis can focus on knowledge shared, but at expense of the wider context beyond the individual participants (Clandinin 2013). While both are useful in combination, they are both limited by their focus.

Instead, I adopted thematic analysis due to its rigour and recognition within qualitative research circles. Allowing for examinations of pattern across a range of data including experiences, practices, perceptions, concepts and social processes, thematic analysis would sit best within a social constructivism paradigm, particularly where an exploration of educational ecology was concerned. Within thematic analysis, there are varying approaches – inductive allows for the generation of identified thematic areas without attempted to fit them into an existing framework, this is the role of a deductive thematic analysis (Braun and Clark 2006).

In this research, data analysis was conducted through a process of inductive thematic analysis (Braun and Clarke 2012). The systematic quality of thematic analysis allows for a process of coding and thematically grouping ‘messy’ research data. This messiness, a marker of the nuanced and complex character of reported experiential data, makes thematic analysis a better fit for the following research over other qualitative data analysis methods (Smith 2015). A key reason for the choice of thematic analysis over other forms of qualitative analysis lies in the affordance of the aforementioned theme generation. Theme generation is a process in which themes that arise from the thematic analysis process are used in comparative analysis throughout the reported case studies to provide inter-study comparability (Guest, MacQueen, and Namey 2011). These themes, acting as markers for comparison, also help address the challenge of transferability in case-based research, allowing future researchers to compare and build upon the findings reported in the following thesis. This inductive, thematic analysis was conducted reflexively. No code book was used, as instead themes and codes were adapted and changed across the duration of the case studies, centred on shared meaning, ideas and concepts over a longer period of time.

Additionally, the process of thematic data analysis acknowledges the impossibility of researchers to maintain impassive objectivity when faced with a social environment in which they are invariably entangled (Braun and Clarke 2012; Nowell et al. 2017). This is represented in the choice of inductive nature of the thematic analysis process, which discourages the use of an initial theoretical lens. Instead, thematic analysis uses the data to inform the process of analysis – in short, attempting to ensure that the data is not analysed with a preconceived notion of what should be discovered. In acknowledging my own positionality on the topic of school-university partnerships for computing education, I attempt to illustrate how my biases (and those of my co-researching stakeholders) influence the analysis of the data collected throughout my work and providing an auditable decision trail when interpreting and representing my recorded data (Nowell et al. 2017).

Following data collection and transcription of audio files, lightweight thematic analysis was conducted on a rolling basis to inform case study iterations, adapt processes of working and engagement, and for use as discussion points in semi-structured interviews with teachers and focus groups with pupils. When conducting this lightweight approach to thematic analysis, I read through available data and began manually coding the data for recurring themes. These codes were then aggregated and categorised under similar themes, integrated into interviews and focus groups as topics for discussion.

The thematic analysis process was followed when developing the conceptual framework. At the end of the data collection process, all data subject to lightweight thematic analysis was revisited and recoded to allow for comparative themes across the case studies. These broader codes were categorised and compared to understand the development of themes and sub-themes across the temporal elements of the partnership. In this initial analysis, several themes were identified for their contribution to answering my research questions, including the opportunity for new approaches to continuous professional development for teachers in computing education, the challenge of resource constraints in schools, and the challenge of power and positionality. Further discussion and elaboration of these themes can be found in Chapter 6 and are used to explore stakeholders' experiences, the school-university partnership process, and the role of technologies.

3.8. Ethical Considerations

In working with a variety of stakeholders in schools and universities, the context of this research meant that I had the opportunity to work with the pupil population. This meant there needed to be full disclosure of the nature of my research to all those involved. The formal ethics policy of Newcastle university states that research involving children must pass through a strict review process to ensure the safety and wellbeing of participants, as children are considered to be a group who are relatively incapable of protecting their own interests and influenced by the power dynamics presented by an adult researcher (Newcastle University 2021). The following research was subject to a thorough ethics review process, and no research activities were undertaken without formal ethical approval.

3.8.1. Research with young people

Firstly, the nature of my research means that I was often in close contact with young people. Naturally, this was always done under the supervision of members of staff. However, policy dictates that most individuals must have a Disclosure and Barring Service Certificate (DBS). Schools can ensure that individuals are suitable to work with vulnerable groups, such as children, on safeguarding grounds (Disclosure & Barring Service 2021). The extended nature of my work means that I had an enhanced DBS check, which was shared with schools where I worked in the classroom. As part of this process, I was not provided safeguarding training through the university, despite being in contact with pupils for extended periods of time.

Another topic of ethical and moral quandary is the choice of research methods and data collection with pupils, with particular focus on their potential to reinforce power dynamics between pupils and researchers. Following BERA guidance, I must acknowledge the importance of young people's agency and adopt methods that allow for their participation (British Educational Research Association [BERA] 2018), regardless or not if they embrace, contest, subvert or refuse these opportunities (Davidson 2017). One such method is positioning pupils as co-researchers, who also can shape and design their learning (Barker and Smith 2001). However, researchers must also be aware of power relations within the groups of young people themselves (Kellett 2011) and how this impacts the contributions these co-researchers make. These relationships require a constant negotiation of power, requiring a level of self-reflection in the researcher who, as the adult in the relationship, maintains the underlying social power in the research relationship with young people (McCartan, Schubotz, and Murphy 2012).

I used NSPCC ethical guidelines to infrastructure my work with young people to address these challenges. Firstly, during my work in the classroom, young people were aware that I was undertaking research work. I introduced myself and the purpose of my research when first working with the pupils and what this means for participant confidentiality when undertaking observational work (NSPCC 2020). In case of child protection concerns that may arise during my work, I would be responsible for acting upon these concerns and passing these to my teacher colleagues. This process was discussed with school staff before I met with any young people in a classroom setting to ensure there was a clear protocol in the case of child safety concerns. Secondly, written consent was sought from the young person and their parent or guardian (NSPCC 2020). Participation in pupil focus groups was optional, and young people could withdraw from participation with no questions asked, in line with broader ethical guidelines from Newcastle University, BERA and the NSPCC (Newcastle University 2021; British Educational Research Association [BERA] 2018; NSPCC 2020). This is discussed in further detail in Section 3.6.4. Informed consent, privacy and anonymity.

3.8.2. Research in the classroom

Due to the embedded nature of the following research, one must consider the impact of research upon teachers, including their working practices, performativity and emotional labour. Furthermore, researchers must consider the potential for disruption inherent to classroom-based research studies and the moral responsibility of disrupting learning to report upon findings of the research.

Firstly, in the design of classroom-based research, teachers' working practices must be considered and how teachers engage in these practices. According to British government guidance for Teachers’ Standards, teachers can only be legally directed to work 1265 hours over 195 days of the year (with a maximum of 190 days of pupil-facing time and five days of in-service education and training). Of these hours, there is a minimum of 10% protected planning and assessment time, in which they can plan, mark and assess pupil work (Department for Education 2011). Therefore, there is limited time for teachers to engage in external practices without internal support from their school or educational institution.

A further element for consideration when conducting research with teachers is that of performativity. Neoliberal educational policies compromise teacher freedom to offer quality teaching (Appel 2020). Instead, teachers must respond to the market-driven accountability culture, which focuses on achieving targets, indicators and evaluations to prove quality education is taking place (Connell 2013; Ball 2016). This further ties into the notion of burnout, in which teachers must carefully manage the expression of appropriate emotions in the face of stressful and exhaustive working conditions (Schutz and Lee 2014). The performativity of education has led to an underlying tension when researching with higher education institutions – teachers may take part in research to achieve qualifications or recognition for their individual performance, be subject to stratified collegial support, or develop contrived relationships with researchers (Cain 2016; Cain and Harris 2013). In the framing of my own research, there must be questions of whether a researcher in school can represent the truth of teachers with whom they work or whether we only see the performative elements encouraged by the system.

A further element of consideration is that of researcher interruption to the educational environment. Ethical considerations for the wellbeing of teachers and pupils in classroom research are well-developed topics in educational research. Thus, my research draws upon elements of criteria outlined by Hopkins (2002) to address ethical concerns regarding classroom research.

Firstly, research methods should not disrupt teaching commitments, both for the wellbeing of teachers and pupils. In the following research, this was addressed through the involvement of teachers in the design of research and allowing for flexible changes should a method or approach turn out to be unsuitable for the school or classroom context. The quality of a pupil's learning experience was a top priority. While innovation may include inevitable weaknesses in the delivery of learning materials, project termination was a possibility at the digression of the participating education professionals.

In consideration of this, data collection must not be overly demanding on teacher time. Teachers consider their profession overworked in preparation, delivery, and professional development commitments, and data collection methods must respect these existing commitments (Hopkins 2002). Therefore, in my research, I designed data collection to be similar to activities expected of teachers in training. This included a reflective written log (either physical or digital) on their experiences of implementing the teaching artefacts we had designed together and what they might change in future iterations. Recorded interviews were only conducted once at the end of the project to minimise the discrete time teachers had to contribute external to their typical working hours. I conducted interview transcription and subsequent thematic analysis of all collected data to reduce the effort required. However, analysis outcomes were discussed in depth with teachers to ensure that findings reflected our joint understanding as part of *member checking* – this is discussed in more detail in the subsequent section on the power inherent to my role as researcher and the positionality this entails.

3.8.3. Power and positionality as a researcher

The ‘bottom-up’ nature of the AR approach to research helps address some of the challenges inherent to the traditional ‘top-down’ approach to research in the Higher Education sector. However, the fact that *I* am the one to choose the AR approach for this research naturally entails that I possess a power that others involved in my research do not. Therefore, I must take the time to reflect upon my role as a researcher, especially when my research is both long-term and embedded within the school context.

At the beginning of my work, I did not feel like I held a particular position of power or privilege. I was a student involved in the process of learning and had begun my research as somebody not long out of a more traditional didactic form of teaching and learning. Naively, I thought I could avoid the challenge that my university affiliation afforded me in positioning myself as such, with no such luck. In particular, physical and financial access to resources was a distinct and noticeable differentiator throughout the process.

I did not enter this research purely to report on the actions of a community. Instead, I consciously fashioned my position as somebody aware of their position in the university and possessed expertise about what the university had the potential to support and contribute. Significantly, this critical awareness also stretched to things I knew very little, or nothing, about – the formal processes involved in teaching and learning, school policies, what schools and external educational stakeholders could support and contribute over the process of this research. I was not expecting schools to better support the delivery of computing education by themselves, instead attempting to explore a space where stakeholders could collaboratively address this challenge.

Within the realm of power and positionality, I must address the power afforded to me as the author of this research. I have the power to choose the research design, data collection and analysis. I designed semi-structured interview questions and the shape of focus groups (even if I did not dictate the direction they should follow), and my choice of data analysis methods. In my research, in an attempt to address this positionality, research and data collection methods were designed in participation with teachers. Data was analysed, coded, and presented back to stakeholders to ensure the analysis was discussed by those involved in the process, not simply the researcher's product alone (Berger 2013; Frisina 2006).

3.8.4. Informed consent, privacy and anonymity

With these concepts in mind, I now turn to the more formal process of ethics, particularly those outlined by Newcastle University’s research policy. Newcastle University requires researchers conducting research involving human participants to ensure that they are treated fairly and that their welfare and rights are protected (Newcastle University 2021)*.* Therefore, we are supported to seek informed, voluntary consent from those involved in research.

Throughout the case studies, teachers, pupils and other educators were given information sheets outlining the aims of my research and data collection methods. Only teachers were given individual consent forms to participate in the study in the first two case studies. It was typical practice to provide parents with an information sheet and only require their response to withdraw their child from the study. While there was no instance of a parent withdrawing their child from the following research, GDPR and University policy changed to require informed consent from the third iteration of the case study. Therefore, consent forms for parents were included with information sheets at the beginning of the final study, with the continued option for withdrawal at any point. Information and consent sheets can be found in Appendix A.

Information and consent forms made clear that all forms of collected data were to be treated confidentially and anonymously and would be destroyed should this be the participant's wish. All physical data would be kept in a locked cabinet on university premises, to which only I would have a key. In contrast, digitised data would be stored on a secure university server according to Newcastle University policy. Furthermore, this is also compliant with the requirements of the Data Protection Act (1998) and GDPR regarding the storage, use and protection of personally identifiable data (European Parliament and Council of European Union 2016; Stead 2018)

3.8.5. Incentives

The matter of incentives in research is a contentious one. Some consider incentives to be unethical in research design, exerting undue influence on people to agree to research in which they may not ordinarily agree to participate and discourage participants from exiting the study (Grant and Sugarman 2004; Erlen, Sauder, and Mellors 1999). This can further exacerbate power relations between researchers and participants. Alternatively, intrinsic incentives rely on participants' satisfaction in contributing to a cause they consider valuable for themselves and others (e.g. Guyll, Spoth, and Redmond 2003.

Through this research, no extrinsic incentives were used for participants on the assumption that one should try to understand the intrinsic motivations to create, run and maintain educational partnerships. This decision was made to understand that the design, findings and evaluation of the following research should provide a template for others to adopt in developing their own educational partnerships for computing education, and access to incentive resources (e.g. physical, financial) potentially prohibit this adoption.

3.9. Limitations and mitigations of COVID-19

Between 2020 and the time of writing, COVID-19 has seriously impacted this research's design, delivery, and outcomes. This was particularly noticeable in the legacy case studies in Chapter 5. Therefore, it is essential to note that while data collection was planned to include individual interviews with participating teachers and focus groups with pupils, these were unable to take place.

Instead, single interviews with key contact teachers replaced the series of planned interviews to reduce the stress of organising and attending several interview slots. Focus groups were unable to run for several reasons: pupils lacked access to video calling technology, educational timetabling was already an issue of stress due to the rapid change to virtual home-schooling, and the educational partners were already under considerable strain to ensure pupils had sufficient access to schooling. With this under consideration, it was decided that focus groups were an unnecessary burden under the scope of this research.

Chapter 4. Creating and Maintaining a School-University Partnership

4.1. Introduction

The case studies in this thesis aim to identify the opportunities, barriers and challenges for universities and schools participating in and maintaining meaningful educational partnerships for computing education.

This chapter aims to begin addressing Research Aim A by identifying opportunities, barriers, and challenges for school-university partnerships for computing education. The following chapter focuses on creating a partnership between a school and university to support compulsory computing education (Case Study One) and investigating the *maintenance* of such a partnership (Case Study Two).

I begin the chapter with an overview of my case study environment - outlining the social, cultural and educational environment in which the research takes place through an overview of the North East. This section acts as a response to the requirement for qualitative research to provide sufficient, detailed contextual information such that future researchers can make an informed decision about the relevance of my findings to their own context, but also provides the context within the framing of Bronfenbrenner's *exosystem* layer on learners' relationship to their local area, geography, history, and their impact on cultural values.

I follow this by introducing Case Study One and describing how the partnership process outlined in the case study began and the factors that enabled this to be a viable opportunity to explore school-university partnerships for computing education. I then provide an overview of methodology in the context of Case Study One, detailing the process of recruitment, content development, delivery and sustainability measures involved in creating a partnership for computing education. I then round off Case Study One with the related findings.

Moving on to Case Study Two, I explore the experiences involved in the ongoing maintenance of a school-university partnership for computing education. I provide an overview of the specific methodological decisions made for Case Study Two, followed by an overview of the planning, delivery, and sustainability measures undertaken to maintain an existing school-university partnership. I conclude the chapter with the findings relevant to maintaining a school-university partnership for computing education.

4.2. The North East

The following section exists in response to the need for contextual information on the research, to provide the thick description in the interest of data transferability. From an ecological perspective, it is important to consider the environment in which a study takes place to understand the lived experiences of power, relationships and resources within a given environment based on political, economic, social, and educational factors – both historical and current (Kemmis 2009; Epstein 2014\). Furthermore, a critique of qualitative, experiential research centres on its lack of generalisability due to the highly contextual nature of the environment of research (Hayes 2012), to which Guba (1981) recommends the implementation of a thick description of contextual factors which influence upon the research environment, such that future researchers can gauge the transferability of the following research design and interpretation to their own domain.

Each of the case studies explored in this thesis are located in the North East of England, largely within the metropolitan county of Tyne and Wear. This county (bordered by Northumberland to the north and west, Country Durham to the south and the North Sea to the east) comprises five metropolitan boroughs: Gateshead, Newcastle-upon-Tyne, North Tyneside, South Tyneside and Sunderland.

Known for its role as a centre of Roman wool trading in the 14th century, the North East of England would become more famously recognised for its coal mining, heavy engineering and shipbuilding industries during the Industrial revolution. Described as "a *powerhouse of the world in the nineteenth and early twentieth centuries, it was a [place] of inventors and entrepreneurs"* (Purdue 2011, p. 7); the North East was the birthplace of improved steam locomotives, turbine propulsion systems and pioneering electric lighting. However, there were early warning calls that the 'carboniferous capitalism' would eventually exhaust available coal seams. There would be an uncertain future for the coal and shipbuilding industries that were the staple of the economy

Despite the artificial injection of warfare spending to the economy during World War II, the focus on military production had left the industry of the North East with no time or resources to invest in modernising or diversifying manufacturing practices. While cities invested in commerce, administration, and commerce, outlying areas with a stronger focus on heavy industry suddenly became unbalanced. A steep decline in manufacturing jobs - a drop of 16% between 1961 and 1991 (Purdue 2011) paved the way for further social stratification of the North Eastern working-class populations by the mid-20th century.

In 2015, the Index of Multiple Deprivation, which examines financial wellbeing and access to resources, reported that Newcastle has lower rates of homeownership, higher rates of unemployment and higher rates of underage pregnancies in comparison to the national average (Ministry for Housing Communities and Local Government 2015a; Office for National Statistics 2015). When broken down to ward-level, wards with roots in industrial economies have lower life expectancies, higher rates of fuel poverty and higher levels of child poverty (Office for National Statistics 2015; Casla 2018; Newcastle City Council 2019).

Reports of the state of education in the North East demonstrate how primary school pupils rank above the national average. They are noted to significantly out-perform their national counterparts in reading, writing, and mathematics (Newcastle City Council 2018). However, as the pupils enter secondary school, there is a dramatic decline in academic achievement – particularly for those young people from socio-economically deprived areas. Compared to the national average, children in the North East are leaving school with less than 5 A*-C GCSEs (Ministry for Housing Communities and Local Government 2015b). Furthermore, many secondary schools are judged to be below the national standard by the education standards inspection agency OFSTED (Newcastle City Council 2018). These results are most notable in areas of de-industrialisation, with a noteworthy decline in achievement between ages 11 to 16 (Northern Powerhouse 2017).

Computing education has been positioned as an approach to encourage societal inclusion. However, with only 9% of pupils taking computing at GCSE, Newcastle ranks 105th of 152 local authorities in England in the take-up of computing education opportunities (ONS 2017; Royal Society 2018b).

The government provides funding measures to provide schools with extra funding dependent on pupil deprivation level (as a proxy for Socio-Economic Status – SES), known as the 'Pupil Premium' (Foster and Long 2018). There are concerns that secondary school pupils do not benefit from this extra funding in the North East, leading to poor academic achievement and engagement (Northern Powerhouse 2017). This poor access to funding and support contributes to the high numbers of young people (aged 16-24) in the North East who were not in employment, education or training - 14.0% versus a national average of 11.1% (Powell 2018; Office for National Statistics 2019). Pupil premium students have also been underrepresented at Computing GCSEs, comprising only 19% of entries, compared to the average of 26.6% (Kemp, et al., 2016).

Compound levels of political, social and economic disadvantage, like those seen in the North East, have been linked to what has been termed as the 'emergence of a digital underclass' (Helsper and Reisdorf 2017; PriceWaterhouseCooper 2009; Robinson et al. 2015). This term is defined as the process of poor digital skills leading to increase social exclusion from society (DiMaggio and Garip 2011). These disparities begin to paint a bleak picture for the progression of young people in the North East (Bradshaw 2020), as the entrenched nature of socio-economic status has the potential to exclude citizens from developing the digital skills needed to take an active part in modern society. This ongoing challenge cements the need to support computing education in the North East, focusing on the sensitivities of the cultural, political, economic, social and educational context. This perspective drives the methodological design of this study, with a focus on lived experience, embedded working and long-term investigation.

4.3. Case Study One: Methodology

Case Study One was conducted during the first academic term, in which I collaborated with the computing department of a local secondary school to develop a new programming curriculum. This curriculum was intended to support the transition from block to text-based programming to fulfil the Key Stage 3 National Curriculum requirements for the school.

4.3.1. Background of partnership: stakeholders and relationships

The University: Newcastle University is a research-focused, pre-1992 university in the North East of England. It is both a 'red-brick' university, denoting a non-collegiate institution focusing on producing practical knowledge (Eggins 2010) and part of the Russel Group, a self-selected group of public research universities across the UK. Newcastle University presents itself, from a strategic perspective, as a civic university (Newcastle University 2018; 2019). The focus on 'civic' is mainly economic, as the strategy outlines the university's intention to further align research with the needs and priorities of local industry and economy (Newcastle University 2018). However, this can be attributed to universities being required to meet standards to gain funding, such that investing government, industry or business partners perceive a potential partnership to be of potential profit (Olssen 2016). Despite this, the policy development document acknowledges the university's role in fostering equitable societies through externalising research outcomes.

The document stresses the importance of university contributions to place-based policymaking and the development of bi-directional partnerships, where engagement is mutually beneficial and built upon a diverse range of opinions, perceptions and information (Newcastle University 2018; 2019).

My role: This research came about as part of my studentship in the Centre for Doctoral Training in Digital Civics. Digital Civics, as a particular perspective on the role of technology in daily civic life, positions researchers to question and respond to social inequalities, challenge the status quo of existing relationships, and work with citizens to critically engage with underlying power structures of existing systems. Central to Digital Civics approach is the idea of how people, place, and relationships between entities can be positioned to improve quality of life for communities (Olivier and Wright 2015). Within the framing of Digital Civics, I was able to propose my own collaborators and research area – beginning with my Masters research exploring undergraduate students going into schools to support computing education (Venn-Wycherley et al. 2019). The findings of this research would eventually lead to the topic of this thesis – exploring the potential for partnership working between schools and universities. This particular background no doubt influenced the way in which I engaged, and was supported to engage with school partners by peers and mentors within the Doctoral Training Centre.

The Local Economy Partnership Organisation: The integration of career-based learning in young people's education to improve attainment, discipline, and attendance, to strengthen the local talent pipeline and provide an increased capacity for educational equity led to the North East Economy Partnership (NEEP) to introduce a local Education Challenge in the North East. NEEP would organise local businesses and organisations to engage in challenge commissioning for schools in the North East, and develop project-based education challenges.

In the early summer of 2018, Newcastle University was contacted by NEEP about the potential for collaboration on the development of education challenges as an employer with one of their participating schools – Ivy Community College.

The Partner School: Ivy Community College are a non-selective, mixed-gender secondary school based in the North East serving over 800 pupils aged between 11 and 18. The school itself is geographically situated in an area of socio-economic deprivation, with over 40% of the pupil population identified as disadvantaged due to familial upheaval or financial difficulty. As a school, they were part of a northern education trust, a further organisation consisting of university, college, school and employer collaborations for the benefit of young people. The Trust encouraged collaborative partnerships and engagement in research activities that improve social mobility and tackle disadvantage.

Existing relationships: I had already undertaken some limited work with Ivy School and their computing department as part of the CLIMB project, where I had worked to pair computing undergraduate students with teachers to design and deliver three computing lessons using the BBC micro:bit (Venn-Wycherley and Kharrufa 2019). While this particular study is covered in full in my paper 'HOPE for Computing: Towards the Infrastructuring of Support for University-School Partnerships', I did not directly interact with Ivy beyond organising the engagement and follow-up interviews. However, it is important to note that there were previous links with the school with which I engaged. Additionally, there had been previous contact between NEEP and Open Lab (of which I was not involved). Still, there was some form of pre-existing relationship, which meant that initial contact over the project could be surfaced with more ease due to these professional connections.

Desire for partnership: In the case of this Education Challenge, the acting Head of Computing at Ivy had a keen interest in launching a programming-based project in September of 2018 to address several self-identified challenges in the delivery of Key Stage 3 computing, including:

- *Teaching staff are unfamiliar with computing knowledge and struggle to deliver activities beyond block-based programming.*
- *Year 8 requires text-based programming.*
- *Many members of the department are not confident in delivering Computer Science, particularly those that did not previously specialise in ICT, but Business instead.*
- *Students in Year 8 only have one lesson of Computer Science per week which doesn't offer much scope for in-depth learning of programming.*

Excerpts from Appendix B1 – Initial Wish List

As a school, they were keen to improve to improve staff content and pedagogical knowledge and confidence, with the belief that this would contribute to an improved level of student engagement in computing. To achieve this, the school suggested a 12-week timeframe across three terms. Two classes of students would participate in the curriculum on a carousel basis (with two bottom-set classes following an alternative scheme of work due to time constraints). The opportunity to work with six classes of students across three iterations would allow for the cross-case study comparisons and allow for iterative development on the approach to such a partnership.

This would begin with a visit to Newcastle University's School of Computing. The university would set them a challenge that could be solved using computing skills and physical computing kits with a tangible link to the environment in which they lived and learned. Pupils would then plan how to respond to this challenge over the next ten weeks. The scheme of work would culminate in a celebratory event at the University, where parents, carers and local employers would be invited to attend. The university would act as a challenge commissioner, and I would take a role in the classroom to support teachers in using the physical computing kits.

Pre-partnership discussions: during these initial talks with Ivy, the teachers and I discussed the use of supporting technologies currently used in the classroom – both for supporting teaching and learning and those specifically in the delivery of computing. The predominant form of communication would be via emails between myself and the teachers. From teachers to students, Google Classroom was the virtual learning environment (VLE) of choice within the school, with each class having their own virtual classroom for the distribution of materials, assessments and discussion topics set by the teacher in an admin role. Pupils had become accustomed to the use of Scratch for their early programming learning, but Python was the language of choice in later Key Stages, and therefore the choice was made to introduce Python at this point. To engage pupils in this transition, the school highlighted the BBC micro:bit as a form of physical computing device with which they had previous successful engagement experiences in the past and access to two class sets of kit.

4.3.2. Participants

This first case study would involve working with two classes. Class 1 comprised 28 pupils (16 female and 12 male), and Class 2 comprised 26 pupils (14 female and 12 male), who were both taught by Teacher1. She was a female teacher with nine years of teaching experience and a degree in ICT Secondary Education but was required to teach computing. Both Class 1 and Class 2 were considered the highest ability classes within their year group for computing and had one 50-minute computing lesson per week during their winter term.

The school chose these two classes, and I was not involved in the discussions about their choice. However, in early conversations with staff members, there was the perception that the higher ability students would be ‘easier’ to work with due to good behaviour and engagement with their learning. Ensuring that I worked with well-behaved pupils was likely to be a *better* experience in achieving a set goal of a partnership without the challenge of disruptive classroom behaviour and lack of engagement perceived of lower ability classes. This point is potentially rooted in performativity in education, outlined in Chapter 3, in which teachers and schools are pushed to appear ‘marketable’ and ‘high-achieving’.

4.3.3. Approach

Due to the limited understanding of the partnership process between schools and universities for the development of curricular resources and support for compulsory computing education in the North East of England, this particular section of the study adopted an instrumental, exploratory case study approach (Yin 2003; Lazar, Feng, and Hochheiser 2017). This approach is detailed in Chapter 3 and is founded on the concept that while the study is a product of its environment, the instrumental case study approach seeks to generate broad and novel insights for the application of School-University partnerships beyond its initial context.

In the following case study, the main unit of analysis was the two classes across the term, including the teacher, pupils and myself as the research partner.I adopted an Action Research approach to the design and practical engagement of the research (Hayes 2012), such that I spent significant periods working in the classroom environment and directly supporting the delivery of the sessions in collaboration with the teacher.

4.3.4. Data collection

In following the qualitative approach outlined in Chapter 3, I drew on a variety of qualitative data sources during the case study to provide triangulation of data through a variety of perspectives to satisfy the needs of data confirmability, dependability, and credibility. I kept a field note diary to record my observations throughout the process, as did the teacher I worked with during this particular case study, which could later be used to compare observations as part of the analysis and interpretation process. These comparisons would serve as the foundation for the semi-structured interviews conducted with the teacher at the end of the case study period. Pupils were encouraged to give feedback during each session, which I could then record as part of my ongoing field notes. Additionally, pupil-produced learning artefacts were considered a form of data collection, both in the process of their production and their outcome, which were then explored at the end of the case study. Furthermore, pupils from both classes undertook a survey at the end of the 12 week period, encouraging them to share their opinions on what they considered the most fun, what they would recommend changing in future iterations, and what they would recommend to keep the same. Fifty-two responses were received.

4.3.5. Ethics

This case study was awarded formal ethical approval by Newcastle University's Ethics Committee, in line with their ethical policies and procedures for working with children as an identified vulnerable population (see Appendix F).

Any reference to pupil data would be provided anonymously. Pupils involved in the study were provided with an information sheet and consent form that provided information about their role in the research process and how a parental figure could officially withdraw them from the research process. These forms can be found in Appendix A.

Teachers who had been flagged as potential participants for the study were sent an information sheet that provided further information about the research element of the project. Once sessions began and the teacher I would be working with had been identified, I sent a consent sheet for her to sign and return. These can be found in Appendix A.

Once the consent sheet had been returned, the teacher was presented with a Field Note diary. The teachers and I then discussed how we would record our observations and how these would contribute to the research and curricular development. This would then provide a basis for the interviews at the end of the Case Study, which would also be an opportunity to debrief the research.

4.3.6. Data analysis and interpretation

The primary method of data analysis was inductive thematic analysis, where emergent coding noted areas of importance arising from the data collection process. This method provides a rigorous and systematic method to analyse the complex variety of qualitative data produced and collected during the research process and affording a criticality of personal, social, and cultural meaning surrounding a topic (Braun and Clarke 2012).

During the data analysis phase, I began by reading through the observations recorded in field note diaries across 14 teaching weeks by myself and the teacher. These records detailed observations of interactions in the classroom and conversations between myself, teachers and pupils. They also included the thoughts and feelings of myself and the teacher at the time of writing. These observations were then used to structure our interview discussions, resulting in 52 minutes of recorded audio. I transcribed these teacher-researcher interviews in full before being subjected to the iterative phases of thematic analysis suggested in Nowell (2017).

This approach to thematic analysis involved a prolonged engagement with the data to provide familiarity with that which has been collected during the research process, before the generation of initial codes (Braun and Clarke 2012). Printed transcripts were hand-annotated with initial comments before a holistic review of observational data, interview data and pupil-supplied survey responses were used to generate more meaningful themes and definitions through digital annotation. These themes were then used in discussion with stakeholders in this project – teachers and Education Challenge stakeholders – and my supervision team to test the credibility of these interpretations before being used as the basis of the report for this case study.

4.4. Case Study One: Planning and Delivery

The element of content development in the partnership process has strong ties to that of the AR cycle, with a particular focus on establishing your relationship with a community partner to understand mutual goals when developing the scope of research. The following section outlines the content development process for setting up this school-university partnership project, including the commissioning of a challenge, the role of physical computing devices, assessments, visits to the university, CPD, their VLE and the research process.

4.4.1. Commissioning a curricular challenge

Within this particular project, the external requirements of participating in the Education Challenge required the commissioning of a challenge to which pupils could respond through classroom learning and design activities. Ivy wanted a way to support the professional development of their computing staff in order to be able to engage their pupils in active learning. I was searching for a way to support this process and share what I had learned with the wider computing education community – both practical and academic.

Regarding the commissioning of the challenge, Newcastle University were the perceived challenge commissioner. However, it was largely down to *me* to develop a problem space from which pupils could begin their computing work – something on which I could act as a subject expert and bring a depth of experience that would sit in a series of assessable checkpoints for the requirements of the school. A further criterion was that it had a link to the local community, echoing the local links of the Ford NGL curriculum development.

In developing a challenge for the project, with the requirement that it be based on the local community and the university, I developed a challenge focused on environmental improvement tied to the Urban Observatory research group. The Urban Observatory is an open environmental data monitoring lab aiming to develop our understanding of the urban environment and the potential of cities of the future. Surrounding Newcastle and Gateshead, there are approximately 1,000 sensors that monitor environmental indicators such as air quality and biodiversity, with readings being openly available for use by the public. In discussion with teachers and the Urban Observatory, we set an open challenge for improving the school environment by creating a 'School Observatory' – attempting to improve overcrowding in the lunch queue, opportunities for pupil voice concerning school issues and environmental monitoring. In pairs, pupils would pick one of these topics and then plan what they needed to complete the project by the end of the 14-week slot.

The curriculum was developed collaboratively with the teachers, to ensure that we were able to meet school expectation for assessment, homework and lesson content. An early example of this collaborative document is overleaf, in Figure 5.

While the content of these sessions shifted in response to pupil progress and understanding, this helped to create an early foundation between myself and the partner teacher as I gained an understanding of what would be required from the partnership to meet the accountability requirements of the school. This schedule development process would change for Case Study Two onwards, as a more formalised undertaking.

Date	Type	Content
11/09/18	Event	• Timetable at

12/09/18	Lesson 1	• Recap the project, clarify any questions.
		• Student begin developing their proposals
		  ○ Exploring problem area
		  ○ Putting together a response
		  ○ Deciding on accessories

17/09/18	Lesson 2	• Finish proposal. 21st, 19th September deadline. (Homework task if not finished)
24/09/18	**Checkpoint 1**	• **Baseline activity, get students to reflect on scratch programming knowledge**
01/10/18	Lesson 3	• Students begin development
08/10/18	Lesson 4	• Students continue development.
15/10/18	Lesson 5	• Students continue development.

22/10/18	**Checkpoint 2**	• **Presentation. Each team has 2 minutes to present how their proposed idea meets the brief (and by extension the national curriculum)**
		  ○ **Can be done in groups, bringing in peer support/assessment**
		  ○ **Can also use this to identify where there's need for particular tutorials**

29/10/18	Lesson 5	• Students continue development.
05/11/18	Lesson 6	• Students continue development.

12/11/18	**Checkpoint 3**	• **Students given a series of problems to solve. E.g. how to record and sort a series of input variables on the microbit**
		  ○ **These problems are aligned with areas of the national curriculum**
		  ○ **Based on baseline test, assess progress**

Figure 5. An excerpt of an early collaborative schedule of lesson content, assessment and homework in Case Study One

4.4.2. Roles and responsibilities

The project-based learning approach to the Educational Challenge meant that there was confusion about the levels of collaboration required to develop the learning resources. This allocated development time was also coupled with the beginning of the summer holidays, which meant that collaboration was difficult to coordinate between teachers and NEEP staff, and some initial confusion about roles and the experience brought to the project. The majority of material creation and curriculum planning became my responsibility, despite possessing no official or accredited training in educational design and delivery for computing.

4.4.3. Making use of physical computing devices

From Ivy's requirements, this would need to involve the use of physical computing devices in the form of the BBC micro:bit as a way to explore the impact on pupil engagement when engaging in creative and physical computing practices. Despite their positive impact on learner engagement in wider research (Sentance et al. 2017), few examples beyond basic tutorials demonstrated how these physical computing devices could be better integrated into the curriculum. Ivy was already in possession of class sets of micro:bit. These were used in limited lessons throughout the different year groups, but they wished to integrate these further into their computing curriculum for Year 8. Therefore, curricular materials would need to be created as part of this project.

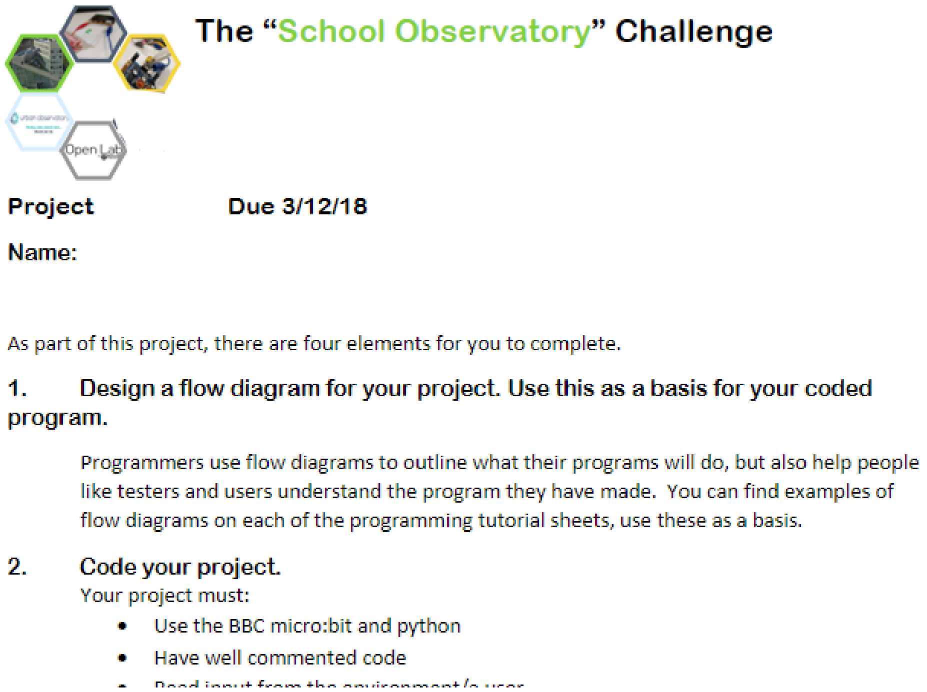
There was a disconnect between the scope of the challenge and the limitations of the available physical computing technology. By themselves, the micro:bits are not particularly suited for environmental readings, yet peripheral kits could provide this functionality. After some discussion, the decision was made to purchase 30 ElecFreaks Tinker Kits through my available research funding, as they provided a range of sensors and outputs that the pupils could use to respond to the challenge. However, learning materials did not exist for these kits, and as such, a further 30+ tutorials were required to explain how the pupils might engage with these additional sensors. In the early plans for the project, curricular development and materials were intended to be delivered collaboratively.

However, the introduction of the physical computing devices was highlighted as a key motivation for pupil engagement in the teacher field notes ('*pupils excited for loaning micro:bits!!! (Teacher1, Case Study One, teacher observational notes)* and that more could be done to introduce the Tinker Kits as exciting opportunities that pupils could borrow and take home to work on outside of school hours.

4.4.4. Integrating assessments

As part of the curricular development, we needed to ensure regular assessments to evidence pupil learning as part of school accountability as a learning institution.

There was also a need to ensure that this curricular innovation provided computing education benefits and met the standards of coding education (Fink 2020; Portnoff 2020). Assessments would be created collaboratively between myself and teachers to ensure they met the criteria required by school policy, according to National Curriculum requirements (see Figure 6, below)



The "School Observatory" Challenge

Project **Due 3/12/18**

Name:

As part of this project, there are four elements for you to complete.

1. Design a flow diagram for your project. Use this as a basis for your coded program.

Programmers use flow diagrams to outline what their programs will do, but also help people like testers and users understand the program they have made. You can find examples of flow diagrams on each of the programming tutorial sheets, use these as a basis.

2. Code your project.

Your project must:

- Use the BBC micro:bit and python
- Have well commented code

Figure 6. An overview of the assessment design for the Case Study One, in line with school policy to demonstrate assessments at the start of the module

The Google Classroom class would be used to host the test as a Google Doc, allowing for automatic saving and pupils to be able to return to it when needed (e.g. as part of a homework).

4.4.5. Organising visit days

In line with the other Education Challenge curriculum topics, the teacher and I planned a visit day for the pupils. They would come to the Urban Sciences Building (USB), the home of Newcastle University's School of Computing, to introduce their challenge and begin planning for their project. This would happen while having direct access to Newcastle University computing researchers, allowing pupils to ask questions about their project and have an opportunity to engage with people they would be unlikely to meet during traditional lessons. In the final week of the project, pupils would return to the USB to present their final ideas back to the University. The session would be open to parents, carers and guardians of the pupils and those affiliated with the wider Education Challenge to celebrate what had been achieved by the young people.

The visit day would be my first interaction with pupils and the class teacher with whom I would collaborate to deliver the first iteration of the curriculum, shown in Figure 7 (with an excerpt of the presentation found in Appendix D). The event was delayed in starting, and pupils were distracted by the novelty of the building, the content and the equipment with which they were presented. However, the teacher noted in their field diary that the visit day was important in motivating the pupils to participate in the project, which left them excited and with fresh ideas. From the school perspective, the challenges of having the visit day as the first session meant there was little chance to organise pupil logistics (e.g. the pairs they would work in or ensuring that there were stronger links made to curriculum requirements).

Figure 7. Pupils visit the university for the first time

At the end of the project, pupils returned to the university to participate in a final celebration event with their micro:bit creations, and saw parents, guardians, researchers and members of staff from Newcastle University, and those involved in the Education Challenge (NEEP members and local employers in technology and manufacturing) invited to attend. The event lasted two hours, opening with a brief presentation from the Education Challenge team before attendees were invited to visit the pupil project stands to talk about the projects developed over the term, as shown in Figure 8. The end of the event would involve the presentation of pupil participation certificates from the Head of the School of Computing.

Figure 8. Pupils talk to a researcher about their project

Before the event, the pupils were tasked with creating their own “trade fair” stands, knowing that they would have a table and poster stand of which they could make use. Pupils were anxious leading up to the event, worrying that they would not know what to say or ‘*look stupid in front of people’ (pupil in Class 2, Case Study One, observation note)*. However, the creative elements of the trade fair managed to engage pupils who were not as engaged with computing. When asked what their favourite part of the project was, one pupil responded, ‘*I found it really fun being able* *to talk to some visitors from the university about my project' (pupil, pupil survey).* While there were some initial concerns about going to the university, this later was a positive experience. Many asked for more opportunities to engage with researchers and members of the university.

4.4.6. In the classroom

Lessons lasted 50 minutes, with the first 10-15 minutes being dedicated to introducing computing concepts required by the National Curriculum, delivered within the scope of the Education Challenge. In our initial plan, it had been decided that I would take the lead in delivering the first class, and the teacher would then deliver to the second class later in the week. However, in practice, the teacher and I found that attempting to delineate between the two roles (lead and support) was challenging when we had complementary expertise in classroom management, computing education and micro:bit programming. As such, we often taught in tandem, moving to support one another when we encountered areas of difficulty in the day-to-day delivery of sessions.

4.4.7. Delivering CPD

A further goal from Ivy was the support of their teaching staff in subject-specific CPD. This CPD session would be arranged during an afterschool slot at a later date when there was a gap in their CPD schedule, and it was agreed that teachers would be able to prepare and review the session materials before the session in their allotted PPA time. Any questions or concerns outside of the days I would be present in school would be communicated via email.

Teacher training was expected to occur at some point during this case study, but plans were still in the process of finalisation, and no final date was organised during the planning process. There was the need for some flexibility in deciding this date, based on wider school factors such as in-house and whole-school CPD provision, which was still in development. Due to the longer-term nature of the research, there was no immediate need to finalise a date for this teacher training.

4.4.8. Understanding technologies in-place:

As part of their Learning Trust, they were expected to use a prescribed virtual learning environment (VLE). All staff and pupils would have access, with varying access permissions dependent on role. The platform was integrated with Google Services, such as Google Drive, Google Classroom and Google Mail, and was the typical method of communication when dealing with the school. Rather than designing a new delivery method, the teacher and I would use existing technical infrastructure to deliver the materials for this curriculum for the ease of integration for staff and pupils alike.

When first planning work in the classroom, I was aware of the VLE system in use at Ivy. However, the nature of the system meant that I would need to ensure the teacher had access to the materials as I did not have direct access to the VLE to share resources with pupils and staff. This often confused who was leading the session or providing an overview of materials or activities, resulting in some disjointed learning delivery in the classroom. However, later in the term, I was provided with a staff login to the VLE system to help design the outline of materials. Each class had their own Classroom group. I could upload weekly tasks on a Feed view, create a micro:bit tutorials repository, provide automatic marking to quizzes and assignments, and provide pupil feedback.

4.4.9. Research in schools

Concerning my own goals to explore and understand the experience of creating and participating in a School-University partnership for computing education, I would engage the teachers in formal, semi-structured interviews to assess the partnership process. These final reflections would focus on identifying opportunities, barriers, and challenges for these differing stakeholders when participating in partnership with the university and understanding what it means to ensure that the partnership was meaningful and sustainable for those involved.

Following the end of the teaching sessions, I arranged to interview my partner teacher to review the early findings of this case study. Arriving at school, I found that they had agreed to cover a lesson for a colleague. While we initially tried going through the interview questions during this lesson (both feeling a little guilty that we had not reached out to confirm availability), the teacher and I devolved into a casual chat to rearrange the interview in a quieter environment. However, the school environment is rarely quiet and non-interruptive – the subsequent interview session was interrupted by pupils moving classroom due to the need for access to the computer suite or behavioural issues, a staff rendition of Over the Rainbow, and an impromptu harmonica solo.

4.5. Case Study One: Findings

Case Study One reports the creation of a partnership relationship between a school and university to support compulsory computing education, from prospective partnership to project outcome. The purpose of this Case Study is to begin to address **Research Aim A** in identifying opportunities, barriers and challenges for school-university partnerships for computing education, particularly through the reported experiences of stakeholders and the processes necessary to achieve computing curricular design and delivery.

Therefore, the following section reports the findings of the actions undertaken during the creation of a school-university partnership for computing education, including reflection upon the process and experiences of those involved. This began in informal discussions with the partner teacher and the head of department and formed part of the 60-minute semi-structured interview with Teacher1 throughout Case Study One, which took place at the end of the case study. From these discussions, and subsequent thematic analysis of the interview, field notes and pupil feedback, the following themes have been identified for elaboration in the remit of school-university partnerships for computing education: navigating the disconnect between schools and universities, understanding of pedagogical approaches, designing for sustainability, constraints of a school environment, locus of control in school-university partnerships, domain upskilling for teachers and connecting to the school community.

4.5.1. Navigating the boundaries of accountability: "As teachers, we've always got to justify what we're doing and why, otherwise we're held accountable for it" (Teacher1)

A key motivator of this research is understanding how universities can engage in curricular design and delivery of computing education in schools. In response, the first theme arising from my data analysis regarding the *creation* of school-university partnerships, is the challenge of navigating accountability in the partnership process.

As previously noted, teachers are under an immense amount of scrutiny regarding their professional practice within a highly performative educational system. Their teaching decisions must individually respond to the market-driven accountability culture, focused on achieving targets, indicators, and evaluations to prove quality education is taking place. This limits the creative space in which teachers can explore innovative approaches to curricular development and delivery, as they must justify their classroom decisions in line with statutory guidance. While researchers are also held accountable for their work, through frameworks such as the REF and KEF, university and funding policies, and ethical standards, this is not nearly as stringent as their school teacher counterparts.

The sentiment of accountability in teaching practices was highlighted by the teacher recounting her exasperation with another external researcher with whom they'd been discussing curricular developments, saying '*You can't just- unless you've been given "all access" to say "we're going to do this project this term, doesn't really matter that it won't happen very often". As teachers, we've always got to justify what we're doing and why, otherwise we're held accountable for it*' (*Teacher1, Case Study One, Interview).*

Following this particular challenge, the teacher recounted a story of a researcher discussing taking the pupils out of school with two weeks' notice, to which she responded: *'Well, no. In our school, it's a term you have to give up to 12 weeks' notice or you can't take them out. Things take time in schools and they just don't realise that, don't they not?*' (*Teacher1, Case Study One, Interview).* Navigating the boundaries of what is possible of each partner in a research relationship is an important step when establishing early educational partnerships between universities and schools.

A further demonstration of navigating accountability in school partnerships was the lack of consideration for the written school report for that term. Official statutory guidance is such that schools must send a written report to parents/guardians reporting on their child's progress (Department for Education 2014). As such, the writing of school reports is a typical end-of-term activity in which teachers note how a child is progressing in class, areas for improvement, and comparisons to previous reports. The atypical nature of our research project had implications on this process, with the teacher noting that:

> *When I was writing my reports this time, I was struggling with what I could write in my reports... So I could comment on group work, I could comment on their involvement, but then apart from that every kid had the same sort of paragraph like "They were part of the trailblazer where they went there and did this" and I changed one or two lines so "The student behaved really well" or "They proved to be enthusiastic computer scientist …Because it was completely different from the normal classroom experience. - Teacher1, Case Study One, Interview*

When the teacher and I discussed how we might respond to this challenge, we concluded that this was an inherent risk in conducting exploratory research and that future partnership processes would need to acknowledge existing school accountability structures in the early stages to prevent similar occurrences.

4.5.2. Understanding of pedagogical approaches: "Actually teach students how to do it instead of sending tutorials" (Pupil survey response).

When creating a school-university partnership to support pupils' learning, an effort must be made to understand pedagogical approaches currently in use in school to prevent unnecessary disruption for the sake of novelty.

Firstly, the early stages of a school-university partnership with educational intentions are rooted in the different institutions' pedagogical expectations. Universities adopt an independent approach to learning in which they are introduced to information and encouraged to support their own understanding. In comparison, early secondary school pupils have experience with a more traditional form of teaching than this exploratory project would provide, typically guided through activities as directed by a teacher. The project-based nature of this newly designed curriculum encouraged pupils to adopt a more independent approach to their learning, allowing for exploration through the provision of independent programming tutorials that the pupils were able to refer to explore the capability of the micro:bit.

However, this exploratory approach is far different from the typical approach to teaching and learning encountered by these pupils - *'The kids were using them really well, but the kids are so used to being told that "this is exactly what you need to do" that they didn't- that not all of them took it to the advantage that they should'*

(Teacher1, Case Study One, Interview), supported by my field note observations in which I noted '*students find scheduling difficult? Don't know how to complete? Not used to having control over their own learning.*' *(my observational notes)*

While the teacher and I were exploring a new teaching method, hoping to observe changes in pupil engagement with the topic, we had not necessarily considered how pupils might react to this change when they had never encountered this style of teaching before. This was mirrored in the frustration of one pupil, who, when asked what they would like to change about the project, anonymously replied, '*actually teach students how to do it instead of sending tutorials' (pupil, pupil survey)*. To respond to this challenge, we decided there was a need for more structured content to better scaffold pupil learning and support them in approaching exploratory learning methods in the classroom.

This can be demonstrated in the early stages of the school-university partnership process, where the teacher and I chose to design the curriculum to align with the university's School of Computing research to provide a real-world link between computing skills pupils learn and their application. During the project, pupils were challenged to promote environmental improvements within their own school. The teacher and I gave examples of overcrowded lunch queues, pupil voice in school issues, and environmental monitoring.

This link to the university, both as a physical location and a knowledge entity, helped ground the project as pupils could see how their computing knowledge would '*all come together' (Teacher1, Case Study One, teacher's observational notes)* in the form of the smart technology underpinning the USB building. However, this was a challenge as it was not a domain area with which pupils were familiar.

This disconnect became evident in the classroom. Some pupils followed the provided examples during their project exploration time, while others created responses that were only partly related to the project scope yet were highly imaginative. One pair of pupils created an automated potpourri air freshener (see Figure 9), which used the micro:bit and a 180-degree servo to move a handmade fan over a bowl of homemade potpourri.

Figure 9. An automated air freshener project created by two Y8 pupils

While initial attempts had been made to ensure there was little disruption to the pupils, pupils who were not comfortable with the project scope struggled to engage with the projects. They were observed to lose interest or become distracted when faced with the tutorials and exploratory learning time. Through the pupil survey conducted at the end of the project, pupils raised the question of being able to choose a project outside of the given challenge scope as they were not interested in lunch queues or motion detection.

In support of this point, the teacher noted that '*You're always going to get a few people who don't engage. We had a few who didn't, they just sort of slip through the net'* (Teacher1, Case Study One, Interview). During our discussions, the teacher and I decided that the scope needed to be more defined to support pupil exploration. However, it was important to link back to university research to provide the practical grounding for their projects.

4.5.3. The digital infrastructure of schools: "Half the time I still don't know how that works" (Teacher1)

In educational ecologies, technology is an important consideration in the infrastructuring of space and relationships (Nardi and O'Day 1999), as it allows for the development of ideas, knowledge and practice (Clayton 2016). Each school has their own particular technological infrastructure, with a particular choice of virtual learning environment, firewalls and restricted access to their internal WiFi networks.

This security typically stems from safeguarding requirements to limit potential threats to the wellbeing of pupils. However, this also impacts the dissemination and use of resources, with unexpected results.

Due to Ivy's position within their Learning Trust, the creation, collaborative development, and dissemination of teaching and learning materials related to the project were conducted entirely through the Google suite. While I was aware of this from early in the process, I had not entirely considered the challenges of these technologies, which adopted the *different time, different place* approach to communication.

Before the project, I was invited to be a shared user of a folder accessible to Ivy's department. I could place and organise resources for easy viewing by teachers with no access to sensitive pupil information. I would be able to work on resources in my own time, at my desk at the university, without needing to be physically co-located with the teachers. However, when starting lessons, there were challenges in ensuring the resources, tutorials and assessments were correctly uploaded. These would have to be passed through the partner teacher as I had no access to the Google Classroom VLE. In my early observational notes, I wrote '*difficult to get access to documents -> am I allowed access?' (my observational notes)*. This lack of certainty led to confusion about how these resources were shared, what structure they should be uploaded to ensure pupil access, and the teacher's reliance on conducting extra unnecessary work in transferring unfamiliar files to her Classroom layout. This process was made to be even more challenging because access to Microsoft 365 products was not permitted on the school WiFi, which is incidentally Newcastle University's choice of platform for online storage. In my field notes, I noted that there were certain times in which I would need to transfer files from my academic online storage to the teacher and had to use my personal phone's data to hotspot the transfer to mitigate these limitations.

In discussion, the teacher and I talked about how the setup of the technological environment in schools, including Classroom, added to the confusion in some lessons, with the teacher stating, *'To be fair, you didn't know about Classroom- Then you realised how that would work- Half the time I still don't know how that works (laughs)' (Teacher1, Case Study One, Interview)*. To address this, I was then provided with a school staff login, such that I could access the VLE, share resources and contribute to the sharing of materials alongside the teacher.

4.5.4. Designing for sustainability: "I don't what this to be something we stop using and forget about" (Teacher1)

The teacher emphasised a further theme of the importance of designing for sustainability in the early stages of partnership and ensuring the long-term benefits of curricular innovation in the classroom. During the interview, when covering the topic of sustainability of the developed resources, the teacher responded, *'I don't what this to be something we stop using and forget about. Like the Sphero balls, we've never had them out the box, we just don't have time*' (*Teacher1, Case Study One, Interview).* This became a key point of discussion – previous attempts to introduce physical computing devices such as the programmable Sphero balls were bought and no longer used, despite the financial investment. Micro:bits had already suffered a similar fate. An early release of thousands of free units to school children had little real impact on teaching due to a lack of curriculum-related teaching and learning resources.

This was something the teacher was keen not to see repeated. Ensuring well-planned and well-resourced materials when adopting computing education technologies in the classroom became a clear theme for discussion. The importance of sustainability was such that new resources would need to consider the environment in which they were deployed, the confidence and understanding of the teacher involved in their delivery, and the clarity with which they were related to curricular requirements.

4.5.5. Constraints of a school environment: "It's awful to say but in the grand scheme of things they haven't got time" (Teacher1)

A particular theme of the constraints of working, teaching and collaborating in the school environment was evident from multiple sources of data collected throughout my work with Ivy during Case Study One. When considering a partnership between schools and universities, one must consider the *meso-factors* of performance measures, poor curricular cohesion, educational expenditure cuts, limited impact on policy development and neoliberal educational performativity on the school environment during the initial stages of a school-university partnership.

These constraints were evident in the hasty rearrangement of meetings. On one occasion, I arrived at school for the meeting and noted, ‘*Meeting got changed + nobody told me – not super impressed but seems to be communication problem -> lots of factors at play, with lots of participants’ (my field notes)*. I later found that the teacher I was meeting had been called in for a meeting with the headteacher. Still, at the time, I felt that my time was being wasted as I had arranged my own diary to travel to the school, taken a twenty-minute taxi ride and waited in the staff room for the teacher to appear.

At the school level, accountability for project outcomes was entirely down to the individual teachers participating in the partnership research project. In this case study, my key contacts were the head of the computing department and my partner teacher, despite the fact that SLT is better positioned to create, maintain and break relationships due to their capital within the school environment. During an informal discussion, I had expressed my surprise that I’d had no contact with SLT during my time on the project, despite being in the school twice a week and working on the part of the Education Challenge project. In response to my query, my partner teacher responded, ‘*They just don't have time for it though- it's awful to say, but they haven't got time in the grand scheme of things. I think, having a good relationship with the head of department (is just as important)’* (*Teacher1, Case Study One, Interview)*.

4.5.6. Locus of control: “I'd feel comfortable telling a student teacher 'this is where you're going wrong', but I wouldn't have felt comfortable saying that to you” (Teacher1)

A further theme that arose during the reflection period was the perceived control of university representatives in the early stages of a school-university partnership and how this influenced stakeholder relationships, researcher roles in the classroom environment, the expectation of outcomes and the handling of pupil behaviour in the classroom.

Returning to the concept of educational ecologies (Bronfenbrenner 1986; Hodgson and Spours 2013), it is important to consider how the indirect environment of the *exosystem* impacts upon the individual learner through the partnership – in this situation, the perception of the university and control they maintain in a given situation. The position of universities in the community is mired with challenges of academic capitalism, power and control (see Section 1.1.3), centred upon the perceptions of traditional positions of leadership in community engagements (Miller and Hafner 2008). While my research acknowledges these challenges in its design, ensuring there were opportunities for genuine collaborative development through discussion, feedback and re-design of research, this was still a challenge that arose from the analysis of data collection.

To address this, the collaborative elements of the partnership were introduced into the process. However, questions still remain about the role of power and position in these relationships. When asked how a teacher might respond to the emergence of such concerns as those listed above, the teacher responded, '*I'd feel comfortable telling a student teacher telling them 'this is where you're going wrong' but I wouldn't have felt comfortable saying that to you. I would have had to wait for you to spot it yourself'* (*Teacher1, Case Study One, Interview).* This meant that the initial stages of the partnership project were not always mutually directed, with deference falling to the university to avoid uncomfortable conversations in the face of perceived power hierarchies.

However, she noted that the use of the field note diaries for recording observations and the post-lesson chats these inspired meant that there was conscious space to engage in mutual feedback and redesign.

Furthermore, in the early stages of the partnership, the teacher notes that she was not sure what the project would entail nor how she was expected to work with an external representative from the university, despite research being designed to ensure this was communicated. While expectations and roles had been discussed between myself and the head of department, these had not been communicated to the teacher with whom I would actively be working within the classroom. This communication failure led to a mismatch of expectations, in which I was expecting equal contribution to the development and delivery of materials. She was told that '*somebody was going to come in, said that they were going to do project-based learning, this is how it will work in lessons, this is what you should expect, this is what could be done-*' (*Teacher1, Case Study One, Interview)*. During the first few sessions, this meant that delivery was a little awkward and stilted, and both the teacher and I were unsure where each of our roles began and ended with the teacher expecting '*someone from the university is gonna come in and they're gonna do everything'* (*Teacher1, Case Study One, Interview)*.

Harkening back to traditional forms of universities in schools, these early perceptions of the role of researchers in research meant that it was equally difficult for use to gauge our roles, despite early efforts in planning. However, in practice, we endeavoured to remain flexible in our roles to ensure that the pupils were receiving appropriate levels of instruction. We could also use these sessions to gain a deeper understanding of our roles in creating and delivering material in the classroom, ranging from the initial instruction of computing concepts and challenges to classroom behaviour and management.

This is exemplified by the changing nature of our roles in the classroom. In the early stages of the project, I took on the role of instructor and the teacher took the role of manager – stepping in to clarify concepts when I had been unable to explain them in a way understood by the pupils. Later observations demonstrate how this process became more fluid and natural over time – I gained an understanding of appropriate ways of dealing with minor classroom behavioural issues, and the teacher had gained exposure to the typical challenges encountered by pupils in their use of the micro:bit and associated peripherals. Where one of us encountered a challenge, we were able to step in and support the other through our established skills and knowledge, with an understanding of where these boundaries lay during classroom delivery.

4.5.7. Domain upskilling for teachers: "I thought I might pick some things up in the lesson, but didn't think I would end up as knowledgeable as I am" (Teacher1)

The theme of confidence in the teaching of computing, particularly how the project supported the development of teacher confidence, was another key element arising from data collection in Case Study One. Ivy's key goals from the project were to support their teachers in developing their text-based computing skills and confidence in deploying these skills in the classroom. Researcher-teacher partnerships can be critical to supporting computing education in the classroom, with particular potential in providing domain upskilling and confidence-building for classroom teachers (Schutz and Lee 2014; Lee, Ivy, and Stamps 2019; Plane et al. 2018; Brennan, Jimenez, and Peragine 2016). Computing teacher confidence was highlighted as one of the key areas for investigation in the 2017 Royal Society report, which encouraged this exploration of partnership working to improve computing education.

The partner teacher during Case Study One actively distanced herself from being a 'computer science teacher' and admitted that she lacked confidence in the early stages of participating in the project. When asked what she felt she might get out of participating in the project, she responded, *'I thought I might pick some things up in the lesson, but didn't think I would end up as knowledgeable as I am.'* (*Teacher1, Case Study One, Interview)*. She attributed this to several factors, such as the support provided by the developed resources and the provision of CPD.

At the end of the project, when asking the teacher how her confidence in the delivery of computing-related content had been impacted, she reported that despite still being hard as a subject, her perception of the subject had changed over time, saying '*I definitely feel more confident with it- and it's made me want to do computer science. I wasn't bothered about doing computer science before doing all this, but now I feel like I can do this'* (*Teacher1, Case Study One, Interview)* due to the exposure to the computing resources, with the support of a specialist in the room to address unpredictable challenges in the implementation of the concepts in practice by the pupils.

4.5.8. Continuous professional development: "At the end of the day we're educators so we have to learn either way" (Teacher1)

In addition to the support of teaching confidence, the Royal Society report also requested further opportunities for in situ continuous professional development for teachers linked to external partners in industry. This theme also arose in my own research, highlighting an important consideration in the early stages of creating a partnership – identifying areas of mutual professional development.

Regarding the development of teachers computing-specific knowledge, I delivered a 90-minute CPD session to 6 teachers from Ivy, including the teacher with whom I was currently partnered and teachers with whom I would later work during Case Study Two and Three. During this session, I noted the personal and professional difficulties that I felt during the delivery, '*Some teachers dismissive and reluctant… is it my age that's an issue? Do I feel like I have legitimacy in this setting? What are my qualifications for being there?'* (*my observational notes).* While I had a background in computing and could walk through the required text-based coding and micro:bit concepts, I felt unsure how useful this session was to teaching practices.

When discussing the impact of the provision of CPD with my first partnered teacher, they noted that they had required CPD hours that they needed meeting and were in specific need (‘*crying out’* (*Teacher1, Case Study One, Interview))* for subject-specific CPD. However, there would need to be consideration of the school’s approach to CPD. Other schools may not provide this level of support to their teachers to engage in external training provision and may be reluctant to give up their time outside of their directed hours.

A potential solution was that of asynchronous CPD – that teachers could undertake in the time suitable to them through online training delivery. Teachers could watch, take notes and undertake formative assessments to gauge their understanding. When asked if this was a suitable method of support, the teacher replied *‘at the end of the day we're educators so we have to learn either way’* (*Teacher1, Case Study One, Interview)* and noted that some teachers were able to go explore and *play* with concepts in their own time, teachers would also be likely to search for resources on reputable platforms, either related to the technology they were using or general teaching resource websites such as the Times Educational Supplement (TES). The importance of this online training would be to make it as easy as possible and link this to a related scheme of work that would outline the topics covered and the number of guided learning hours it might take to complete. When applying this notion to the replication of these resources, structure and associated training was noted to be important in supporting teacher confidence in implementing new teaching resources and methods. In allowing teachers to explore the newly developed content, they would be able to prepare a few lessons ahead of the content they were teaching to pupils and thereby feel more confident.

4.5.9. Connecting to the school community: “They also sang me happy birthday” (My observational notes)

During the initial stages of the partnership, I was inherently aware of the ‘us vs. them’ divide of being an external research partner working in the school environment. In the beginning, there were clear divides in the environment and how the teachers and I differently inhabited this environment. Safeguarding policies identified me as an outsider through my obvious VISITORS badge that I wore at all points during my visit to the school. In early visits, I was collected by the teachers from the visitors' waiting room and taken to the correct part of the school, feeling like I was being directed through a maze of hallways, stairs and classrooms. I was made tea and offered biscuits in the computing staff room while I perched on the chair of a currently-busy member of staff.

However, over time this began to change. Early in the process, I was organised to receive a staff badge which denoted me as a temporary member of staff, allowing me to walk to and from classrooms without supervision. Later, I learned how staff members took their teas and coffees and delivered them in-between period changeovers. I mentioned that it was my birthday that week and the next in-class session '*They also sang happy birthday and gave me chocolate. Made me feel part of the class, was embarrassing but also nice' (my observational notes)*. In preparing for this work, my literature review on boundary crossing and the challenges of working within a resource-scare, time-intensive educational environment, I was prepared to be the constant 'friendly outsider'. While I still felt the disconnect between myself and the environment, the people I worked with – pupils, teachers, and other staff members – welcomed me into their working and learning spaces as they grew more comfortable with my presence.

4.6. Case Study Two: Methodology

Case Study Two was conducted with two second set Year 8 classes and two members of the computing department from Ivy Community College, in the spring academic term.

4.6.1. Recruitment

In Case Study Two, I continued to work with Ivy Community College and was directed to work with the subsequent Year 8 classes timetabled to engage in the programming module. Class 3 consisted of 24 pupils (14 female and 10 male) taught by Teacher2, the current acting head of Ivy's computing and business department with five years of teaching experience. He self-reported as confident in his computing knowledge and often volunteered himself to engage in innovative teaching practices and training (e.g. he was a key participant in previous computing research conducted in his school, reported upon in (Venn-Wycherley and Kharrufa 2019)).

Class 4 comprised 27 pupils (11 female and 16 male) taught by Teacher3, a male teacher with two years of teaching experience, acting as a contracted maternity cover for one academic year. He had limited computing experience but self-reported as more confident delivering the business-related portions of the Key Stage 3 computing curriculum.

According to the assessment of ability metrics of the school, both Class 3 and 4 were considered to be pupils of above-average ability in computing, based upon previous achievements in Math, Science and the Humanities, and had one 50-minute lesson of computing per week. In addition, the teachers identified both of these classes as having poor classroom behaviour, although only subjective evidence from the teacher's experience was provided to reinforce this assertion. Both classes had been engaged in the business module in the previous school term. Teachers had perceived pupils to have found the module to be boring, which contributed to weak engagement and poor behaviour. Teachers believed that pupils were likely to continue exhibiting poor engagement and classroom behaviour moving forward into the spring term.

4.6.2. Approach

I continued my use of the instrumental, exploratory case study approach (Yin 2003; Lazar, Feng, and Hochheiser 2017), in which the main unit of analysis was the class, with the teacher, pupils and myself as the research partner. In line with an Action Research Approach (Hayes 2012), but aware that I would need to ensure the project could run without my direct support in every lesson, I began withdrawing my presence from the classroom environment to position myself more as a 'friendly outsider' than a 'teacher'.

4.6.3. Data collection and analysis

Data collection and analysis procedures were replicated from those used in Case Study One. Field notes would be kept to record observations by both myself and the teachers in the classroom, which would then serve as a basis for comparison later in the analysis and interpretation process. Semi-structured interviews with the partnered teacher would take place to understand their experience and perception of participating in the project, However, due to the disruption, this took place after the end of the Case Study period. Pupils continued to be encouraged to give feedback during the sessions through verbal conversations with the teacher, which were subsequently recorded in their field notes. In Case Study Two, no final survey occurred as the project was terminated early due to pupil behavioural issues and poor engagement. The end of the project arose from a joint decision between myself and Teacher2. Pupils returned to their original scheme of work for the remaining time, according to the prior agreement with the school.

However, a smaller focus group of 12 pupils from both classes took part in a focus group after the Case Study was terminated. They were asked to respond to similar questions they would have encountered on the survey, encouraging them to share their opinions and experiences participating in the study. The focus group was designed using De Bono's Six Thinking Hats (de Bono 2017) to provide structure to the line of questioning, as it is a technique that aims to scaffold lateral thinking in group settings. An example is demonstrated in Figure 10.

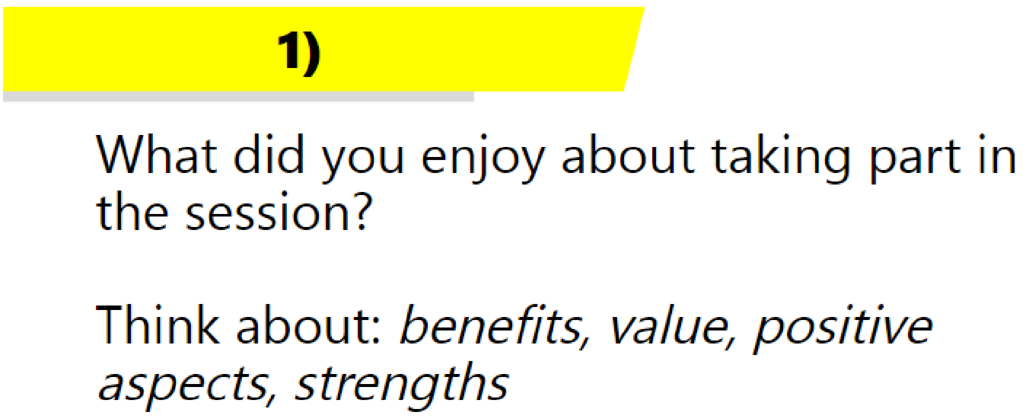


Figure 10. Example questions from the focus group slides using De Bono's Six Thinking Hats structure

During this focus group, I engaged the pupils with questions such as 'How did you feel participating in this project?' and 'If there were one thing you could change, what would it be and why?' Pupils would write down initial ideas on post-it notes to contribute their responses individually, and then we revisited these responses in a discussion as a group.

This focus group lasted 50 minutes and was audio recorded. The primary analysis method remained the same as that of Case Study One as inductive thematic analysis, with areas of importance arising from the data collection process.

4.6.4. Ethics

The following case studies were also approved by Newcastle University's Ethics Committee, with amendments to address key changes in classes and partner teachers. This also included introducing a pupil focus group as a replacement for the survey, as the only key changes were the classes and teachers with whom I would be working.

Pupils were provided with an information and consent form that contained the information about their role in the research project and how a parental figure could officially withdraw them from the research process. These forms can be found in Appendix A. Teachers who were participants in this round of the study were sent an information and consent sheet to sign and return. These can be found in Appendix A.

4.7. Case Study Two: Re-planning and delivery

Recruitment was not a necessary consideration in this particular case study, as the partnership was a continuation of an existing relationship. In the following sections, I provide an overview of the planning process undertaken to address the challenges of Case Study One.

The following section outlines the actions taken to re-plan and re-develop content for Case Study Two, in light of the findings from Case Study One, and changes that were necessary due to changes in circumstance for both school stakeholders and myself. In AR, once an initial action has taken place and is evaluated, these findings can be used to plan a subsequent iteration of research (Hayes 2012). The time devoted to this re-planning was considerably shorter than the first case study. It included the two-week Christmas holiday period, during which there was limited communication between myself and the partner teachers.

A key contrast between Case Study One and Case Study Two was that there was no organisation of a Visit Day to the university. While early informal talks with partner teachers explored the possibility, it was ultimately decided that behaviour during the autumn term had been particularly poor from Class 3 and 4 and that visiting the university would be too much of a challenge regarding behaviour management. During the early stages of Case Study Two, there were plans that classes would still visit the university to present their projects to researchers as a 'hook' to engage pupils in their learning. However, this final visit day never occurred as the case study was terminated due to poor behaviour.

4.7.1. Exploring pedagogical approaches to computing

Exploratory project-based learning had been the pedagogical approach underpinning Case Study One. However, pupils were unsure how to engage with the open learning process that Teacher1 and I had designed. Based on this finding, Teacher1 was keen to ensure that more structure was provided to scaffold pupil learning yet continue to promote pupil engagement with computing concepts through application to real-world challenges, with some element of exploration and reasoning behind their programming skills.

In re-planning for Case Study Two, Teacher2 said '*The original problem, the first time around [Case Study One] is that they weren't… we weren't managing enough of "what had they actually learned and taken away" apart from it, just being an experience and actually learning life skills' (Teacher2, Case Study Two, Interview).* In response to this perception, Teacher2 (in his role as Head of Computing) and I redesigned the pedagogical approach to focus on exploratory, creative and theoretical principles.

In exploring potential pedagogical models to support such an approach, I focused on the HCI Design Studio approach. It reports an improvement in active and engaged student learning with computing concepts (Reimer and Douglas 2003; Koutsabasis et al. 2018). As such, this fit in with the requirements of the larger Ford NGL project, with a focus on pupils responding to a central challenge commissioned by an external partner. The potential for improved engagement would also address Ivy's requirements of the project and address the challenges of structure from Case Study One.

However, the Design Studio approach adopted directly from HE lacks explicit *lecture* elements. Students are expected to structure their extra-curricular learning to support their theoretical understanding, which is not an expected skill for Year 8 pupils.

To address this, Teacher2 and I adopted the key milestones of a Design Studio approach throughout the term, and lessons were delivered to support pupil achievement of these milestones. These included a 1) design brief to outline a challenge for the pupils, 2) a desk 'crit' for teachers and pupils to respond to pupil-generated ideas, 3) a design review to allow researchers to give feedback on pupil responses to the challenge, followed by 4) a presentation and 5) portfolio for pupils to display the outcomes of their work. This would be structured through six weeks of more traditional learning in which the teachers would cover core computing content through short, guided exercises, with a further six weeks of exploratory, independent learning in which they could respond to the challenge. Furthermore, while not intentional, this begins to address Ofsted's call for the use of semantic wave pedagogy in computing across a programme of study Ofsted 2022).

While similar to the exploratory project-based learning approach from Case Study One, it focuses on a combination of theoretical and practical elements to structure pupil learning, with lectures and design activities scaffolding learners in the generation of a response to a given challenge.

However, this approach was not always successful, with some pupils struggling to engage with the early introductory sessions to programming. Of this, Teacher3 noted in our final interview that "*I think it took too long for them to get to the interesting stuff. I think there was too many weeks of doing the basics*," and that there needed to be an immediate hook by engaging with the '*cool stuff'* (pupil, focus group). This was highlighted as a key challenge when motivating the pupils on a topic with which they struggled to engage.

Key to the changes between Case Study One and Case Study Two was the project scope, which had been identified as a challenge to pupil engagement by my partner teacher and me. The wide challenge area of environmental improvement was challenging for pupils to respond to creatively, which frustrated them when attempting to respond to the central curricular challenge. However, the link to university research was considered key and supports the wider educational recommendation that computing education focuses on applying concepts in the real world (Royal Society 2017). Within the scope of a Design Studio pedagogical structure, there are two main approaches in their application (Reimer and Douglas

2003; Koutsabasis et al. 2018): 1) a domain-driven approach that presents pupils with a thematic domain within which they explore and structure their projects and 2) a project-driven approach, in which specific requirements and constraints provide the structure of response.

After discussion with the two new partner teachers for Case Study Two, we decided on a domain-driven project scope centred on assistive technologies for people with physical disabilities, which could be backed up through example projects and applications from Newcastle University. In discussion with Teacher2, we decided that exploring the moral impact of computing would be a potential vector of engagement for pupils while allowing for some freedom of creativity and expression missing from Case Study One.

Despite our best intentions, the scope of the challenge was met with some confusion by the pupils, as they had little concept of the idea of assistive technologies, both within able-bodied and disabled populations. There was also a tendency to overthink potential solutions (e.g. the development of cybernetics), which were unachievable in the time we had available in Term Two. In response to this confusion, Teacher2 and I introduced examples of technologies in use by disabled people through videos, activities, and challenges to encourage pupils in the creative investigation of these issues. However, while some of the pupils could respond, these were typically pupils who had some form of experience with disabilities (such as family members or friends). Pupils without previous experience tended to return to impractical solutions and struggled to respond to the challenge scope.

4.7.2. Lessons plans and materials

In response to this new, structured pedagogical approach, a need to meet internal school requirements and the novelty of the Education Challenge wearing off, the decision was made to use the typical Ivy's lesson plan template to organise lessons, provide targets and learning objectives, and provide mitigations for interruptions or poor understanding (see Figure 11, below). These would include lesson plan content for teachers, and an overview of related activities, thought-prompting activities and assessments to be hosted on Google Classroom.

What will I learn in this module?
In this unit you will develop a range of skills and knowledge in subjects that we offer at GCSE level in Year 9. This will include some topics that are covered in GCSE computing. You will be commissioned a challenge by computing researchers from Newcastle University, and learn about how they use technology in their research projects. You will work on developing a response to the challenge, and present your project back to the researchers.

How will I be assessed in this module?
You will be assessed three times in this module: • The first assessment will test your current knowledge of computing before you start your lessons, this is to see how much you already know and will be completed as a quiz online. • The second assessment will be through short quizzes around individual computing concepts • The final assessment will assess the knowledge and understanding of computing concepts, python programming and the BBC micro:bit you have gained over in this unit.

Home Learning	Careers
You will be set two pieces of home learning in this module: • The first piece of home learning will include developing and delivering a survey to two people around your project idea • The second piece will be to design and create supporting media for your project (poster/video/powerpoint)	There are a large number of careers in computing and computing research, including: • User Experience Designer • Human-Computer Interaction Researcher • Software Developer • Website Designer • App Developer Why not spend some time checking out some of these jobs to see if they are something you may be interested in working towards.
Independent Study	**Notes**
You need to earn **60 BitPoints** each term by completing Independent Study tasks and submitting these to Google Classroom. You can access the tasks by clicking here.	

Figure 11. An excerpt of the collaboratively developed Lesson Plan Overview document that detailed assessment, session content and links to further careers as required by Ivy's internal policies

The Education Challenge was the original impetus for Newcastle University's involvement with Ivy's Community College, in which the School of Computing would act as 'challenge commissioners' in a larger project between Ford NGL, Edge and the North East Local Enterprise Partnership. In Case Study One, there had been more involvement from these Education Challenge partners, but this interaction lessened as we moved into a second iteration. This may be because the focus was transferred to new initiatives in other schools in the North East, and our part to play was considered to be over. However, this also meant that my partner teachers and I were not tied down to meeting the targets of an external project, and we had more flexibility in how this was approached.

The decision was made to translate the tutorial element and the previous lesson slides into the Design Studio structure, using the lesson plan template. The draft would then be passed to Teacher2 for him to finalise, approve and use to generate the first three weeks of lesson materials for Case Study Two. After three weeks, Teacher2 and I would evaluate this new approach before creating the next set of lesson materials. The first six weeks of the curriculum would form the theoretical element, ensuring that pupils were equipped with an introductory knowledge to text-based programming and key computing concepts. The final six weeks would allow for a guided exploratory response to the brief before culminating in a visit to the university to demonstrate what they had produced.

I had sent materials to Teacher2 during Case Study One such that he could use them to develop the main learning materials for Case Study Two, which we would then review before the start of lessons in January (see Figure 12, below).

Let's design a helpful technology!

In today's lesson, we are going to create our own brand new technology to help people with physical or mental disabilities. We can use this as a way to think of ideas for your own projects too!

Starter: What are three different ways that computers and technology can help people with disabilities? Do some research online or think about your own experiences
1. 2. 3.

Figure 12. Example of a worksheet created by Teacher2

However, this work was a low priority compared to other elements of Teacher2's workload, such as preparing GCSE and A-Level students for mock exams in January. Meanwhile, I had been busy finishing Case Study One but spent the Christmas break reviewing materials and structure where possible. However, communication between Teacher2 and myself was stilted due to the holiday break. At the time of starting Case Study Two, there was a limited structure in place, meaning that elements of lesson materials were being created in advance of each session between Teacher2 and myself. Occasionally, a joint review of materials was forgotten until the day of the lesson and became '*rushed and displaced' (my observational notes)* when delivered in the classroom due to avoidable errors.

4.7.3. Assisting in the classroom

During Case Study One, I had been positioned as an equal leader in delivering the content. In Case Study Two, plans were made for me to be in a support role in the classroom. I would introduce the challenge from the university and attend every session, but the partner teachers would lead in the classroom delivery and behaviour management, and I would act in a support role where needed, both for pupils and teacher. This decision was made to provide more flexibility for the teachers who felt more confident in the delivery of materials, as well as identify areas of support in the transition to delivery of materials outside the partnership and allow for adaptability in the face of more behaviourally challenging classes.

However, this was also partly because my partnered Teacher2 was the Head of Department. In this role, it was clear that he was accustomed to a level of authority and leadership, unlike the mutual approach I had adopted with Teacher1. To ensure there was some level of comparison between the classes, I ensured that my role was consistent across both classrooms with both Teacher2 and Teacher3.

4.7.4. Integrating into the school environment

I was still added to the Classroom VLE, to be able to provide support through the platform, add or edit materials, and view pupil responses to the brief. Importantly, there were no plans to repeat CPD in this case study.

By the time of starting Case Study Two, I had been working with members of staff from Ivy through the planning and delivery of Case Study One. I had received my staff badge, spent many hours in the computing department staff room and knew most teachers by name and their preference of hot drinks (tea, instant coffee – black or with milk, the fancy instant coffee sachets kept on a specific desk). I felt like I was ‘fitting in’ to the school environment and assumed that most of the computing teachers knew my work and purpose in the department.

4.8. Case Study Two: Findings

Following the re-planning of this case study, informed by the findings of Case Study One, there was a need to evaluate the case study findings and plan appropriately for the final case study of the investigation. This process began in informal discussions with Teacher2 and Teacher3 during the delivery period, which formed the 60-minute semi-structured interviews at the end of the case study. While a pupil survey was not implemented in the case study, there was one focus group of 18 Year 8 pupils from both who contributed their experiences of participating in this project. From these discussions and subsequent thematic analysis of the interview, field notes and pupil feedback, the following themes have been identified for elaboration in the remit of maintaining existing school-university partnerships for computing education: collaborations and communication, constraints of time and space in schools, the impact of unexpected interruptions, working with young people, sharing outcomes and the challenge of diversifying to different schools.

4.8.1. Maintaining continuous collaboration and communication: "It was all through the grapevine rather than a direct introduction" (Teacher3)

A key finding from Case Study One was the importance of communication and how a researcher might best engage with school stakeholders to clarify their position. I felt, erroneously, that the department was well aware of my role in the school and that introducing myself would not be much of a challenge. However, I had not anticipated that the dynamics internal to the computing department would also affect this, which led to the developed theme of *continuous* collaboration and communication from my ongoing research.

Unlike Case Study One, where I had months of preparation time before starting classroom sessions with pupils, Case Study Two began just weeks later. Between finalising my data collection from the final visit day for the first two classes and the Christmas Holidays, I had minimal time to consider the reality of beginning a new iteration. I was familiar with Teacher2, as he was one of the key contacts for this research, and I had worked with him briefly in my Master's research project. I had yet to meet Teacher3 beyond some limited interactions over lunchtimes. He was quieter and tended to prepare materials during the social opportunities I had to meet other teachers between lessons. When asked what he had heard about the project before starting the first lesson, he replied:

> *Yeah, so… really the first thing I heard was just through what Teacher1 was teaching and the fact you were coming down and helping with the classes, and then obviously we had that training the session which was all I really heard about – it was all through the grapevine rather than a direct introduction through it. – Teacher3, Case Study Two, Interview*

Contributing to this perception was that my research goals would be made clear to participating teachers, and the fact that I would be taking more of an assistant role would require less disruption than my team teaching role in Case Study One.

This was not an issue for Teacher2, who was comfortable in his role as a computing teacher and my key contact for the project , and had been involved in the organisation and support of Case Study One from the schools' perspective. When asked about the start of the project, and how we had come to explore the university as a potential partner, he replied:

> *I was considering something else. I was going to do something completely different with Year 10 actually. The problem with [Tech company] was… they couldn't adapt to what we needed, so it was kind of a… "We'll take the kids for a day or a week." But what they're teaching them will be nothing useful to them in terms of the curriculum, so I kind of scrapped that and we were looking for something where we had someone to work closely with us and actually adapt to our curriculum. Uhm, which was where you came along which was very useful. – Teacher 2, Case Study Two, Interview*

Teacher2 felt that university were able to provide longer term engagement, adapt to the curricular needs of a school environment, and collaborate in a way that industry partners were unable to achieve.

However, as the key initial contact and the acting head of department, Teacher2 had been involved throughout, whereas Teacher3 was newer to the teaching profession and was on maternity cover, so was also new to the school. At the final reflective interview, when asked what Teacher3 felt about the university-school dynamic, he said that the early sessions were mired in uncertainty, as he had been wondering, *"Is there parts that you're going to teach? The more specialist stuff? Which parts will I teach? While you're teaching, I could be doing this or that. Understanding that if you're doing some delivering, what am I supposed to be doing?*" *(Teacher3, Case Study Two, Interview).*

During the final interview, when discussing how we might address this challenge in future iterations, Teacher3 made a series of suggestions that he believed would have helped him better prepare for the collaborative process: informal introductions, a point of contact, and discussion of boundaries.

The informal introductions were suggested to take place over lunchtime, where researchers could provide an overview of their background, planned research and contact details. The teachers could understand *why* a researcher was in their space, their goals, and the plans they would be undertaking to achieve these goals. Of particular importance to Teacher3 was the setting of boundaries, noting that this would help '*everyone know exactly what, where, when… where to stand (in the classroom when teaching), what's going on. It'd be a nice touch…. Instead of being like "Who's this stranger?*' *(Teacher3, Case Study Two, Interview*). I had been unaware that Teacher3 had not been more involved in internal discussions about the project, which led to challenges over the delivery of content in the classroom.

In my first observational note I recorded for Case Study Two, I wrote '*[Teacher3] Unsure of purpose of research initially -> worth having a chat w/ teachers as initial start of new project*' *(Case Study Two, my observational notes)*. Assuming that *continuing* a partnership did not require introductions like creating a partnership, I had unwittingly not provided introductions to myself and my research for my partner teachers, which led to a rocky transition into a second iteration.

In discussing the importance of developing working partnerships, and the importance of introductions to ascertain an individual's purpose in visiting the school environment, Teacher3 said '*As teachers, we are suspicious if there's another adult in the school that we don't recognise, like "why are you in my classroom" and I'd stop you and ask "who are you? What are you doing?"' (Teacher3, Case Study Two, Interview)*. This suspicion of an unidentified adult in a school environment is linked to child safeguarding measures. All visitors to the school must be identifiable (typically through the wearing of visitor lanyards) and accompanied by members of staff from the school. Teacher3 also contributed that this helps identify a friendly outsider from a critical outsider, noting that *'If we see you in the corridor, we can say hello to you and that. We'd know you were with us. You were going to be helping us out. As opposed to just some… OFSTED person.' (Teacher3, Case Study Two, Interview).*

Acknowledging this friendly vs critical dichotomy led to boundary setting discussions and the importance of introductory conversations in addressing challenges in delivering co-designed teaching materials. This need for boundaries was expressed through a request for traditional scheme of work '*Something to say, "this happens on* *week 1, this happens week 2" with some clear direction of where it's going week on week'* (*Teacher3, Case Study Two, Interview).* This would clarify the week's intention in advance and support his understanding of the delivery of the lesson materials in the classroom.

4.8.2. Constraints of time, space and resource in schools: "6 weeks is not really a lot of time to cover [content]" (Teacher2)

Expanding upon teacher-researcher dynamics in the classroom, one must also consider the impact of space and time on the learning environment. Space was an important factor in how lessons were run, with classrooms set up to accommodate as many desktops as possible for pupils to access (see Figure 13, overlead). Both Class 3 and Class 4 remained in the same classroom throughout and consisted of *'the luxury of three rows' (Teacher3, Case Study Two, Interview)* of PCs, with the teacher's desk and SMARTboard at the front of the room.

There were many challenges connected to these particular spaces. In my observations, I noted how the spaces between these columns were just enough to squeeze through to help pupils, and those sitting at the columns' furthest edges would struggle to read text on the SMARTboard at the front of the classroom and begin to lose interest. Pupils reinforced this in the focus group, who, when asked what they would change about the project if they had to do it again, replied *'bigger classrooms'* and that '*there wasn't enough time' (Pupils, Pupil focus group).*

As higher ability learners, Classes 3 and 4 only had one 50 minute lesson per week. Much like classes 1 and 2, the teachers and I struggled to balance the learning of theory and practice in computing, such that our sessions met the requirements of the National Curriculum and engaged pupils in something novel and creative. To offset this, I offered to run some lunchtime sessions for pupils to attend, at the request of pupils themselves. These were pupils who had been disengaged during the lessons, and therefore I offered a set of two lunchtime sessions – one for each class. However, my observational notes for this particular week demonstrated the poor engagement – '*Only the engaged pupils, who had already finished their work, showed up. They seemed to want to show they were keen, so I let them stay in the IT room and we chatted instead. Pupils who asked for these sessions didn't show up. Should I bother doing this again?' (my observational notes)*. The ability to support pupils with extra timetabled sessions was beyond my power and was decided at the school level (beyond even that of the computing department).

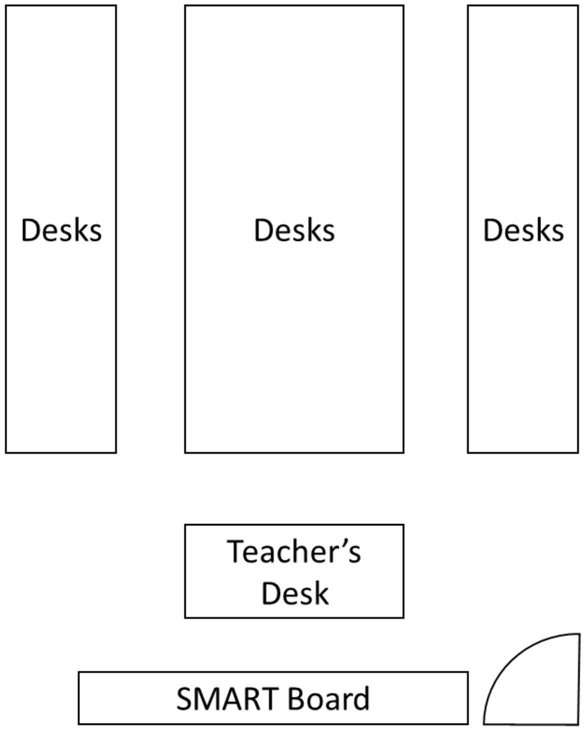


Figure 13. Example layout of one of the classrooms

As noted by the pupils, the constraints of delivering these sessions were not only physical, in the sense of space, but were also keenly felt in the time available to engage with pupils:

> *6 weeks is not really a lot of time to cover- it's only six 50 minute lessons, by the time you've done an introduction, you've got 40 mins six times… so actually, in 240 minutes… [sighs], 4 hours… they're not getting a lot out of it. – Teacher2, Case Study Two, Interview*

A further example of the constraints of the school environment was through the teacher's observational diaries. I had purchased a diary for each teacher from Paperchase (and one for myself) at approximately £5.50 each, as I'd wanted a sturdy notebook with pre-printed dates to be able to best cross-reference findings between the diary entries. When presenting one to Teacher2, he had asked if he could just take notes online instead – because '*It's expensive! It's PaperChase!'* (*Teacher2, Case Study Two, as noted in my observational notes)* and that he wanted to keep it clean and tidy rather than writing his entries inside. We agreed that he could make notes online but could still keep the diary if he wanted to take physical notes.

4.8.3. The impact of unexpected interruptions: "It was a weird time, there was no flow to lessons" (Teacher3)

A further challenge to the constraint of time available for face-to-face teaching was an ongoing school behavioural problem with the purposeful triggering of school fire alarms. In the fourth lesson, after 10 minutes, a fire alarm interrupted Class 3. After about ten minutes, we were free to return to the classroom but found we only had 20 minutes left to introduce a topic, work through an activity and pack up. Teacher2 made the executive decision to recap some materials from previous weeks and that the week's topic would be covered in the subsequent week. However, the fire alarms continued throughout the half term, causing continuous disruptions to the scheme of work we had planned. In conversation, the teachers had never experienced anything like it before. During one interview, Teacher3 said:

> *'It was a weird time, there was no flow to lessons because by the time you'd get them in, then the fire alarm would go off. That's ten minutes. You'd get them back in and they'd be all hyped up, and then you'd spend ten minutes settling them down and look up and realise "well there's 15 minutes left… what can we basically do in the next 15 minutes that's gonna get them- that's going to be worthwhile?" Because we missed ten minutes at the start, and then 10-15 minute gap, and then another ten minutes to get them settled, I've got 15 minutes left! I'm not gonna get through it, so it's like "Right, go back to what we're doing last lesson and recap it."' – Teacher3, Case Study Two, Interview*

Pupils began to demonstrate poor engagement. One of my observational notes from noted, '*Also tiring managing the classroom, some students really difficult and not paying attention' (original emphasis from observational notes).* This was also corroborated in Teacher2's interview, where he stated that he was unsure if the eventual termination of the case study was due to the disturbances of the fire alarms, to the point where pupil behaviour had meant "*we couldn't get through the content, or because they were talking over people" (Teacher2, Case Study Two, Interview).*

Teacher2 and I re-planned sessions to focus more on the Tinker Kits, noticing how disengaged pupils were more likely to pay attention in previous classes when using the peripheral kits. They requested a session on the sound element of the micro:bit, which had been planned but interrupted by a fire alarm. Teacher2 had asked me not to attend that particular week to see if '*taking away the researcher would have any impact on behaviour' (Teacher2, Case Study Two, email correspondence)*, believing that removing me from the classroom would be a punishment for the pupils. Teacher2 reported an improvement in behaviour, but our conversations made it clear he did not expect this to continue long-term, and I was invited to return for subsequent lessons.

The subsequent week, the lesson began, and within the first ten minutes, there were three temporary on/off fire alarms which left Teacher2 and pupils confused about how to proceed and led to high levels of disruption in the classroom. A handful of pupils engaged, but the rest were highly disruptive or not paying attention to instructions from Teacher2. In a brief discussion, the teacher highlighted that pupils had only four weeks to design and create projects, and there was little to show for their efforts. In this lesson, Teacher2 decided that the best decision would be to cancel the project.

In Class 4, Teacher3 had engaged a '3 strikes and you're out' approach to behaviour. In my observational notes, I had recorded how keenly aware he was not to exclude them from the project. He discussed with Teacher2 about splitting the class so they could continue to engage with the content, with me as a teacher. However, this would never came to fruition, and Class 4 would also be removed from the curriculum project a week later.

Through this experience, I lost confidence in my role within the classroom, writing '*[I] Worry that I'm not having an impact and it's causing unnecessary work for teachers -> is it trying to change things too drastically?... Even with a confident computing teacher, students disruptive and disengaged? How do you manage engagement?' (my observational notes).* Pupils returned to their normal scheme of work from previous years and continued to demonstrate poor engagement. In discussions with the teachers, they still wanted to go ahead and engage with the subsequent class of Year 8 pupils in the next term, as this behaviour had been expected of this particular group of pupils from the very beginning of the project.

While I never fully understood the root of the fire alarm problem, it was important to note the impact these interruptions had on the learning environment. These interruptions, and their consequences, illustrate the potential issues that can derail classroom-based projects and the precarious nature of school-based research.

4.8.4. Perceptions versus experience of young people: "You would expect top sets 1 and 2 to kind of… have behaviour right." (Teacher2)

Underlying these unexpected interruptions was the challenge of working with young people, emphasising the behaviour of the Year 8 pupils with whom I was working. Both teachers had already undertaken one term of teaching with their respective classes. They had expressed previous doubts about the potential classroom behaviour issues these classes may present during the study. These perceptions were reflected by the fact that there was no initial visit day to the university planned for Case Study Two by decision of the school, as pupil behaviour had been identified as being particularly poor for the two classes involved in the study. There were concerns about the viability of taking the pupils to the university environment and the disruption this would cause. Instead, it was planned that I would present the challenge in school as a representative of the university, introduce the assistive technologies that my research group worked with within the realm of health and social care, and provide support in pupils' early project brainstorming work.

However, Teacher3 lamented the lack of university visit available to the pupils. During the final lessons, leading up to the project's cancellation in this particular iteration, Teacher3 and I discussed the feelings of moral failure that we were presented with depriving Case Study Two pupils of an opportunity offered to their peers in Case Study One.

> *I think that's what I felt like as well, towards the end. It was a shame, that row there [gesture to classroom] missed out on something that wasn't their fault, for missing out on. They didn't get to do the fun thing at the end, because another portion of the class messed around. That's why I said to Teacher2 "I feel bad for those who tried." There was a portion of the class who wanted to do well, and wanted to try. They missed out because the other portion just didn't. – Teacher3, Case Study Two, Interview*

Particularly from Teacher3's perspective was the notion that there were pupils who were being punished for consistently trying hard, yet not being rewarded in a similar way to their peers. However, there was an underlying belief that it was just '*the unfair nature… of life and education' (Teacher3, Case Study Two, Interview)*. From my perspective, it felt like a failure in anticipatory planning had led to this moment. I broached this subject with Teacher3, saying *'It's one of those things that's sat really heavy on me, and I'm like "What do those kids think now?"' (Myself, Case Study Two, Interview).*

In an informal discussion of potential alternatives, the teachers and I first visited the idea of an end-of-year visit for those who had behaved well during the project. However, this was dismissed due to time constraints. The teachers and I then briefly proposed splitting classes into two, providing further support for differentiation in tasks and challenges for pupils were well engaged with their coding activities (see Figure 14, overleaf). Teacher3 noted during our final interview that these would be too intensive to ask of a teacher's workload.

Discussing this challenge with the final focus group, pupils asked if they could still go to the university because it was '*unfair that everybody else could go' (my observational notes, Case Study Two).* This included pupils who had not been particularly engaged in their lessons but felt disappointed that the opportunity was no longer available to them. Some pupils said they were glad because they were nervous about presenting their projects. However, this is similar to the sentiments expressed by pupils in Case Study One, who later reported that they enjoyed the process.

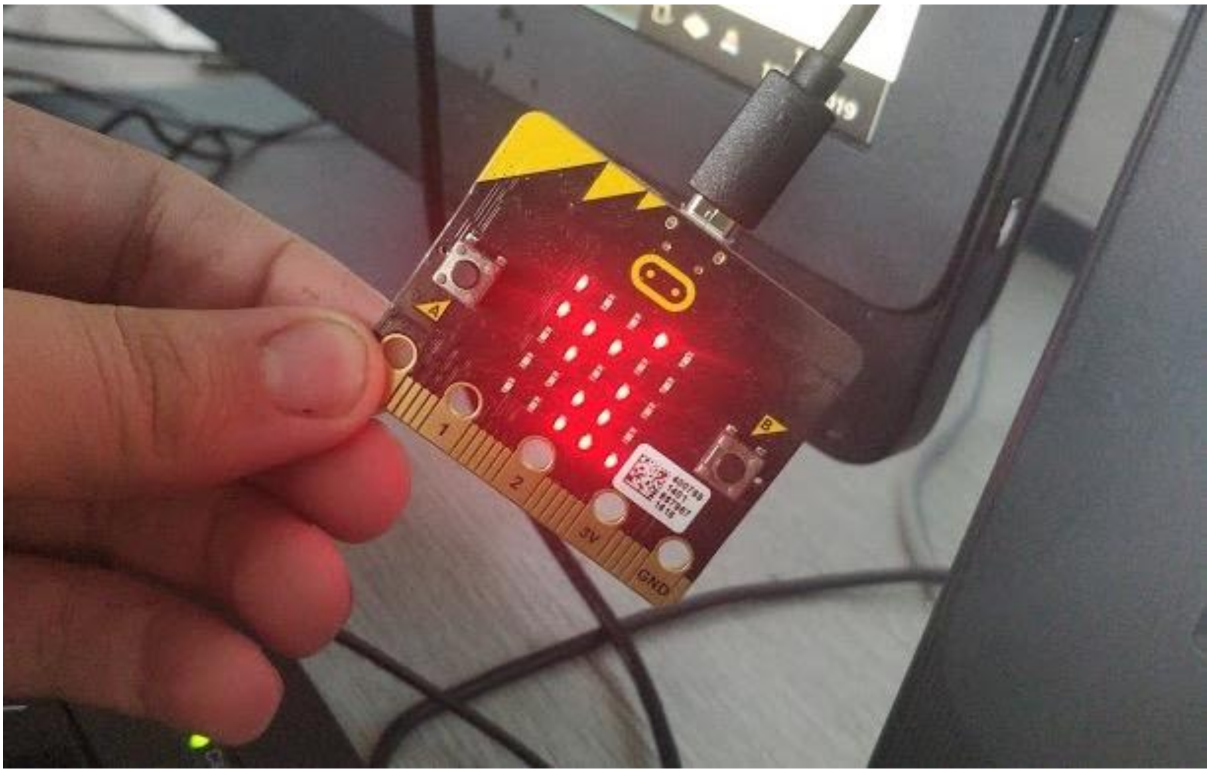


Figure 14. A pupil demonstrates their code on a micro:bit

During the sessions, ongoing verbal and physical disruptions from a small number of pupils led to class disruption, meaning that teaching was often interrupted and had to be repeated several times to complete activities. Teacher2 noted that the behaviour of this group was particularly challenging and wondered if the previous computing module they had worked through had been the root of these challenges, saying:

> *Maybe, if we done the micro:bit thing at the start of the year, when we were setting boundaries and expectations, they might have had more of a- but by that point I think I'd lost them a lot, particularly from our previous scheme that we'd done… Business and uh- yeah. It's a bit dry. I think I lost them a lot during that. –Teacher2, Case Study Two, Interview*

Teacher2 believed that the previous content, a module on business studies that involved creating design and marketing for a fictional travel company, had left pupils disengaged, with poor expectations of the subsequent computing module we had created for them. However, when talking to pupils in the focus group, one pupil said '*I thought it was going to be really boring to start with, but actually I really started to enjoy it…*' (*Pupil, Pupil Focus Group)* and expressed disappointment that the project was finished.

During the focus group, it became clear that pupils had enjoyed engaging with the micro:bits and were frustrated with the behaviour of their classmates, saying that they wanted to '*change how the class acts' (Pupil, Focus Group)* or:

> *I think that people ruined the subject because they were being very silly and very stupid and they weren't listening to any of the information so that made Megan and Teacher2 think that no one wanted to do the subject at all – Pupil, Pupil Focus Group*

However, some of the pupils in the focus group made it clear that they also found the experience to be boring. One particularly disengaged pupil, who had been notably disruptive throughout the experience, pointed out that computing was irrelevant and that Kim Kardashian would say computing is "*a waste of time*" (Pupil, focus group). This sparked a discussion amongst the pupils that this might not be the case, as she had a strong online presence and her own range of apps and digital games. Exploring this idea further in the pupil focus group, we began to discuss why they found the project boring and disengaging, which brought up a tangent about pupil perceptions of computing. Those pupils who found computing particularly *boring* were those who did not see themselves as the typical computing students and identified more with arts and humanities:

> *PUPIL_D: I want to make a website like Amazon?*
>
> *MEGAN: Really?*
>
> *PUPIL _D: Not really*
>
> *MEGAN: Not really. Well, what do you like in school?*
>
> *PUPIL _D: Art, but that's not a computer thing.*
>
> *MEGAN: I was wondering about that. Well, what about designing the project? You could design a website like Amazon. We call it User Experience and how we design things to make people feel and how they use it. Think about apps, some of them are boring and some are pretty. Instagram is kinda a nice one.*
>
> *PUPIL _D: Oh*
>
> - *Excerpt from pupil focus group, Case Study Two*

This demonstrates the disconnect between pupil perceptions of computing, self-identification and the possibilities of using computing and digital technologies when considering classroom engagement and behaviour.

Homework was also an area of contention. While, according to Teacher3 in our final interview, the school did not have a strict homework policy, pupils were limited in their engagement with the reflective quizzes created by myself and Teacher2. When asked about this, Teacher2 responded, '*It wasn't that they wouldn't do it, but because we made it… it was ten questions and I thought it wouldn't be… I thought they could do it really quick, they could have done it on their phones with Google forms. It wasn't a big ask, but… the results were nothing out of the ordinary*' (*Teacher2, Case Study Two, Interview).* This engagement was also reflected in my own observational notes when Teacher2 decided to re-visit the homework as a starter activity, that it was '*very rushed, and the average was 2/16'*. However, some automatic marking gave incorrect marks for opinion-based responses.

When asked to reflect on the course of this particular iteration and its subsequent cancellation, both teachers expressed disappointment that we had to stop the classes before reaching the end but acknowledged that they were both challenging classes. Concerning this class, Teacher2 said, "*It was a challenging group of kids, behaviour was a challenge and… particularly for a second set group of kids, where you would expect top sets 1 and 2 to kind of… have behaviour right. Whereas the difference in behaviour from set 1 to set 2 was massive.*" *(Teacher2, Case Study Two, Interview).* As mentioned in previous chapters, the top sets were chosen to smooth the way of the project, but in reaching Set 2 pupils, we were confronted with a more challenging teaching environment.

Teacher3 explained that '*Year 8s in all schools, especially in this one, are notorious for behaviour and attention and engagement' (Teacher3, Case Study Two, Interview)* and did not believe this behaviour to be out of the ordinary. However, the perception of Year 8s was not always congruent with the experience of the pupils themselves and led to broad assumptions being made about behaviour and engagement with the project.

4.8.5. Researcher expectations and personal impact: 'Disappointing end to a lot of hard work' (My observational notes)

The early cancellation of the project was particularly hard on a personal level. My later pupil surveys were interrupted, and the clarity of my role in the subsequent weeks was muddied, leaving me feeling both stressed and tired. I sent in my end of term surveys that I had conducted in Case Study One. However, teachers forgot to work through them with the classes, meaning I could not get a wider range of pupil perspectives on their experiences (although a later focus group was organised to address this issue). My last observational note of Case Study Two was '*Disappointing end to a lot of hard work! ☹' (My observational notes, Case Study Two).* The disappointment came from multiple angles: the worry of what this meant to my research, the dissatisfaction of having to terminate a project to which I had contributed considerable time and effort, and the feeling that I had a negative impact on my partner school. During the focus group, I shared with the pupils how I felt disappointed that we were unable to complete the project or visit the university and used this as a springboard to discuss how we could make it more interesting:

> *MEGAN: Right, emotions! Write down what you felt about the project!*
>
> *PUPIL_C: Who wrote disappointing?*
>
> *MEGAN: Me, I was disappointed that it didn't work out-*
>
> *PUPIL _C: oh, right. Why?*
>
> *MEGAN: I spent lots of time, I wanted to make it fun and it just didn't seem to work. So I'm disappointed it didn't work out*
>
> *PUPIL _D: Do you not think it's boring, teaching kids?*
>
> *MEGAN: No, I love it! I chose to do this*
>
> *PUPIL _H: -that's probably why you were disappointed.*
>
> *…*
>
> *PUPIL _D: She must be so angry at us.*
>
> *MEGAN: Who? Me?*
>
> *PUPIL _D: Yeah*
>
> *MEGAN: [laughs] No, not at all. If you didn't feel like you learned something… [pauses] So experiments, you want to try out if something is true or false right? Like a hypothesis in science, have you done that yet?*
>
> *PUPIL _D: Yeah*
>
> *MEGAN: Well, my idea was that if we do this [gesture to the table – meaning the project] you will enjoy it. Some people did and some people didn't. Now I want-*
>
> *PUPIL _C: And it never happened*

MEGAN: -to know why it happened.

- *Excerpt from pupil focus group, Case Study Two*

From the point of the discussion, I observed that pupils became more open with their opinions and were willing to express how they felt about participating in the project through more constructive comments and contributions. They discussed what had bored them and what might be done to improve their engagement – with visit days and classroom visitors being popular suggestions amongst the group. Through the admission of personal and emotional vulnerability, I engaged pupils in a more constructive conversation about their experiences and perceptions of the project.

4.8.6. Digital approaches to supporting computing education: "It would take less time, and you could have a bigger window" (Teacher3)

While no specific CPD sessions were provided during Case Study Two, this was still a topic that arose several times through the final interview session with both teachers, particularly how CPD could be delivered in a *different time, different place* paradigm (Schmidt and Bannon 1992; Ackerman 2000), rather than the synchronous, geographically co-located sessions of CPD.

Of this more traditional approach to CPD, Teacher3 said that the typical experience fell short of requirements, reporting his experience as '*[You get told] "Right, on Monday you're staying back for two hours." And you forget it all! Because, on that night you learn about how to do- what a- what a micro:bit is, the functionality, and you learn everything in two hours. Then you walk away thinking "I forgot half of that." (Teacher3, Case Study Two, Interview)*. When asked to expand on this, Teacher3 outlined how the restriction of time and resources meant it was difficult to arrange departmental CPD.

Instead, an 'as-and-when' approach might fit better into the busy teaching schedule, '*You'd be given a micro:bit and Tinker Kit and some tutorials- some video tutorials. Then you can do that in your own time… Or… when you've got a free, or over a lunchtime. You could spend 20 minutes, half an hour having a bit of a play around, know what I mean? It would take less time, and you could have a bigger window.' (Teacher3, Case Study Two, Interview)*. In this asynchronous, geographically separated approach to supporting the development of computing teachers, communication and collaboration-based technologies can convey information without the need for immediate consumption, such as online training platforms like Udemy or Coursera.

Teacher2 felt that one of the key successes of the partnership was the CPD elements, saying "*I think our staff found the CPD session you did really helpful, I think I wish that we could have got more of them in actually, but then I think the staff you've been alongside teaching has really helped them has really boosted them as well.*" He felt that the in-person elements of the partnership could support teacher's practical knowledge. However, when discussing the role of technology felt that traditional teaching materials that would guide teachers through the elements would be most useful, particularly for non-specialists.

A particular challenge highlighted by the Royal Society Report (2017) was the need to share research outcomes supporting computing education. When asking partnered teachers how they might engage with research, they noted the time and effort required to engage with academic outputs, with Teacher2 saying, *'A big issue is the time. Academic papers… You can spend an hour and a half, know what I mean? I haven't got an hour and a half. I've got ten minutes. So there needs to be more… user-friendly approaches*' (*Teacher2, Case Study Two Interview*). Teacher3 reported during our final interview that he was more likely to pick up research outcomes from blogs, podcasts and video platforms, particularly if he was going to address certain problems or challenges encountered in teaching computing.

4.8.7. *Different school, different approach: "If you're working with ten different schools, you'll need to know their ten different ways of doing things*" *(Teacher3)*

Underpinning this case study was the understanding that while the teachers and I were slowly iterating upon a scheme of work that applied to this particular school environment, different schools would have different approaches to how they designed and delivered materials, learning objectives and homework. Teacher3, having done his teacher training with another local school approximately three miles away, noted the challenge of this by saying:

> *SchoolA hated objectives, they thought it was an absolute waste of time to say "Today we're going to be learning XYZ" because they should understand that as they're going through the lesson. SchoolB wanted clear objectives and*

they needed to keep referring back to the objectives… Every school has a different way of doing things, so if you're going to be working with ten different schools… you'll need to know their ten different ways of doing things. Some schools will demand objectives and some schools will say "absolutely no objectives." – Teacher3, Case Study Two, Interview

From an ecological perspective, the schools within the region must act within the bounding frameworks outlined by government educational policies (or else uses these policies to structure their own approach to educational provision), which drive the behaviours of schools regarding such elements as learning objectives, homework and learning materials. While the implementation of these policies differs between individual schools, the different approach of each school draws the question back to that of transferability of school-university partnership processes for computing education, particularly regarding the creation of curricular materials.

The common unifying factor is the National Curriculum for Computing and its outline of recommended skills for Key Stage 3 pupils. While not all schools are required to follow the National Curriculum (e.g. independent schools or academies), there is a tendency to follow these curricular recommendations as these are the skills assessed by examination boards. Therefore, despite institutional differences, there is an underlying structure in curricular content that is important to address.

4.9. Discussion

Throughout these first two case studies, I aim to begin the identification of the opportunities, barriers and challenges for universities and schools to create and maintain meaningful educational partnerships for computing education. The framing of an educational ecology can provide the descriptive and analytical terminology to visualise the complex interplay of people, materials and relationships within an environment. Through this framing, we can begin to understand how to best configure partnerships between schools and universities to support computing education. In response to the findings highlighted above, presenting the initial exploration into the experiences of stakeholders involved in school-university partnerships, I contribute considerations for other researchers who wish to engage in meaningful, mutual relationships with school partners for the benefit of computing education. These points for discussion include exploring Hora's (2011) notion of 3rd

space, power dynamics in early partnership relationships, and the digital pathways and roadblocks in creating and maintaining school-university partnerships.

4.9.1. Finding the 3rd space

The dimensional approach to educational ecologies considers several factors, including bounding frameworks, relationships, culture, pedagogy, space and access to resource, and technology. It is important to consider the interplay of a complex and multi-dimensional ecological system of education and how this impacts the negotiation of varying needs, interests, and aims of educational partnerships, also known as the *3rd Space* (Hora 2011). Brokership is proposed as a method to navigate this 3rd space, in which individuals acts as intermediaries when navigating logistical, cultural and communicative boundaries between universities and schools (Leat and Thomas 2018a; Malin and Brown 2018; Gu 2016). This can promote cultural, structural and logistical compromise, addressing mutual trust and respect in school-university collaborations (Mclaughlin and Black-Hawkins 2007).

However, there is little guidance on how brokers *find* this 3rd space, consider the values of those involved, or successfully navigate the bounding frameworks within which actors must work (Akkerman and Bakker 2011).

Within a school culture, a supportive environment which values experimentation, new ideas, and wider interactions around teaching and learning is important – and is not a rare occurrence, with neoliberal educational performativity advocating a need for teachers to engage in constant improvement in results produced (Ball 2016; Connell 2013). However, researchers must use this opportunity to gain a more nuanced understanding of the school environment and the domain influences that impact this space of learning. In doing so, they can begin to work towards the negotiation and reconciliation of two highly different education-based environments.

Recommendation: Researchers engaged in educational partnerships may not always appreciate the culture of the schools with whom they work. The school-university partnership processes must acknowledge the required acclimatisation for both a researcher and their partnered school. This space allows for the negotiation of disconnects between the two communities to arrive at the *3rd space*, in which professional relationships can begin to form independently of institutional boundaries.

4.9.2. Power and relationships in developing partnerships

The traditional perspective of universities conducting research in the community, in the role of producers of knowledge for consumption of the general populace, can cause partnerships to suffer from issues of perceived social hierarchy between partners (Davidson 2017; Slaughter and Rhoades 2009). There is a need to build educational partnership processes that encourage clarifying expectations, varied perspectives, and mutual respect of strengths and expertise in collaborative engagements between schools and universities (Radinsky et al. 2001). Therefore, I explore the opportunity of designing for mutual respect when developing a school-university partnership process.

In the early design of this case study, I designed opportunities for critical reflection upon the work we were conducting. This aimed to provide space for my partner teacher to direct the project such that we could achieve mutual aims with particular consideration of our capacity, flexibility and access to administrative support (Pollock et al. 2017; The Royal Society 2017). However, despite these intentions, through early discussions of the project, there was early reticence for my partner teacher to provide this formative critique. Working collaboratively helped us understand the boundaries of what could be said and done, yet further exploration of designing for mutual respect is an opportunity to develop school-university partnerships. Not only was this vital to the development of the partnership itself, but also formative in critical reflection of my power and positionality as a researcher, looking to challenge my underlying values and actions when undertaking partnership work with a defined community.

Recommendation: Schools may be wary of working with academics and Higher Education institutions due to the transactional approach typically undertaken in community-engagement research. Keeping a research diary and using this to record personal observations, thoughts, and feelings towards the research process in which you are engaged provides opportunities to engage in discussion and re-design of the research process itself. This is not an immediate solution to the challenge of mutual respect but is more valuable in an iterative, long-term approach to the development and sustainability of educational purposes, allowing for the adaption of the partnership process.

4.9.3. Digital pathways and roadblocks in the creation of partnerships

Throughout the case studies comprising my research was the undercurrent and *underuse* of digital technologies in the infrastructuring of the initial partnership process. This is particularly evident from discussions held throughout Case Study One and Case Study Two centred around the provision of subject-specific CPD by external computing specialists and the challenges centred on digital policies in schools.

To begin elaboration on the theme of digital infrastructuring, I will first introduce the challenges experienced by the teachers regarding computing CPD. While no specific CPD sessions were provided during Case Study Two, this was still a topic that arose several times through the final interview session with both teachers. This typically centred on how CPD could be delivered in a *different time, different place* paradigm (Schmidt and Bannon 1992), rather than the synchronous, geographically co-located sessions of traditional CPD.

Of the more traditional approach to CPD, Teacher3 said that the typical experience fell short of requirements, reporting his experience as '*[You get told] "Right, on Monday you're staying back for two hours." And you forget it all! Because, on that night you learn about how to do- what a- what a micro:bit is, the functionality, and you learn everything in two hours. Then you walk away thinking "I forgot half of that." (Teacher3, interview)*. When asked to expand on this, Teacher3 went on to outline how the restriction of time and resources meant it was difficult to arrange departmental CPD. Instead, an 'as-and-when' approach might fit better into the busy teaching schedule, '*You'd be given a micro:bit and Tinker Kit and some tutorials- some video tutorials. Then you can do that in your own time… Or… when you've got a free, or over a lunchtime. You could spend 20 minutes, half an hour having a bit of a play around, know what I mean? It would take less time, and you could have a bigger window.' (Teacher3, Interview)*. In this asynchronous, geographically separated approach to supporting the development of computing teachers, communication and collaboration-based technologies can convey information without the need for immediate consumption, such as online training platforms like Udemy or Coursera.

A particular challenge highlighted by the Royal Society Report (Royal Society 2017) was the need to share research outcomes in support of computing education. When asking partnered teachers how they might engage with research, they noted the time and effort required to engage with academic outputs, with Teacher2 saying *'A big issue is the time. Academic papers… You can spend an hour and a half, know what I mean? I haven't got an hour and a half. I've got ten minutes. So there needs to be more… user-friendly approaches*' (*Teacher2, Interview*). Teacher3 reported during our final interview that he was more likely to pick up research outcomes from blogs, podcasts and video platforms, particularly if he was looking to address certain problems or challenges encountered in the course of teaching computing.

In educational ecologies, technology is an important consideration in the infrastructuring of space and relationships (Nardi and O'Day 1999), allowing for the development of ideas, knowledge and practice (Clayton 2016). Each school has their own particular technological infrastructure, with a particular choice of virtual learning environment, firewalls and restricted access to its internal WiFi networks. This security typically stems from safeguarding requirements to limit potential threats to the wellbeing of pupils. However, this also impacts the dissemination and use of resources, with unexpected results.

Due to Ivy's position within their Learning Trust, the creation, collaborative development, and dissemination of teaching and learning materials related to the project were conducted entirely through the Google suite. While I was aware of this from early in the process, I had not entirely considered the challenges of these technologies, which adopted the '*different time, different place'* approach to communication.

Before the project, I was invited to be a shared user of a folder accessible to Ivy's department, in which I could place and organise resources for easy viewing by teachers and with no access to sensitive pupil information. I would be able to work on resources in my own time, at my desk at the university, without needing to be physically co-located with the teachers. However, when starting lessons, there were challenges in ensuring the resources, tutorials and assessments were correctly uploaded. These would have to be passed through the partner teacher as I had no access to the Google Classroom VLE.

I wrote ‘difficult to get access to documents -> am I allowed access?’ in my early observational notes. This lack of certainty led to confusion about how these resources were shared and what structure they should be uploaded to ensure pupil access. It also relied on the teacher to conduct extra unnecessary work in transferring unfamiliar files to her Classroom layout. This was made to be even more challenging because access to Microsoft 365 products was not permitted on the school WiFi, which is incidentally Newcastle University’s choice of platform for online storage. In my field notes, I noted that there were certain times in which I would need to transfer files from my academic online storage to the teacher and had to use my personal phone’s data to hotspot the transfer to get around these limitations.

In our final interviews, the teachers and I discussed how the setup of the technological environment in schools, including Classroom, added to the confusion in some lessons, with Teacher1 stating, *‘To be fair, you didn't know about Classroom- Then you realised how that would work- Half the time I still don't know how that works (laughs)’*. To address this, I was then provided with a school staff login, such that I could access the VLE, share resources and contribute to the sharing of materials alongside the teacher.

Chapter 5. Ending and Legacy of a School-University Partnership

5.1. Introduction

In Chapter 4, I identified opportunities, barriers, and challenges associated with creating and maintaining an early school-university partnership for computing education. The purpose of Chapter 5 is to continue to address Research Aim A to identify opportunities, barriers, and challenges for school-university partnerships for computing education. In particular, Chapter 5 contributes to the exploration of the ending and legacy of the school-university partnership process and the lived experiences of those actively involved in such a process, including the re-negotiation of roles in an evolving process, the challenge of resource constraints in the school environment, and the importance of recognising the power and expectations in school-university partnerships centred on computing education.

In this chapter, I also explore the legacy of the partnership, examining how the process during and following school-university partnerships for computing education can support teachers, improve curricular content and develop pedagogy in compulsory computing education in the UK. The legacy approach focuses on exploring how schools that do not directly engage in educational partnerships with universities can still be positioned to make use of their findings.

I begin this chapter with an overview of the methodological design of Case Study Three, which is then followed by an outline of the planning, delivery and findings in response to the findings of Case Study One and Two in Chapter 4. I then detail my findings of ending a school-university partnership for computing education, with relevance to Research Aim A.

I follow this section with the methodological design of Case Study Four, which is then followed by an outline of the study's planning, delivery, and findings. This chapter then concludes with a synthesised findings section, pulling insights from both of these legacy case studies towards a better understanding of how universities and schools can best work in partnership to explore curricular design and delivery for compulsory computing at a wider scale.

5.2. Case Study Three Methodology

Case Study Three was conducted over 12 weeks, with two third set Year 8 classes and one computing teacher from Ivy Community College, during the summer term.

5.2.1. Recruitment

In Case Study Three, Class 5 comprised 21 pupils (10 female and 11 male) and Class 6 comprised 22 pupils (11 female and 12 male), both of whom were taught by Teacher4 who had over 15 years of experience in business and computing. She was also only contracted for the academic year to cover the maternity leave of another member of staff from Ivy's computing department. The ability metrics of the school classified her two classes to be below-average ability classes compared to their year group. Therefore, both classes had *two* timetabled 50-minute computing lessons per week during the term.

5.2.2. Approach

In line with both Case Study One and Case Study Two, I continued my use of the instrumental, exploratory case study approach (Yin 2003; Lazar, Feng, and Hochheiser 2017), with the main unit of analysis being the class, with the teacher, pupils and myself as the research partner. I positioned myself completely as the "friendly outsider" to the classes but worked continuously with Teacher4.

5.2.3. Data collection and analysis

Data collection and analysis procedures were replicated from those used in Case Study One and Two but relied more heavily on Teacher4 to take field notes as I was no longer consistently present in the classroom. These would then be used as the basis for the semi-structured interviews to understand their experience and perception of participating in the project. Pupils continued to be encouraged to give feedback during the sessions through verbal conversations with the teacher and me in my role as "friendly outsider", which were subsequently recorded in field notes. A final celebratory event took place at the end of Case Study Three. The primary analysis method remained the same as that of Case Study One as inductive thematic analysis, with areas of importance noted from the data collection process.

5.2.4. Ethics

The following case studies were also approved by Newcastle University's Ethics Committee with amendments to address key changes in classes and partner teachers. As with the previous case studies, pupils were provided with an information and consent form that contained the information about their role in the research project and how a parental figure could approve their participation and the process to officially withdraw them from the research process at any point. Teacher4, as a participant, was sent an information and consent sheet to sign and return. These forms can be found for reference in Appendix A.

5.3. Case Study Three: Re-planning and delivery

The following case study directly continued the overall partnership process with Ivy, building upon the existing relationships from Case Study One and Two. The subsequent sections outline the re-planning undertaken in light of the challenges highlighted in previous Case Study Two, the delivery of this final case study, and the process of reflecting on the growth and sustainability of a partnership in its final active iteration.

The significant changes between Case Study Two and Case Study Three involved a more structured approach to the teaching and learning process. This included a scoped-project challenge with a specific programming outcome, positioning myself as the 'friendly outsider' to pupils to provide intermittent feedback and support and discussing how to finalise the ending of the partnership for the given academic year. These topics are discussed in the following subsections: structuring teaching and learning, pupil behaviour and engagement, my role as a visitor, outputs for dissemination and the end of a partnership.

5.3.1. Structuring teaching and learning

Unlike Case Study Two, I made plans to formally meet Teacher4 and work through the findings of both Case Study One and Two to discuss and plan our mitigations. The Design Studio pedagogical structure permits for two key approaches in their application (Reimer and Douglas 2003; Koutsabasis et al. 2018): 1) a domain-driven approach which presents pupils with a thematic domain within which they explore and structure their projects and 2) a project-driven approach, in which specific requirements and constraints provide the structure of the response.

Case Study Two had adopted a domain-driven approach, in which pupils were given a thematic area within which to respond, which led to confusion and frustration for pupils and was difficult for teachers to support due to the variations in code bases. Teacher4 and I decided that the subsequent iteration of the Design Studio approach would need a more structured scheme of work to support pupil learning, a similar underlying codebase to support teacher delivery in the class, and an allowance for pupil personalisation and creativity. Therefore, the teachers and I adopted a project-driven approach in which pupils would be assigned a structured design brief with specific requirements and constraints to structure their projects. This approach would help to address the challenge of constrained time and resources in lessons and provide a more traditional pathway for learning for pupils to improve engagement whilst still allowing pupils to create projects within the framing of their everyday realities.

This contributed to a reimagining of the project's central challenge by creating Digital Voting Posters, based upon the PosterVote project undertaken in Open Lab (Vlachokyriakos et al. 2014), to engage pupils in discussions about the possibility of group-enacted social change in the school community. Known as 'Micro:Vote ', pupils would pick a topic they wanted to improve in the school and create posters that encouraged others to vote on potential responses to the chosen challenge (see Figure 15 for the teacher PowerPoint that introduced this concept in lesson)

The micro:bits would be programmed to record responses and provide a synopsis of the voting results. Each pupil-created voting system would have the same base code to achieve a voting counter on the micro:bit, which would be built upon in each lesson, while the ultimate topic and visual design of the poster would be the pupils' decision. The teachers and I encouraged pupils to build upon this base code as a stretch goal – e.g. turning on lights when a specific number of total votes was reached.

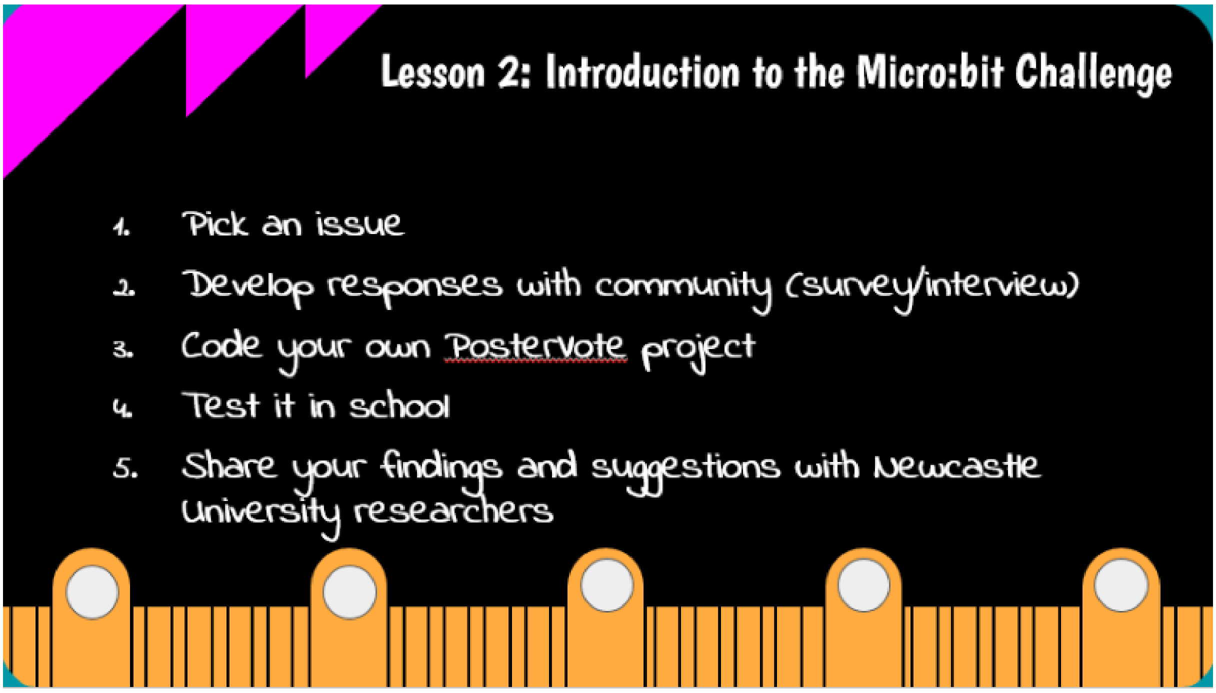


Figure 15. The powerpoint developed to provide an overview of the project to pupils

In Case Study Three, pupils in Class 5 and 6 had two 50-minute lessons per week. Therefore, the new scheme of work was structured to teach pupils the practical elements of creating the digital voting system across 20 lessons (10 weeks). Some lessons were “non-critical” to allow for delays or disruptions. The last four lessons would be devoted to pupils finishing and personalizing their posters and voting systems, ready to present to stakeholders from the university. This scheme of work is outlined overleaf, in Table 1, with the critical path lessons highlighted in yellow.

Lesson
Lesson 1 - Baseline testing and micro:bit research
Lesson 2 - Introduction to micro:bit - create name badges Notes: Students need to download the code after each modification made and reload it onto the micro:bit Task 2a is an extension task and can be further extended by adding additional images and text to continue to stretch.
Lesson 2a - Create custom images
Lesson 3 - Introduce the project, generate ideas If students complete the Ideation Square before the rest of the class they could start to sketch out ideas for the poster that will be used for the Micro:Vote . Now they know what question they are going to ask they will have an idea of what to include. NOTE, the poster will work with the micro:bit to make a multiple choice question where participants can vote for one of the choices.

Table 1. An excerpt of the outline of planned lesson structure, including the 'critical path'

The students would record classwork in an individual digital portfolio known as the “Researcher’s Workbook” to address the lack of guided discovery in Case Study One and Two. This was based on the approach of the business studies module that Class 5 and 6 had just finished (the same module attributed for the disengagement of Class 3 and Class 4 in Case Study Two). However, Teacher4 reasoned that the structure of the workbooks, and the fact that they acted as digital repositories, would help pupils continuously develop and iterate upon their project ideas and computing knowledge. A “Researcher’s Handbook” would act as an informative document to which pupils could refer if they wanted further information or guidance on the topics they had covered in class but were not obligatory. An example of the Researcher's Workbook is overleaf, in Figure 16.

Counting button presses

Recording the different button presses on the Tinker Kit voting buttons.

Download the "recap.py" file from classroom and load it on python.microbit.org. This example does not current work – can you identify :
Five bugs that stop the code from working
1. 2. 3. 4. 5.
Three different data types
1. 2. 3.
The differences between a variable and a constant

Figure 16. An example activity held in the Researcher's Workbook, it would act as a repository of code and learning that students could return to when developing their Micro:Vote systems

Design reviews were planned three weeks before project hand-in. They would be conducted by two or three Newcastle University researchers, who would visit the classes to provide feedback on their projects and interact with the pupils.

This scheme of work would culminate in a university showcase for pupils to demonstrate their projects and portfolio materials to the wider School of Computing, similar to the event held for Class 1 and Class 2 in Case Study One.

5.3.2. Pupil behaviour and engagement

When discussing the inclusion of a visit day, Teacher4 and I reviewed the challenging behaviour that had led to the termination of Case Study Two and what this meant for our subsequent partnership. Teacher4 was positive about her classes and their overall engagement, although she mentioned that some girls would be more challenging to engage with as they were less likely to care about computing, saying, '*They're more interested in fake tan and eyelashes' (my observational notes)*. While the potential challenge of pupil behaviour and lack of engagement might impact an individual student's attendance of the final visit day to the university, preventing their attendance would only be in cases of extreme behaviour issues.

5.3.3. My role as visitor

To address the misconception from Case Study Two that I was "*just another boring teacher*", Teacher4 and I agreed that I would only attend sessions where an expert presence was justified in the Design Studio approach (e.g. introducing the challenge, evaluation) and delivery of lessons would be the responsibility of Teacher4. Additionally, I would no longer wear my school staff badge and instead wear a bright green visitors badge to be marked as an "outsider" to the pupils.

5.3.4. Outputs for dissemination

During our re-planning chat, Teacher4 noted that she would not be employed by the school at the point of the visit day, as the teacher for whom she had been covering maternity would have returned in the final weeks of the term. Teacher4 was more than happy to attend the event regardless, as she said it was unlikely that she would get another job over the summer holidays.

A challenge of academic research was its lack of applicable materials for the teaching and learning context. This began a discussion of how the university might support a fixed-term role for Teacher4 to support the development of dissemination materials from the research project. There would be room to develop the curriculum materials teachers and I had created to share with the wider secondary computing education community. A further benefit would be to have teacher input on writing an academic research paper to contribute to the small number of school-driven research papers on the UK computing context (Waite 2017). At the end of the project, Teacher4 joined Newcastle University as a visiting member of staff for a period of one calendar month, as we worked collaboratively to create learning materials that teachers could utilise in their own classroom environments, such that this work had an outcome that would be accessible and meaningful for computing education professionals.

5.3.5. The end of a partnership

Case Study Three would be the final case study of the Ivy Community College partnership. Teacher2, who was maternity cover for the head of the department, was relegated back to his position as a normal member of staff. Eventually, he left this position for a promotion to head of a computing department at another school. Both Teacher3 and Teacher4 finished their maternity cover contracts at the end of the academic year. Teacher3 left the teaching profession at the end of the academic year, and Teacher4 moved to another local secondary school for a more permanent position. Only Teacher1 remained a permanent member of staff at Ivy Community College by the subsequent academic year. This also coincided with the ending of the Ford NGL project, which had been the perceived purpose of the project within the school's senior management.

5.4. Case Study Three: Findings

The following section outlines the findings of implementing this partnership approach to computing curriculum development, with a particular understanding that this would be the last iteration undertaken with Ivy Community College. The 'visitor' role meant that my classroom observations were much more limited than in previous case studies. However, Teacher4 and I would often communicate via email or WhatsApp on the progress of the pupils, which served as the basis of the final interview at the end of the study, in which we discussed the experience of collaboratively developing a computing curriculum, exploring the impact of roles, challenges and barriers. Pupils from both classes participated in a 50-minute class-based focus group during the last session of the term to share their project experiences and suggestions for improvement (the interview schedule with the full range of questions can be found in Appendix C). Much like the focus group in Case Study Two, this iteration of the pupil focus group was designed using De Bono's Six Thinking Hats (de Bono 2017) to scaffold lateral thinking in the group setting. During this focus group, I engaged the pupils with questions such as 'How did you feel participating in this project?', 'What did you most enjoy?' and 'If there were one thing you could change, what would it be and why?'. However, due to the larger groups in this focus group, pupils were provided with personal sheets to record their initial responses. We then finished with an open discussion amongst the pupils.

All data collected underwent a process of inductive thematic analysis. The following themes have been identified for further exploration within the scope of the experiences of maintaining school-university partnerships for computing education: creativity in diversifying a failing curriculum, engaging with expertise, the constraints on communication, the confidence of pupils, the importance of flexible schemes of work, the process in partnership, whom to work with, and ending a partnership.

5.4.1. Creativity in diversifying a failing curriculum: "They could colour, enjoy and make pretty" (Teacher4)

The Royal Society report noted a need to diversify and modernise a failing computing curriculum to improve pupil engagement in the topic (The Royal Society 2017). The following theme explores the impact of employing a partnership approach on developing a computing curriculum, with a stronger focus on application and creativity in computing concepts.

From the perspective of designing new curricular approaches to compulsory computing in secondary schools in the UK, across both Case Study Two and Case Study Three, the teachers and I had been exploring the viability of the Design Studio approach as a pedagogical structuring of a creative approach to computing education. In Case Study One, the exploratory nature of the curriculum that Teacher1 and I had co-designed would have made this a difficult venture without constant support from an external partner. However, in moving towards this more structured approach, with a design brief, desk crit, design review, presentation (see Figure 17, overleaf) and portfolio, both the teacher and I observed an improvement in pupil behaviour across the course of the module. This was corroborated by the drop in the number of 'behaviour codes' (official records of poor behaviour) assigned to pupils in the summer term. Class 5 had a collective of 20 behaviour codes in the autumn and spring term, which dropped to only one in the summer term. Class 6 had 39 behaviour codes in autumn and spring and received only five in the summer term.

Additionally, during this final reflective interview on our project experiences, Teacher4 recounted an event that had particularly surprised her, centred on a group of three female pupils who initially had been reluctant to engage with the project and computing overall. Similarly, the pupils in Case Study Two did not see themselves as 'computing students' and were more interested in dance, art, and media. However, towards the end of the project, these three pupils were working on the creative elements of their poster systems at lunchtimes and after school.

Figure 17. Pupils demonstrate their poster creations during the visit day

Of this event, Teacher4 noted how the creative focus of the project had allowed for this engagement from pupils who might not traditionally engage in computing, saying, *"if [the project] had just been code without something they could colour, enjoy and make pretty, I don't think they would have been as engaged*." *(Teacher4, Case Study Three, Interview).* This was particularly relevant for pupils who found computing to be dry and disinteresting, and potentially address the challenge that typical computing pupils are highlighted to be *"academically strong, mathematically able… and overwhelmingly likely to be male*" (Berry and Kemp 2017a), drawing criticism that the subject is not accessible for young people from disadvantaged backgrounds who are most at risk from social-digital exclusion (Robinson et al. 2015; The Royal Society 2017; Matheson 2017; Berry and Kemp 2017b). When asked how the creative elements had engaged the young people, Teacher4 responded that '*projects like this make it [computing] interesting and make it real, it's a hook' (Teacher4, Case Study Three*, *Interview)*.

When talking to these pupils about their experience in participating in the project, they reported that creating the poster and other creative materials meant they had to go back and try to understand the computing concepts they had used. This finding begins to suggest how creativity might be better positioned in the broader computing curriculum to engage reluctant pupils in their computing studies.

5.4.2. Engaging with expertise: "The fact you came in, made it more real" (Teacher4)

A further recommendation of the Royal Society report was a need to focus on collaboration opportunities between computing experts and teachers and that external parties should *spend time in the classroom context* with little clarification of what this means in practice. In earlier case studies, I positioned myself as a teacher or teaching support, yet in this case study, I had more distance from the pupils and was more strongly positioned as an outsider.

In exploring this theme, I outline the impact of embracing my position as an external party to the school environment and what this meant for both pupils and teachers.

From earlier findings, I noted an improvement in pupil engagement with computing. However, this was not to say that there was no bad behaviour when I visited the classroom as a visitor. Class 5 had a double lesson, in which they had two 50-minute lessons back-to-back in the afternoon. On this particular day, fellow researchers were invited to the second lesson to provide feedback on pupil projects. I had been in school to support a different lesson unrelated to the project, so I joined the class early to help them prepare.

That afternoon, behaviour was particularly challenging with pupils throwing objects and shouting in the classroom and pupils from another class coming in uninvited to interrupt. They were distracted and disengaged and did not listen to instructions from Teacher4. We briefly considered cancelling the researcher visit but deemed it to be too late in the organising process. While I went down to the visitor reception to collect my colleagues, Teacher4 expressed her disappointment in the class and how they were potentially going to present themselves to visitors (*teacher observational notes)*.

By the time I arrived with my university colleagues, the pupils were polite and engaged with the researchers. There was no trace of the previous behaviour I had seen, and as we were leaving the school, Teacher4 caught up with us to share that the first thing the pupils had asked after we had left, which was if they had '*pulled it back*' with their improved behaviour for the rest of the lesson. In our final interview, Teacher4 noted that: *"[The pupils] did care. They really did care. But they wouldn't show anybody, because that's not cool" (Teacher4, Case Study Three, Interview).*

During the final interview, Teacher4 and I discussed the university's pupil-facing role in school-university partnerships as external visitors and challenge commissioners. Of our involvement, the teacher said that the involvement made the project '*more real'* and that "*the kids really respected having an expert who came in to help... I think, having you there made a massive difference to how seriously the kids took* it." Pupils also reported that they would have preferred "*even more researchers*" (*Pupils, Case Study Three, my observational notes*) in the classroom to assist with their projects if it were possible.

However, despite these benefits, Teacher4 acknowledged that scaling such an approach would be difficult and that visiting and engaging every school would be impossible with a limited number of university researchers. When discussing this challenge with Teacher4, we mentioned that '*ten schools would be two solid weeks [of visits]' (Interview)*, which would be unfeasible levels of engagement for university researchers on top of existing responsibilities.

A potential suggestion to respond to the challenge of scalability was to adapt the 'letter to Santa' approach, in which the final assessment for pupils would be to write a report to the university to receive feedback on their work, to '*make it real for them, if they get a response' (Teacher4 Case Study Three, Interview).* Pupils suggested a similar idea in the focus group. One pupil suggested that 'the best school should go to the university and other schools should send letters to Megan', and Teacher4 suggested that there was potential for the letters to be sent by email. However, this would need to be discussed with participating teachers in each school to understand the external communication restrictions of the institution. Typically, pupil emails are restricted to the school, with only teachers and staff able to message external addresses. Teacher4 noted that other teachers may not be inclined to pass on the pupil messages but would depend on the individual teacher and their assigned workload. Instead, there was potential for video resources to replace the need for some researcher visits reducing workload.

5.4.3. Constraints on communication: "Schools are busy… you get in your classroom and you teach your kids" (Teacher4)

One of the early challenges of Case Study One was the locus of control, in which Teacher1 initially felt uncomfortable contributing or correcting me in my role as a researcher in the classroom. However, this improved over time to develop into a mutual working partnership. In Case Study Two, I had assumed this partnership would carry into the second iteration and was mistaken, leading to early challenges in the design and delivery of lesson content. In approaching Case Study Three with this new understanding and developing content, and outlining roles before lessons began, I hoped to address these challenges and ensure mutual communication.

The position of Teacher4 as maternity cover also meant that there were early challenges when beginning the planning of the newest iteration of the project, saying, *'I didn't know if you'd been coming in for years or whether it was a new thing. You were just there, you make a cuppa and I was like "This is great!" and that was it! For new staff, it's different because you just don't know if it's a regular thing or not. You could have done it for the last five years, and I would never know,' (Teacher4, Case Study Three, Interview)*. This was a similar position to Teacher2, and a challenge identified by Pollock et al. (2017). Learning from the mistakes from Case Study Two, I ensured we had at least one planning and preparation session to discuss the outline of the project, with multiple informal touchpoints through email and WhatsApp. When asked about how this influenced the partnership, Teacher4 responded, '*You were a fabulous support all the way through, you really were. Not just in the class, I could contact you about anything that I wasn't sure about and bounce things off you as well*' (*Teacher4, Case Study Three, Interview).*

However, the teachers and I still encountered challenges when working together despite best intentions. This a need to provide a detailed overview of what had already been achieved in Case Study One and Case Study Two, with Teacher4 raising this in our final interview: *'I thought the other teachers had done the poster project too… It wasn't a fault of yours. Schools are busy and you get in your* *classroom and you teach your kids. You know there's other things going on, but you just… don't take a lot of notice.' (Teacher4, Case Study Three, Interview)*. Despite dedicating time to engaging with Teacher4 and outlining roles and responsibilities in more detail, there was limited time before the beginning of the term. While my schedule was more flexible, Teacher4 had to work on the bases of planning, preparation and assessment lessons within her teaching schedule, meaning that time limitations restricted the mutual communication in the early stages of the new teacher-researcher partnership.

5.4.4. Confidence of pupils: "I learned to never give up" (Pupil)

Similarly to the pupils in the previous case studies, pupils were nervous about attending the university and meeting researchers. When discussing this in the final interview, Teacher4 highlighted it was possible that some pupils had never even been to Newcastle City Centre before (a trip of approximately seven miles), and fewer would have had any interaction with the university, making the visit a daunting prospect. Despite this, during the final focus group after the visit day, one pupil reported enjoying being '*trusted to go off on their own and work'* to prepare for the main exhibition and that this level of trust helped them to feel more confident in the work they produced. Pupils also noted that in attending the visit day, they '*felt like [their] confidence was boosted by explaining what [they'd] learned' (Pupil, Case Study Three, Focus Group)* and that they "*could actually talk about what computers do*" *(Pupil, Case Study Three, Focus Group)* when presenting their work to attending university researchers during the exhibition element of the visit day.

In particular, one thing that both Teacher4 and I noted was pupil surprise when university staff were unaware of the micro:bit and that they had a better understanding of the devices. Teacher4 related this to their lack of comparison to the wider digital world *'they're experts, and they don't understand that they're experts. It's a big thing for them.' (Teacher4, Case Study Three, Interview)*. She felt this provided pupils with confidence in presenting their work during the visit day.

When the teachers and I discussed the potential for such a difference between the classes in Case Study Two and Three, Teacher4 commented that Classes 5 and 6 '*would give [programming] a shot in a way that the previous group didn't*' as these classes were used to iterating upon code in the face of challenge and failure to get things right the first time. This perspective was further evidenced by one group of students during the desk crit who had 140+ versions of their final code, as they wanted to experiment and personalise their project in response to feedback from peers, family, teachers and visiting researchers. When asked directly about their experiences on the project during the focus group, pupils reported that the project '*stretched my mind and made me think'* and they *"learned to never give up*" when they encountered programming-related problems.

Furthermore, the improvement in behaviour was corroborated by a surprised Teacher2, who also attended the visit day as a chaperone, remarking upon the confidence and professional behaviour of Classes 5 and 6 in preparing their stand and presenting their work during the visit day event.

5.4.5. The importance of flexible schemes of work: 'I spent too long on making sure they had the right question… then they changed the question' (Teacher4)

The new approach to the design of the curriculum, with a structured yet personalizable voting-based project, led to an observed increase in engagement, allowing pupils to explore personal interests within the scope of 'improving the school environment'. This was demonstrated further by a group of pupils in Class 5, who were initially disengaged and disinterested in computing, creating a poster voting system to promote access to the school dance studio by allowing pupils to vote for their preferred day of use so that the school could provide supervision. This was a personal challenge for these pupils, who wanted more time to practice dance routines but found that the dance studio was only supervised in very rare circumstances. In Class 6, a group created a poster for voting on the reorganisation of the lunch queues in the cafeteria, as they explained it could often take 20 minutes to purchase food and that they sometimes got food just in time to return to class and were unable to eat. In linking the computing project to personal interests and motivators, pupils became more engaged in the concepts to achieve some kind of resolution to their experienced problems.

However, some pupils struggled to reach an engaging topic within the scope of 'school improvement'. To support the development of their response, I introduced HCI ideation techniques in the classroom, such as Ideation Squares. However, a lot of time was spent trying to support pupils to develop their topics, saying *'[Idea* *generation] a transferable skill for them… but I think I spent too long on making sure they had the right question… then they changed the question halfway through anyway, because they had one they didn't like. So I think… we focused a lot on that with the expense of other things' (Teacher4, Interview)*, resulting in extra lessons dedicated to developing a topic with which pupils were happy.

In response, Teacher4 suggested that the topic for the poster could be completely open, allowing pupils to engage further, saying *'[even if] it was something like 'who do you think will get relegated this season?' [in football] and they had five teams that they could choose from... Just, any multiple-choice question would do the same thing*." The Design Studio structure would allow for such flexibility while retaining the supportive structure of a logically similar code base through voting systems.

When working through the delivery of teaching materials, only the critical path lessons were completed. While this was slower than expected during the planning phase, it demonstrated flexibility not previously experienced in Case Study One or Case Study Two. Implementing a critical path meant that Teacher3 was able to extend lessons where pupils were engaged or repeat certain topics if engagement had been poor in a particular session. Tutorials developed for Case Study One were then used as extension activities for pupils who finished their tasks early.

5.4.6. Process in partnership: 'I didn't realise different groups had done different things' (Teacher4)

During our re-planning chat, before the beginning of lessons for Case Study Three, Teacher4 and I discussed roles and responsibilities in the upcoming curriculum to ensure that there was a level of clarity and understanding that had not been achieved in the previous iterations in the classroom. The final interview demonstrated the value of such a meeting in the partnership process, particularly when conducting iterative work with a partner school. As Teacher4 noted, *'initially I misunderstood your role and thought you were delivering it, and I was supporting you in delivering it' (Teacher4, Case Study Three , Interview).* Teacher4 had heard about the project from other teachers who had participated and had been present during the informal departmental staff room conversations but was unaware of the changes between each iteration:

> *To be honest, I didn't know a great deal. I knew who you were and you were doing something with micro:bits. But I didn't know- I didn't realise that the different groups had done different things, I thought that… I said something to another teacher and they didn't know what I was talking about, and I thought they'd done [the voting project] too. I don't know what I thought, because I knew you were there but I didn't really fully appreciate what it was that you were doing. – Teacher4, Case Study Three, Interview*

In ensuring process milestones, such as the preplanning meeting, we could better negotiate and outline roles before starting the classroom-based lessons. With an initial understanding, these could then be proactively changed as required, rather than the reactive nature of Case Study Two.

5.4.7. Whom to work with: 'Year 8 aren't a high priority in any school' (Teacher4)

In discussion with Teacher4, it became evident that Key Stage 3 pupils were not focused on curriculum development and engagement compared to older pupils who were subject to external examinations. When probing this further, she replied, '*unless you've got a teacher that's really interested, but even then… Year 8 aren't a high priority in any school, because you've got GCSE and A-Level, then you've got "the rest"' (Teacher4, Case Study Three, Interview).* This ties back to the UK's accountability-driven nature of neoliberal education structures, where league table achievements are key to school success. This implication means that computing curricula for Key Stage 3 pupils can be seen as less important. Therefore less attention is paid to the development of engaging content for those pupils who may initially struggle to engage with theory-heavy learning. This also ties back to the constraint of exam boards, which dictate what content must be learned at Key Stage 3, 4 and 5, driving the development of curricula and the subsequent engagement of pupils. When asking about her experiences with the current computing curriculum, the teacher highlighted the pressure of exam boards, saying:

> *The problem is with schools, that the exam boards don't know that... they're so prescriptive in what they've got. They have things to cover and they do pay a little bit of lip service to HCI and things like that… but it doesn't engage the kids. So much theory… Just insane amounts of theory, but that- you'll never need again potentially. – Teacher4, Case Study Three, Interview*

This has ongoing repercussions for how schools teach computing at Key Stage 3, with computing expert teachers typically assigned to GCSE and A-level classes to focus on delivering computing concepts, theory and practice for examination purposes. Teacher4 reported that schools often avoid teaching text-based programming in Key Stage 3, as schools do not have the staff or expertise to address text-based programming for younger pupils. When engaging in partnerships to support computing education, researchers must consider these factors and how external influences such as educational policy and accountability structures can influence the school population and interventions highlighted as partnership activities.

5.4.8. Ending a partnership and the exploration of legacy: 'She's got micro:bits and she's quite happy to try' (Teacher4)

Much like the creation of a partnership, there comes a time when a partnership must end. This ending of a partnership can stem from various reasons: achieving a given aim, a finite amount of resources, changing circumstances or irreconcilable differences between partners. In the case of this particular partnership, it had been underpinned by a larger regional focus on the development of career-based learning in school curricula through wider ecological partnerships between academy trusts, local industry and national educational charities. While achieving separate aims to that of the Ford NGL curricular work, my own partnership with Ivy was also inextricably tied to its lifecycle within the framing of the school environment. Once the project ended, wider support for engagement with the university would also be assumed to end.

I felt there was a possibility to continue engagement with the school beyond the scope of the Ford NGL work, even if this required further iterations. However, the final interview with Teacher2 conducted part of the way through Case Study Three demonstrated larger plans for the Key Stage 3 curriculum.

> *At the moment the plan is that we'll have a running theme throughout the entire two years of Key Stage 3. Where the students work for a gaming studio, but then when they do topics there'll be three topics a year but it'll be like a different department of the business, so like they'll design a website, look at hardware and software, do creative unit where they'll create a games cover… They'll create a game in Zork in Year 7. Year 8 they'll do the business-y side and they'll look at marketing, staffing and recruitment… then data representation, don't know how it'll slot it to the business idea… finally with micro:bits, I think the intention is to create some sort of thing for the business.*

> *Whether we go down the route of voting or uhm…. I'm not sure yet, but definitely micro:bits. - Teacher2,* Case Study Two, *Interview*

While the work the teachers and I had achieved *may* be relevant, there were plans to create a Key Stage 3 computing curriculum that focused on a wider computing perspective, integrating the programming concepts within a holistic framing of business and computing through project-based learning. There would be space for the materials we had created, but not the 'university-as-commissioner' element that had been integral to the case studies throughout. The partnership elements no longer appeared to be necessary to Ivy.

However, this ended up being a more tumultuous experience due to rapid changes in staffing at the end of the academic year, with staff returning from maternity leave – many of these were teachers I had never met, including the returning head of the computing department. Suddenly, relationships that I had been building across the year were no longer meaningful to the school, and communication lapsed in the subsequent academic year of 2019-2020.

Despite this, the Ivy partnership led to an exploration of the outcomes of this project with a further school known to Teacher4. When discussing the potential for future teacher engagement, Teacher4 recommended that we jointly get in touch with Elm Church, where she had worked previously and had good personal and professional connections with the head of the computing department *'I have got a teacher who would try anything that we do with [this curriculum project]. She's got micro:bits and she's quite happy to try- I'll speak to her, but you could definitely get in touch…They'd be happy to do any testing, and try out some resources'* (Teacher4, *Case Study Three* , *Interview*). This suggestion was the prelude to Case Study Four and the exploration of the legacy of partnership projects and their outcomes with Elm Church and Jasmine Gorge.

5.5. Case Study Four: Methodology

Following the end of the Ivy Case Studies, Case Study Four was planned to explore the partnership process and use the developed materials during the spring term of 2020.

Case Study Four was run in collaboration with two schools. The first was Jasmine Grange School a mixed secondary school close to Newcastle City Centre. As of

2020, almost two thousand students were enrolled, with a quarter of these students being identified as eligible for free school meals. The second was Elm Church Secondary School, part of a Church of England Trust through-school based in Northumberland, with an enrolment of over 900 students with 37% identified as being at risk of socio-economic deprivation, based in an area with a strong history of mining industry and subsequent social deprivation. Following a series of critical Ofsted inspections, each school unit within the through-school was separated into 'standalone' schools with their own governance. In this case study, work was undertaken with the secondary school element of the through-school.

However, due to the impact of Covid-19, Case Study Four was terminated at week 8 following the closure of schools and uncertainty regarding home schooling in the early days of the pandemic.

5.5.1. Recruitment

Jasmine Grange was recruited through my previous associations with a member of the Senior Leadership Team with whom I had worked closely during my Master's research project. Following the culmination of my Master's project, I had limited contact with the school as they were undergoing serious restructuring regarding their place in a local education trust. I felt like my contribution to a potentially 'risky' curriculum development would be unwelcome in its trial stages. However, following the work with Ivy, the curriculum was in a more stable state, and I contacted the school with the offer to make use of the resources and training we had created. It was decided that this project would run with their Year 8 classes and include 3-4 teachers. From previous experience, Jasmine Grange staff had a wide range of computing abilities, yet coding initiatives were undertaken mainly in practice by the more confident computing teachers.

Jasmine Grange already had class sets of micro:bits that they used sporadically through the academic year with their Key Stage 3 pupils. Their teachers were more technically confident that other schools with whom I had previously worked.

Elm Church was recruited through Teacher4 of Case Study Three, who had previously worked at Elm Church before moving to Ivy. She had a strong relationship with the Head of Computing at Elm Church and offered to connect us to discuss exploring the re-use of the Micro:Vote resources with their Year 9 classes and 3-4 teachers. While there had been poor Ofsted inspection results, the Head of Computing identified gaps in their delivery of compulsory computing at Key Stage 3. She was particularly interested in how the curriculum resources could support the confidence of non-technical teaching staff in the delivery of programming.

Elm Church had a class set of micro:bits, but these were rarely used. Teachers reported that they tended to be used once or twice towards the end of the year, outside of the scope of curriculum-aligned lessons. Elm Church had also done some previous work with Newcastle University in previous years but found that the researchers had done a short series of lessons and data collection but had never contacted the school once they had left. Teachers were unaware of any work had been published or used based on their interactions and had found that the lessons themselves had only been loosely tied to the curriculum.

5.5.2. Approach

While I continued using the instrumental, exploratory case study approach (Yin 2003; Lazar, Feng, and Hochheiser 2017), this was much lighter than in my previous case studies. Unlike my work with Ivy, I did not have a pupil-facing role. I acted in a support capacity by delivering early training to participating teachers and providing guidance or clarification via email when needed.

The plans for both schools were to invite me as a special guest for students to present their work, gain feedback, and participate in a focus group session on their experiences. However, the interruption of Covid-19 meant that this did not happen.

5.5.3. Data collection and analysis

Data collection and analysis procedures were replicated from earlier case studies, but again, with a much lighter approach. I would keep my own field notes to record observations of my interactions, and teachers were encouraged to keep their own notes for discussion during the semi-structured interviews held at the end of the project. A replication of the focus group in Case Study Three was planned, but ultimately, I could not run this investigation element due to Covid-19.

Each school proposed one teacher participate in an online semi-structured interview lasting 60 minutes, a decision motivated by the challenges of early pandemic organisation and childcare responsibilities. The primary method of analysis remained the same as that of Case Study One, involving inductive thematic analysis, with areas of importance noted from the data collection process. Due to audio issues, the Elm Church interview was only partially transcribed.

5.5.4. Ethics

The following case studies were also approved by Newcastle University's Ethics Committee with amendments to address key changes in schools and partner teachers and the change in focus of some teacher interview questions, which were focused on the differing dynamics of the legacy university-school relationships.

5.6. Case Study Four: Planning and Delivery

Unlike my previous case studies with Ivy, my role within the classroom was minimal in Case Study Four. I contacted the school, provided training to introduce the curriculum to the chosen teachers within the computing department, and provided ongoing support if elements were not clear. Throughout the process, I would continue to take notes and conduct interviews with teachers at the end of the project. The following section outlines the process of adapting resources, including the concept of legacy, adapting the Micro:Vote resources, translating between VLEs, and the culmination of the challenge.

5.6.1. The concept of legacy

A key challenge of university-school partnerships is the finite nature of possible relationships, including scale and sustainability. In the North East, there are five Higher Education Institutions with their own computing departments – in the 'Schools North East' network alone, there are approximately 1,150 schools (although this is a range of stages from first schools to Sixth Form colleges (Schools North East 2021)). If split equally, each university would have 230 individual schools to support – an unlikely feat. However, this is only if one considers the benefits of a school-university partnership solely internal to the relationship itself and has no impact beyond this relationship between a university and its school partner.

During the process of a school-university partnership for computing education, particularly in the realm of curricular development, resources are created for both teaching and learning purposes. Ensuring that these are positioned as Open Educational Resources, intentionally created and licensed for people to own, share and modify would mean that the produced resources could be more easily adopted and adapted by others (UNESCO 2012). This would allow for further schools to engage in the outcomes of a partnership without direct participation with a university, addressing the challenges of access and scale while also producing resources of use to educators (Vanderlinde 2010, Cain 2016). The output of such resources is considered the legacy – the longer-term impacts of school-university partnerships beyond the direct relationship.

5.6.2. Adapting the Micro:Vote resources

Jasmine Grange planned to use the existing Micro:Vote angle explored with Ivy, with the university still acting as the challenge commissioner to whom the pupils would respond by creating their voting posters.

Elm Church teachers planned to frame the challenge as internal to the school itself, with findings being presented to the schools as areas of improvement as part of 'Student Voice' initiatives. While there was still a link to the university research, this school positioned the university and its expertise as a springboard for university research rather than as a commissioner.

Both schools were given access to the materials created by Teacher4, including a teacher's guide to the resources, lesson slides, tutorials, code scripts, researcher's workbook and researcher's handbook. Both schools were invited to freely adopt or adapt the resources required by their school policies and practices. The possibility of visit days was proposed as a final celebration should the schools wish to organise such a visit.

5.6.3. Translating between VLEs

The Micro:Vote curriculum had been stored on a Google Drive, as Ivy had been a Google Education school (meaning that Office365 education and storage solutions were blocked through their access policies), and the creation of the repository of materials was easier to draw across from Google Classroom into a standalone Google Drive.

Jasmine Grange was an Office365 school, meaning that all Google-based VLE resources and storage solutions were prohibited through school access policies –

while it was easy to move the materials across to OneDrive, the challenge lay in links to existing Google Form assessments.

Elm Church was making the transition to becoming a Google Education school. While they had minimal experience, the teachers saw the adoption of the Google Micro:Vote curriculum as a chance to familiarise themselves, and later the pupils, with their new VLE.

5.6.4. Culmination of challenge

In the original Micro:Vote, pupils were invited to the university to present the culmination of their work. In the case of Jasmine Grange and Elm Church, both schools planned to deploy the curriculum to an entire year group in the same term, meaning that there were over 350 pupils presenting their work by the end of spring term 2020. In light of this particular challenge of scalability and proposals from Ivy teachers, I discussed potential alternatives with teachers and allowed them to plan their own culmination presentations.

Jasmine Grange teachers decided that they would have internal class-based presentations. Then, pupils would write an email to the university outlining the work they had achieved and what they had learned and would be a stand-in for a required literary assessment. While it was planned that I would receive each email and use inbox rules to sort these emails into a relevant folder, I would send an overall class email back to reduce my workload. Further, the key contact teacher and I discussed how template emails could be used to automate responses to each class if this project were to scale to a wider range of schools and classes. For this particular iteration, I chose to write a personalised email response to the class to ensure there was some form of feedback from the university. However, I acknowledged the challenge this might pose at scale.

Allowing pupils to use the findings of their Micro:Vote systems to propose evidence-based changes was of particular interest to the teaching staff. Elm Church had an internal school podcast and made arrangements for the pupils to share their work in podcast format, with the intention being to raise awareness of pupils' proposed changes to the school environment. The findings from the podcast would then be shared via a single class email with the university, and the same response process would be adopted as that of Jasmine Grange to ensure a manageable workload for me as the contact researcher.

5.6.5. The impact of lockdown

During Case Study Four, a nationwide lockdown was introduced in response to the Covid-19 pandemic. As a result, both Elm Church and Jasmine Grange schools were closed while alternative arrangements were made for virtual educational provision. This was a period of significant upheaval. As a response, I decided not to chase up teachers on the status of the curriculum until the situation became more stable.

However, the time to reach stability was significant. In the interest of completing the research, I reached out to conduct interviews with teachers and explore the ongoing use of the resources. Both schools expressed their interest in adapting the resources. Still, ongoing pressures of the pandemic and changes in staff meant that communication was infrequent, and the post-lockdown use of the resources is unclear.

5.7. Case Study Four: Findings

In Case Study Four, I did not interact with the pupils taking part in the Micro:Vote curriculum and focused my research on teacher experiences adopting and adapting legacy materials from a previous school-university partnership for computing education. Both Jasmine Grange and Elm Church proposed one key teacher participate in a 60-minute semi-structured interview via Skype after the case studies were cancelled due to Covid-19. From these discussions and subsequent thematic analysis of notes and transcribed audio, the following themes have been identified in the remit of exploring legacies of school-university partnerships for computing education: perceptions of risk and commitment in adopting external resources, supporting non-specialists through the structure of resources, engagement and differentiation for pupils, technology policies within schools, the broader influence of educational policy and curricular change on adopted resources, and their pedagogical impact on the educational institution.

5.7.1. Perceptions of risk and commitment in adopting external resources: '[We're] always looking out for new resources, new ideas- especially ICT because everything changed so quickly' (Teacher5, Elm Church)

A theme arising from discussions of the adoption of legacy resources of school-university partnerships for computing education was the perception and inherent risk of unpredictable workload commitment, particularly checking the quality and compliance with the requirements of the National Curriculum.

To address these concerns, teachers emphasised the importance of organisation and structure of resources, particularly in a topic with rapidly changing parameters and content. When asked how they typically chose to integrate external content, the Elm Church teacher responded that she was '*always looking out for new resources, new ideas- especially ICT because everything changed so quickly*' (*Teacher5, Case Study Four, Interview).* However, she felt a key challenge was ensuring that resources were appropriate for a given class, with concerns about the quality of teaching resources found online. The teacher from Jasmine Grange also noted this same challenge, saying he '*spent many hours*' *(Teacher6, Case Study Four, Interview)* integrating resources from the Computing at School repository and Times Educational Supplement, in a process that felt frustrating and time-consuming.

When introduced to the Micro:Vote resources, the teacher from Jasmine Grange felt that the resources were well tested with previous schools and were likely to address the learning requirements of Key Stage 3 and required less effort to evaluate their quality before integration. Elm Church teachers described how the structure, using typical teaching practices such as individual lesson plans, starter activities, and assessments, ensured that the resources were easier to integrate into their current teaching approach. A quote exemplified this from the teacher from Jasmine Grange, who reported how the teachers felt they could '*tailor and tweak' (Teacher6, Case Study Four, Interview)* the resources as needed. Yet, it was organised and structured such that it was '*off the shelf and ready to roll' (Teacher6, Case Study Four, Interview).* Overall, this was considered much less effort than adopting unknown resources online, saying, '*This required very little input from me and that was really rewarding and it was just ready to fly... and the materials were of high quality*.' *(Teacher6, Case Study Four, Interview)*

5.7.2. *Supporting non-specialist teachers in computing: 'You had three different teachers teaching differently with different abilities' (Teacher5, Elm Church)*

A further theme for exploration and an identified challenge for computing education on a national scale is the support of non-specialist teachers in computing teaching roles. In Jasmine Grange, a P.E. teacher had been tasked with delivering computing to a high ability Key Stage 3 class undertaking the Micro:Vote curriculum. The interviewed teacher from Jasmine Grange noted that '*she had a lot about her, she prepared for each lesson and went through everything, but because it was all laid out… the kids could really get on with some hardcore programming' (Teacher6, Case Study Four, Interview)*. This was particularly due to the depth of resources, including the teacher handbook and lesson plans, which were described as a '*godsend for the non-specialists' (Teacher6, Case Study Four, Interview).*

In Elm Church, the teachers had a wider range of experience and confidence in computing, with most of the teaching staff at Key Stage 3 being non-specialists. The interview teacher reported that adopting the resources felt like three different curricula were being taught at once, as '*you had three different teachers teaching differently with different abilities*' *(Teacher5, Case Study Four, Interview).* She was unsure how she felt about this variety, with each delivery emphasising particular concepts.

5.7.3. Engagement and differentiation for pupils: 'The kids really liked to get their hands on the micro:bits' (Teacher5, Elm Church)

When asked about the influence of the resources on pupil engagement, the teacher from Elm Church recounted how '*the kids really liked to get their hands on the micro:bits – particularly the lights and the games*.' The teacher from Jasmine Grange noted how classroom behaviour improved, particularly in 'tricky classes' with major classroom behaviour issues, saying:

> *There was one teacher that's got a few very, very tricky classes. I'm not sure how thoroughly he delivered it - the outsides of aspects to it, but the actual programming of the micro:bits really got them on board. So even the most tricky classes got something out of it and the micro:bits, where the higher ability teachers and organised teachers, they got as much as you'd expect. So at every level, regardless of behaviour and ability, every class got something out of it. – Teacher5, Case Study Four, Interview*

Elm Church noted that the role of the university was particularly engaging for computing pupils. They felt it provided a wider range of '*different approaches of computing*' to engage a broader range of pupils in the subject, as the social basis of Human-Computer Interaction appeared to be more appealing to pupils who did not previously consider themselves interested in computing and programming. They were particularly focused on the importance of taking the pupils on trips to engage them in their learning and were keen to visit the university, even if this meant only taking a smaller portion of each class on the visit itself.

However, Elm Church also noted that differentiation of materials was a key challenge in *maintaining* pupil engagement, with the teacher reporting, '*Where we thought that lacked was for the higher (ability) kids, they got it… they knew how to do the lights and turn them on, and it would be great to get them more into the ideas of input and output (with the micro:bit)' (Teacher5, Case Study Four , Interview)*. Teachers adapted the lessons for classes to better suit their perceived level of computing ability and engagement by reducing the activities and providing further guidance. This was not anticipated as part of the workload and was particularly challenging for the non-specialist teachers.

Elm Church also challenged the curriculum structure regarding engagement, noting how the programming and physical computing elements were much more engaging to the pupils. The teacher proposed rearranging the curriculum, noting, '*I wonder if it would be better to do all the research part and then get them to look forward to the programming part later' (Teacher5, Case Study Four, Interview)* as a method to better engage their pupils.

5.7.4. Technology policies: 'There was a few little niggles…' (Teacher6, Jasmine Grange)

While not an immediately prominent challenge, throughout both interviews, teachers referred to the constraints of school technology policies and how they influenced the way they adopted and adapted the legacy resources. As previously mentioned, Jasmine Grange was an Office365 educational subscriber, meaning their virtual learning environments were largely based on the use of Microsoft software and prohibited access to any Google Education applications.

Time had to be taken by the key contact teacher to comb through the resources and ensure that Google Form links were replaced with an Office365 substitute, referring to these as '*a few little niggles*' in adopting the Micro:Vote resources. However, not all of these Google-based links were discovered until the moment of use in the classroom, with the teacher reporting, '*Once it got up and running, and we sorted out- this isn't anything to do on your end – but the first few classes we had to sort out problems with them getting access to the forms because they needed an account and things like that'' (Teacher6, Case Study Four*, *Interview).*

In discussion with Jasmine Grange, this was noted to be an internal issue. Still, considerations should be made for the differing VLE platforms and associated technology platforms on the adoption of legacy materials.

5.7.5. Educational policy and curricular change: 'It's going to be a permanent feature… as long as we do computing' (Teacher6, Jasmine Grange)

A further theme arising from discussions about adopting materials from school-university partnerships was the challenge of a constantly shifting landscape of educational policy and its impacts on the computing curriculum.

During the interview with Jasmine Grange, the teacher, who had many years of experience in curricular development and policy, noted that he (and other teachers within the department) had experienced disquiet in online forum discussions about the place of computing in the curriculum. When asked to elaborate on his thoughts on the role of computing in the future curriculum, he replied:

> *It's a question mark over that one, but I can't see them* not *doing computer next year because I think the planning- (you need proper planning to) make a proper decision like that... There's a national trend to take it out because it's quite a hard course to deliver- because I know you've got the Progress 8, but it's one of these- Computing can sit outside of (Progress 8) and you can, just- do as much maths and core subjects as is possible really – Teacher6, Case Study Four, Interview*

From these discussions, the teacher from Jasmine Grange noted how the changes in educational policy were likely to influence the uptake and continued use of legacy resources. The clear opportunity to tweak resources would be important in their wider scale uptake to respond to future changes. When asked about their use of the curriculum in Jasmine Grange, Teacher6 responded, '*It's going to be a permanent feature… as long as we do computing' (Teacher6, Case Study Four, Interview)*.

5.7.6. Pedagogical impact: 'We're going to use your framework as a guide' (Teacher6, Jasmine Grange)

One of the final themes arising from the exploration of school-university partnership legacy materials for computing education was their incidental impact on pedagogy in the schools involved in the case studies. During the interview with Jasmine Grange, the teacher expressed the importance of contextualising computing in the wider context, particularly considering the ethics and influence of computing on society.

Built from the perspective of HCI, the Micro:Vote curriculum engaged with design, user research and evaluation, and communication elements involved in the presentation of the work undertaken. In response, the teacher reported that he would *'revamp the computing curriculum across the years, go through the units and look at the standalone tasks and how you might put it into a contextualised unit… using your framework as a guide'* (*Teacher6, Case Study Four, Interview).* The pedagogy of the Micro:Vote curriculum was based on pedagogical research conducted in Higher Education institutions yet was reported to be both applicable and useful in guiding curriculum development for computing in compulsory education institutions as well.

5.8. Discussion

In these final two case studies, I aimed to continue identifying the opportunities, barriers and challenges for school-university partnerships for computing education, particularly the experiences and processes that underpin their maintenance and legacy. The following discussion examines the factors one must consider when maintaining an existing partnership versus creating a partnership. These considerations contribute to the process and technologies proposed in the conceptual framework to support school-university relationships for computing education in Chapter 6.

5.8.1. Managing partner expectations

Educational ecologies, and by extension, the educational partnerships situated within them, cannot be divorced from their temporality. Across time, aspects such as relationships, access to resources and bounding frameworks are influenced by the wider social, economic and political environment (Hodgson and Spours 2013; Mueller and Toutain 2015). Therefore, there must be consideration of the changes in practice when a partnership becomes a process of sustainability and not just creation.

The nature of sustaining long-term partnership work requires university partners to better accustom themselves to the educational policies and practices of the school environment. In Case Study One and Two, there was an expectation of university control at the expense of typical working practices for teachers. This was positioned as an experience of *endurance* for teachers who had previous experiences working with those who had not taken the time to fully appreciate the experiences, relationships and resources inherent to the educational ecology. This approach could be endured for a shorter project. Still, for those wishing to engage in sustained, longitudinal partnership work, there must be consideration of the constraints that shape teaching and learning practices in UK schools and how these influence the spaces in which partnership teaching occurs.

5.8.2. Continued communication and digital delivery

In the continuation of a partnership, there may be an assumption that communication processes have become finalised and that methods developed in the creation phase of the partnership remain appropriate for the duration of a partnership relationship. However, as noted particularly throughout Case Study Three, constraints continue to evolve and change throughout the partnership process, requiring constant evaluation of communication methods. Initial communications through in-person meetings quickly became WhatsApp messages when my physical presence was not needed, echoing the literature that points to the need for *in-person* relationships requiring development before the use of communication technologies is introduced (Tong and Walther 2011; Johnson, Al-Shahrabi, and Vines 2020; Khawaji et al. 2013).

The legacy approach of Case Study Four required more limited instant communication and benefited more strongly from structured check-ins via email. This provided a recorded method of communication, in which instructions, suggestions and queries were documented in email threads to provide structure to the engagement, allowing for a lower threshold of relationship investment. The level of active communication in a school-university partnership is time-consuming. It requires adaptation to the unique school environment and its underpinning ecology of resources, relationships, policy, etc. If the legacy of school-university partnerships for computing education is intended to provide *scale* to the impacts of such a process, active and involved lines of communication for all legacy partners would quickly render the process unfeasible.

Through the continued development of communication with sustained partners and those involved in the legacy outputs of an active partnership, the digital delivery of these communications must change as relationships develop. Furthermore, formal and informal communications must be considered – email acts as a trail for accountability and referral that does not require an immediate reaction. Instant messaging can allow for immediate reactions and support but tends towards the informal and unrecorded, beyond the immediate and professional channels of communication.

5.8.3. The impact of partnership legacy

Finally, I want to highlight the influence of a partnership beyond the originating relationship and explore the impact of partnership *legacy*. When discussing the impact of adopting the resources developed through Case Study One to Three, the teachers in Case Study Four referenced the support it provided to their teachers – particularly those who did not specialise in computing.

This was a particular area of deficit noted in the Royal Society report (2017), where non-specialist teachers struggled to deliver the more complex elements of the computing curriculum and support pupil engagement. However, when working with resources developed by teachers, they were provided with opportunities to approach these concepts in a way that could be applied in practice in the classroom.

These findings suggest that the partnership process should consider the legacy outcomes in the design of partnership activities and that the adaptability of resources is considered for differing abilities to support the wider sphere of teachers and pupils who may adopt such resources in the future.

Chapter 6: Discussion and Conclusion

6.1. Introduction

Returning to the original motivation of this research, digital technologies have contributed to a society in which economic and social power rests in the hands of technology producers with little to challenge the status quo. Introduced to National Curriculum policy in 2013, computing education focused on young people developing skills to '*a level suitable for the future workplace and as active participants in a digital world*' (Department for Education 2013b). However, the policy presented little focus on the potential impact of computing on personal and expressive skills. Four years later, this curricular innovation continued with several issues – schools were struggling with content, qualifications and pedagogy, whilst teachers could not access professional development opportunities to address the change in content when moving from the ICT curriculum (Royal Society 2017).

In my research, I explore how universities could help address the shortfalls of compulsory computing education in the UK while navigating the challenges of academic capitalism (Slaughter and Rhoades 2009) and university relationships to space, place and their wider education community (UPP Foundation 2019). Research Aim A comprised of identifying the opportunities, barriers and challenges for universities and schools participating in and maintaining meaningful educational partnerships for computing education. Research Aim B involved the proposal of a framework to support meaningful partnership creation and sustainability through consideration of process and supportive technologies.

I addressed these research aims through five case studies conducted across three secondary schools in the North East. Throughout these case studies, I worked in partnership with teachers and pupils to create a Key Stage 3 computing curriculum aimed at addressing the challenges highlighted by school-identified needs and those of the Royal Society Report, including support for teachers engaging in programming, an engaging curriculum for young people, and support in transitioning from block-based to text-based programming languages. Data was gathered through field notes, interviews and focus groups to understand the stakeholders' experiences involved in the process and identify opportunities, barriers and challenges inherent to the partnership process.

In this chapter, I explore the empirical findings from Chapters 4 and 5 as a lens to explore answers to Research Aim A and Research Aim B. This results in the following subsections that explore Research Aim A's research questions in more detail, starting with A1: *What are the experiences of the stakeholders involved in school-university partnerships for computing education?* Throughout this research, I have focused on the perceptions and impressions of those engaged in school-university partnerships for computing education to explore the development of the relationships and perspectives involved in their creation and sustainability.

The second research question of Research Aim A seeks to understand A2: *What processes are involved in universities and schools working in partnership to explore curricular design and delivery for compulsory computing education?* Through the exploration of process and the influence of time and resources upon the changes in the individual's environment, the exploration of this research question provides a structural foundation to support the development of further research and school-university partnerships for computing education.

The first subsection starts with B1: *How can we conceptualise a model for creating and sustaining school-university partnerships for computing education?* In this subsection, I re-examine the conceptual framework outlined in Chapter 6 regarding its relationship to existing related work from Section 2.4, comparing related models and their concepts, before exploring its potential and limitations for future work.

I then dive into B2: *How can we appropriate and augment technologies in creating and sustaining school-university partnerships for computing education?* I open this with an exploration of how technology can support school-university partnerships' operational and conceptual processes, culminating in areas of future development for HCI researchers interested in the digital infrastructuring of school-university partnerships for computing education.

This section is then summarised as a review of the proposed conceptual framework for school-university partnerships for computing education, guiding future researchers and practitioners who may want to engage in such practices.

I provide an outline of the core contributions of my research, including its contribution to research in the field of school-university partnerships, approaches to computing CPD, and curricular development for computing. I provide the identified limitations of this research and potential avenues for future research regarding school-university partnerships and the support of compulsory computing education in the UK.

This chapter then concludes with a summary and closing remarks surrounding the opportunities, barriers and challenges of school-university partnerships for computing education. It then outlines key implications arising from the proposed conceptual framework.

6.2. A1: What are the experiences of the stakeholders involved in school-university partnerships for computing education?

Research Question A1 relates to exploring the experiences of those involved in partnership activities designed as part of this research, adopting the definition of experience to mean the perception of involvement in activities. The sharing of these perceptions can help us better understand the relationships involved in school-university partnerships for computing education, contributing to the development of the proposed conceptual framework in practice. While the stakeholders involved in school-university partnerships for computing can be wide-ranging, in the following section, I explore the experiences of researchers, teachers, pupils and schools as an institution and how these experiences present opportunities, barriers, and challenges to the school-university partnership process.

6.2.1. The experiences of researchers

The findings of this study demonstrate the experience of a researcher engaged in the creation, maintenance and legacy of a school-university partnership for computing education. The evidence from the study suggests a range of areas of consideration regarding the researcher experience, including opportunities for self-development and reflection that contribute towards the understanding of relationships within the school-university partnership experience.

Firstly, a key experience throughout this research was the opportunity I had to immerse myself in learning about the school environment and pedagogical approach and the development of relationships between myself and teachers. Throughout these case studies, I became more integrated into the school and computing department, allowing me to learn more about designing and delivering computing education in collaboration with the schools. However, this did not happen throughout a single case study and instead was an impact of a rich, prolonged engagement with the school environment. This perspective is supported by literature noting that prolonged, embedded work within an educational community can help researchers gain a more nuanced understanding of pedagogical approaches and procedures (McNall et al. 2009; Loreman et al. 2015; Rivera, Gardner-McCune, and McCune II 2017), with the progression of the recorded Case Studies demonstrating the evolution of the partnership process benefitted by the depth of these teacher relationships.

Furthermore, was the process of my own learning through each iteration of research. These rich, nuanced, and ultimately diverse experiences between each iteration, partner teacher and class could not be replicated in one iteration alone. While the first iteration was designed with due care and consideration of the research aims and questions, I still made mistakes, failed to consider elements or was unaware of practices and policies that were apart from the intentions of the research. Therefore, the long-term, iterative and integrated nature of the research helped to support my own understanding of the school ecology, and how research could ultimately be designed to function within this space. The value of iteration should be greatly valued in research in school-university partnership, to be able to address weaknesses and continue adapting to the needs of its partners.

A second consideration is the challenge of the inherent emotional entanglement with the places, people and projects. As an outsider, I wanted to be accepted as part of the school community – I had school logins and a staff badge that would permit me passage in both the physical and virtual school environment; pupils would talk about life outside of school, and inevitably teachers would make tea. These were not intentional actions of emotional entanglement but a process of navigating challenging personal motivations, biases and perceptions. Work from Sanders (2010) notes the benefits of acknowledging personal emotions in response to research, when researchers confront their anxieties, "*useful data is acquired and new insights arise"* (ibid, p. 110) from working reflexively (Sikes and Hall 2020) and engaging with the vulnerability of emotional connection with data, people and purposes of work and life (Whiteman 2010).

However, these findings also demonstrate the need for emotional safeguarding, as partnerships and projects do fail and can be personally challenging for the researcher – as seen in Case Study Two. The decline and termination of the project hit me particularly hard on an emotional level, as I dealt with feelings of self-directed disappointment and frustration. Warden (2013) notes how "*researchers can find themselves confronted with stigma surrounding issues of subjectivity, 'going native' and even implications of failed research*" (ibid, p.1) in the report on emotional consequences of research. This perception can dissuade researchers from reporting findings where they may appear overly subjective to their research environment. While some readers may continue to argue that the report of emotional vulnerability derails the validity of this research, I propose that the consideration and reporting of such experiences is inherently beneficial to the process of school-university partnerships.

A further key experience to note from this research, particularly for its significant impact on the design and delivery of curriculum activities, was the role of *physical space* and the challenge this presented. For example, within Case Study Two and Three, the classroom's physical design impacted behaviour and engagement, where pupils would struggle to read text elements on the board and follow lessons, which is perceived to have led to poor engagement during some elements of these case studies.

In summary, the findings of this study suggest that the experience of researchers in school-university partnerships is the exploration of vulnerability and immersion in the school environment. These findings contribute to our understanding of the challenges and opportunities such an environment can present to researchers working as part of a school-university process, contributing towards the refinement of the conceptual framework for school-university partnerships for computing education.

6.2.2. The experiences of teachers

As mentioned in the literature review, the success of educational partnerships is often challenged by a partner's poor understanding of a complex and dynamic educational environment, with predetermined social hierarchies, diverse motives, bounding organisational practices and limited access to resource (Newman et al.

2000; Cox-Petersen 2011). In this particular study, I emphasise the reporting of the experience of teachers throughout the partnership and legacy process of Case Studies One through Four, using this research as a platform to outline teacher perspectives regarding the adoption of novel approaches to education and their uncertainty regarding partnership dynamics, as well as the affordances provided by partnership working.

One interesting finding of this study regards the barriers presented by bounding frameworks, such as accountability and curriculum, and the implications this has on teacher confidence in initial engagements of partnership development. The UK school system and its alignment to measuring achievement as a commodity means that teachers are often restricted in their ability to engage with novel educational initiatives (Appel 2020). This research notes how potential risk can deter schools from engaging in the exploration of novel approaches to educational design and delivery (E.g. Case Study Four), but also how a lack of consideration in the design of a partnership can cause further hardship for teachers amongst an already difficult workload (E.g. Case Study One). Therefore, further consideration must be taken to understand the limitations and boundaries of a partnered school during the design stages of a school-university partnership process. This finding is particularly significant for the development of the school-university partnership process. During the creation and early stages of a partnership, partners must be aware of the targets, indicators and evaluations present in school policy (Connell 2013; Ball 2016) to ensure the sustainability of a partnership with a school.

Another interesting finding was the challenge regarding the locus of control – while the initial design of the partnership in Case Study One intended to position the teacher as an equal partner, the partner teacher perceived the imbalance of power in the design and delivery of partnership activities. Time helped to manage these perceptions as the individual partnership relationship developed, but there was a clear regression when swapping partner teachers in Case Study Two and Case Study Three. These findings are in keeping with previous studies that examined the perceptions of equity in educational partnerships (Cardini 2006; Cox-Petersen 2011). While time is a key component of addressing concerns about the locus of control in a partnership, there also must be a clear communication process when widening this partnership relationship to new individuals within an institutional partnership.

A further key finding was the opportunity for professional development for computing staff. Across each case study of this research, teachers noted the importance of domain upskilling as a motivator for participation in the project, including developing their subject-specific computing knowledge (Case Study One) and supporting non-specialist computing teachers in their delivery (Case Study Four). These findings corroborate the benefits outlined by the Royal Society (2017) regarding the potential benefits of partnership working for computing education and further demonstrate that partnerships need not only be supplied by industry organisations but also Higher Education institutions.

Finally, a further finding regarding the experience of teachers participating in school-university partnerships for computing education was the challenge of available time for the partnered teacher. Limited time outside of allocated planning and delivery hours impacted the design and implementation of resources. Teacher2, as the acting head of department had noticeably less time to dedicate than the other partnered teachers in the case studies due to his further responsibilities, and resource development was often left to the last minute in Case Study Two. These findings are corroborated by the Royal Society report (2017) that notes how reduced allocation for computing can either lead to an increased workload for teachers to meet the curriculum requirements or result in a reduced curriculum.

Freeing up teacher time is beyond the scope of partnership research – it is a decision made at the higher levels of the school institution. However, acknowledging the barriers to the availability of participants in a school-university partnership for computing education can ensure that decisions for developing, delivery and evaluation of resources can be undertaken considering these limitations.

These findings contribute to our wider understanding of developing and maintaining equitable relationships between researchers and teachers, particularly for the benefit of computing education practice and delivery, ultimately suggesting future best practices for the school-university partnership process.

6.2.3. The experiences of schools

While a school may not have the individual perception like the stakeholders outlined above, the school acts as a collective representation of senior leadership and teachers who must uphold centrally mandated educational policies and acceptable pedagogical strategies.

As noted in Case Study One, gaining support from SLT may be an opportunity to address the anxiety arising through changes to curriculum design and delivery to ensure that individual teachers are not solely accountable for perceived risks associated with curricular innovation. This was also reinforced by the legacy Case Studies being driven by senior leadership team (SLT) members before gaining traction with computing teachers in the classroom at Elm Church and Jasmine Grange. Before engaging with SLT, researchers must understand school priorities, values and ongoing initiatives. This can be done through research of the school's website and associated documentation available online (e.g. policies, blog posts, OFSTED reports) as well as local news and press releases that give insight into current aims and ventures. Ensuring partnership invitations highlight how a partnership can meet school aims will support researchers in the first steps of developing a partnership process for schools.

Once partnerships are developed, there must be an acknowledgement of responsibilities and time available to dedicate to the project from all parties. For example, SLT time can be limited due to their wide range of further responsibilities, but they do not need to be central figures in the school-university partnership process. Instead, their involvement can support teachers to engage in atypical, exploratory research in the classroom through partnership processes.

Therefore, the present study can suggest that the experience of school as a collective representation of teachers and pupils should be considered in the school-university partnership process.

6.2.4. The experiences of pupils

While not a deciding part of partnership decisions, pupil experience is undoubtedly one of the motivators to improve the computing curriculum. Therefore, the following section outlines the experiences of pupils who were involved in the activities delivered as part of the school-university partnerships explored through this research.

Underpinning the motivation of this entire work was to provide pupils with the opportunity to develop the necessary skills for modern citizenship (Department for Education 2013a; 2013c). However, pupil engagement, particularly among pupils from disadvantaged backgrounds, continued to fall year on year (Wohl 2017; Cellan-Jones 2017; Haigh 2016). This thesis proposed a stronger focus on ‘computing beyond applicability’ as an opportunity to include creativity, identity building and socio-political activist elements (e.g. (Kafai and Vasudevan 2015; Roque, Rusk, and Resnick 2016)) through school-university partnerships. When students were asked about their experiences of participating in sessions delivered as part of a school-university partnership, they reported increased confidence and were observed displaying improved levels of engagement and creativity. These findings suggest pupils have an appetite to engage in novel forms of computing education, particularly those that focus on the appreciative elements of computing education such as confidence, identity building and communication, further presenting school-university partnerships as an ideal opportunity to engage young people in their computing education.

However, there is a challenge regarding the availability of time for pupils. This was particularly evident in Case Study Two, when classes had one 50-minute lesson per week, compared to Case Study Three classes who had *two* 50-minute lessons per week. This was noticeable in the time available for pupils to engage, explore and create in the computing classes. This supports the Royal Society report (2017) that claims that current timetabled hours for computer science do not allow for appropriate exploration of the topics, as these case studies demonstrate how available lesson time impacted how pupils were able to engage in the feedback and design of the curriculum resources – fire alarms and trips away meant that time was a precious commodity when working with the pupils involved. Attempts to offset these limitations through extra-curricular sessions were only attended by engaged pupils who had already finished their work rather than pupils who complained about the lack of time available. These findings suggest that the bounding frameworks inherent to schools are likely to frame pupil engagement with school-university partnership activities. Therefore, consideration should be taken in the early stages of the partnership to explore the possibilities and constraints when working to deliver computing activities for pupils in school.

While not a central focus, these findings provide insight into the impacts of school-university partnerships for computing education on pupils and how this alters how schools can engage disinterested pupils with their computing studies.

6.3. A2: What processes are involved in universities and schools working in partnership to explore curricular design and delivery for compulsory computing education?

School-University partnership processes will be explored through the following research from curriculum design and delivery perspectives as I seek to identify the processes that influence the creation and sustainability of school-university partnerships. These particular processes have been drawn from the design and delivery of case studies and case study findings and their exploration. For ease of reading, these processes have been organised in a loose chronological order to align with the process flow of the proposed conceptual framework outlined in Chapter 6 (with the full revised model available in Appendix E). The following key processes include determining roles and expectations, exploring educational policy as a bounding framework, and sustaining school-university partnerships.

6.3.1. Determining roles and expectations

As the first process to be discussed as an exploration of process within school-university partnerships for computing education, it is important to reiterate that educational partnerships are perceptibly weakened by their poor definitions in the expectation of role, responsibility and contribution of external partners (Radinsky et al. 2001; Baumfield and Butterworth 2007). In my aforementioned case studies, this experience can be attributed to an early mismatch of expectations, largely due to poor internal communication, which went on to have some negative impacts of the design and delivery of teaching resources.

Working with proxies in the early stages of Case Study One meant there was a discrepancy in expected roles and responsibilities, with Teacher1 expecting me to lead the sessions despite initial intentions that this should be a team effort, which was slowly addressed through post-lesson reflections. Moving into Case Study Two, I assumed Teacher3 would be aware of the project and found this not to be the case. This presents the challenge that each teacher must be considered individually in communication practice and that regardless of assumptions, there must be a reasonable level of effort made to communicate purposes to partner teachers and the wider computing department. Findings drawn across the presented case studies of this research imply that researchers should consider informal introductions and discussing expectations and roles with partners. Furthermore, researchers should design *touchpoints* to evaluate, negotiate and re-plan expectations in response to key project aims and developing experiences.

Ensuring that communication opportunities are designed through the school-university partnership lifecycle can help address the challenge of communication in roles, responsibilities and contributions. Furthermore, technology can be a method to ensure clarity of communication regarding the roles and responsibilities of each stakeholder and provide a space to discuss contributions in an equitable manner.

6.3.2. Exploring educational policy as a bounding framework

Throughout my case studies, there has been a constant reference to the role of the educational policy as a bounding factor in educational innovation in schools (Null 2011; Appel 2020; Connell 2013; Ball 2016), which can act as a barrier to the development of school-university partnerships.

When designing a university-school partnership, there is a need to consider the impact of educational policy, such as the national curriculum, on the range of possible actions and innovations available to school partners. While it is possible to innovate within the confines of National Curriculum policy, the schools remain accountable to these governance structures, which the university partner must respect.

For example, in schools that have been placed in special measures, there may be some reluctance to engage in behaviour perceived to be “risky” (as noted in legacy Case Study Four), such as engaging in the development or refinement of existing materials. Internal school directives may prevent teachers from exploring novel or unfamiliar approaches in favour of working to support existing school initiatives or Ofsted recommendations. The outcomes of OFSTED inspections can have a huge impact on schools, eliciting feelings of trauma, anger and exhaustion in school staff (Learmonth 2020; Quintelier, Vanhoof, and de Maeyer 2018).

This also includes exploring network safety and performance policies as one of the key bounding factors of computing education in schools (Pye Tait Consulting 2017). Suggestions for improvement from the Royal Society report (2017) include engaging in constructive dialogue with SLT, service providers and pupils to ensure accessibility to specialist software and hardware that may be introduced during partnership activities.

While educational policies act as a bounding framework within which school-university partnerships for computing education must occur, researchers must have a foundational understanding of their limitations and impacts on the school partner and address the potential challenges that may arise due to this barrier.

6.3.3. Sustainability of school-university partnerships

Regarding the sustainability of partnerships, there needs to be a consideration of changing aims and purpose in response to educational or school policy changes. Stakeholder discussions will need to be undertaken to understand how these changes will provide mutual benefits. In some cases, it may mean that a partnership will reorient its aims where possible. In other cases, this may mean the end of an active partnership.

Adopting technologies to support long-distance learning, such as MOOCs and video conferencing, can provide universities with the opportunity to work with schools regardless of a given geographical distance, meaning a larger number of schools may become involved in partnership initiatives and become more manageable in their sustainability due to a reduction in workload. This may also address the understated challenge of rural schools without traditional connections to local universities with whom they can work to support computing education delivery.

The pandemic has engaged a large portion of the world to shift their engagement practices online. It presents a new area of exploration for virtual partnership building beyond the scope of this particular body of research. However, the use of such technology risks treating schools as a commodity where more is seen as better. Researchers may not take the time to meaningfully engage with schools and their culture, resources, space, relationships and technology, which demonstrably underpin mutually beneficial relationships. Careful consideration should take place when choosing to adopt technology in place of in-person relationships in the early stages of a school-university partnership, and negotiation of its use as a proxy for in-person engagement should be carefully considered in support of partnerships for computing education.

6.3.4. Opportunities, barriers and challenges

In Research Aim A, I set out to explore the experiences and processes of school-university partnerships for computing education, culminating in the contribution of identified opportunities, barriers and challenges for universities and schools participating in and sustaining meaningful educational partnerships for computing education. I have highlighted a range of opportunities, barriers and challenges presented by examining the experiences and processes for school-university partnerships for computing education. In this response to Research Aim A, I reiterate the definitions of opportunity, barrier and challenge adopted in this thesis and relate these definitions to the discussed elements of experience and process highlighted in the above discussion.

Opportunities are factors that present areas of future improvement or exploration within the space of partnerships for computing education, with implications for researchers to integrate into their own practice and research. The key opportunities identified within school-university partnerships for computing education are: *opportunities for researcher self-development and reflection, professional development for computing staff and improved pupil engagement in appreciative computing skills*.

Barriers present factors that are determined beyond universities and schools' scope and are constructs within which these partnerships must operate. There is little room for flexibility or interpretation of these elements. However, work can be done to better understand the constraints and impacts of these barriers on school-university partnerships for computing education. Throughout my work, I identified the following barriers for discussion: *bounding frameworks, availability of teacher and pupil timetabling, and access to physical space and learning resources*.

Challenges are factors that present constraints similarly to barriers yet can be addressed or avoided to some extent through further work. The following subsections present challenges experienced in developing and sustaining a school-university partnership for computing. Each subsection ends in a series of implications for researchers to address when engaging in such relationships. The challenges identified throughout this work include *emotional entanglement with the places, people and projects, power and control in partner relationships, and the determination of scalability in school-university partnerships.*

The subsequent section draws upon these discussions to explore the proposed conceptual framework of Chapter 6 in context and what this means for the underlying framework of school-university partnerships for computing education.

6.4. B1: How can we conceptualise a model for creating and sustaining school-university partnerships for computing education?

Drawing upon empirical findings from Aim A and the body of literature on partnerships between schools and universities supporting educational outcomes, I use the following section to contribute a critical view of the proposed model of school-university partnership for computing education. The following chapter contributes an early conceptualisation of the operational processes involved in creating and sustaining school-university partnerships for computing education, through a lens of educational ecology theory (Hodgson and Spours 2013; Bronfenbrenner, Morris, and Lerner 1998; Mueller and Toutain 2015), followed by an examination of the proposed model in relationship to existing models of partnership and educational ecology conceptualisation. Finally, I summarise with an overview of the model's potential, limitations and opportunities for future development.

6.4.1. Framework infrastructure

The following section outlines the infrastructure of a conceptual framework for school-university partnerships. This bridge between theory and practice can be a general signpost for researchers participating in school-university partnerships and guide research design and sensemaking of phenomena encountered under similar conditions (Rudestam and Newton 2014). However, to ensure researchers can interrogate the proposed conceptual framework, the following section outlines the framework infrastructure, including the theoretical foundations of the considerations regarding educational ecologies (Leonard 2011; Bronfenbrenner 1986), process (Bronfenbrenner, Morris, and Lerner 1998) and dimensions (Mueller and Toutain 2015).

- <u>Process</u>

The chronological element, adopted from Bronfenbrenner's concept of the chronological layer of educational ecology (1998) of the school-university partnership process must then explore how partnership activities must be approached to achieve an educational partnership. The proposed stages in the process for creating and maintaining school-university partnerships for computing education include:

1) Creation: the creation of the partnership relationship between a school and university
2) Design: the design of activities and/or research, in line with partnership aims
3) Delivery: the delivery of the designed activities/research
4) Sustainability: the ongoing maintenance of the activities/research
5) Legacy: the impact of partnership activities, beyond a direct school-university partnership

Furthermore, in adopting an action research approach, the process of this research has naturally reflected an iterative cycle of 'plan-do-reflect-repeat' (Hayes 2012; Elliott 1991), which is particularly applicable to educational partnerships due to its roots in educational research. Each of these processes has been mapped against an element of the Action Research cycle to demonstrate the relationship between each process flow. Figure 18 (below) provides a proposed process framework for school-university partnerships and its mapping to Action Research.

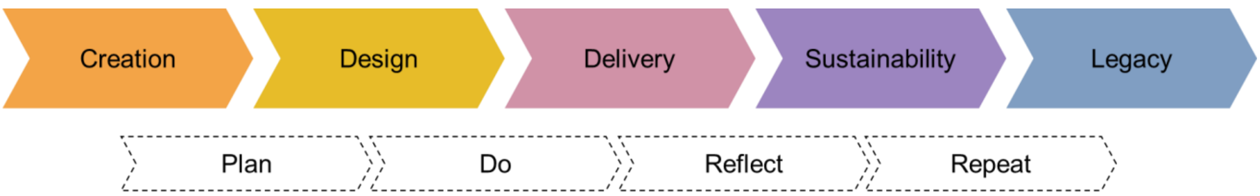


Figure 18. The mapping of Action Research processes to the proposed framework for school-university partnerships

The purpose and recommended actions within each stage are outlined in further detail in the subsequent subsections of this discussion.

- <u>Dimensions</u>

Each stage in the school-university partnership process considers educational ecology dimensions and how each partner contributes constraints and opportunities at each stage. In Section 2.4 I introduced the dimensions of an educational ecology focusing on the relationships between living components, social-cultural practices and material means, based upon work in Mueller and Toutain (2015). This initial framework provided an overview of 1) bounding frameworks (Mueller and Toutain 2015); 2) relationships between people (Hodgson and Spours 2013; Cardno 2012); 3) culture (Foster et al. 2013; Isenberg 2010); 4) pedagogy (Gruenewald 2003); 5) physical space (Mueller and Toutain 2015) and access to resource (Luckin 2008) and 7) technology (Nardi and O'Day 1999). The following Table 2 recontextualises these terms in the framing of school-university educational partnerships:

Dimension	**Definition**	**Literature**
Bounding frameworks	Organisational and educational standards to which a partner is answerable (e.g. REF, National Curriculum, School Policy)	(Mueller and Toutain 2015)
Relationships between people and place	The power dynamics between partners and the skills, knowledge and experience they bring to a partnership	(Hodgson and Spours 2013; 2009; Cardno 2012)
Culture	The ethical ideals, values and practices of those involved in a school-university partnership	(Foster et al. 2013; Isenberg 2010)
Pedagogy	The pedagogical approaches within the school and how this influences the school-university partnership process	(Gruenewald 2003)
Physical space	The location of school-university partnership activities and how this influences the design and delivery of such activities	(Mueller and Toutain 2015)
Access to resource	The availability of resources to facilitate the design and delivery of school-university partnership activities	(Luckin 2008; Sissel 2000)
Technology	A consideration of existing, novel and appropriated technologies to facilitate the school-university partnership process	(Nardi and O'Day 1999)

Table 2. Dimensions of a School-University Partnership

However, while not every dimension will be applicable at each stage in the process, they can act as elements for consideration within the process activities outlined below and provide researchers and partners with a shared lexicon of terminology.

- Technology

Throughout the exploration of Research Aim A, technology has been noted for the role it plays in creating, sustaining, and legacy of school-university partnerships. While technology is an underlying focus of this research, it is also only one subset of the dimensions of a learning ecology. It plays a stronger focus in the organisation of geographically separated people across organisational boundaries and externalisation of outcomes and therefore is not presented in every subset of the conceptual framework presented below unless it plays a key role in a critical process. This is to avoid a reliance on technosolutionism – a belief that technology can address all barriers and challenges – as well as present future areas of work for researchers to explore the role of technology in more explicit detail. In section 6.5 I explore the role of technology in the process in more detail and provide guidance on how technology can be meaningfully integrated into the process of school-university partnerships for computing education.

6.4.2. Creating a partnership relationship

Through this research, the recruitment of schools was primarily conducted through direct or indirect relationships and a focus on the potential risks a school might be undertaking in participating in a school-university partnership for computing education. This points researchers towards the importance of positive rapport and transparency in expectations when undertaking recruitment activities. The recruitment of partners in an educational ecology may occur naturally through existing relationships (as in this study) or could involve directly approaching schools with opportunities. Additionally, improving the university's visibility as a potential partner to schools can help schools to approach the university about the possibility of partnership. The key activities involved in the creation of school-university partnerships for computing education are outlined in Figure 19 overleaf.

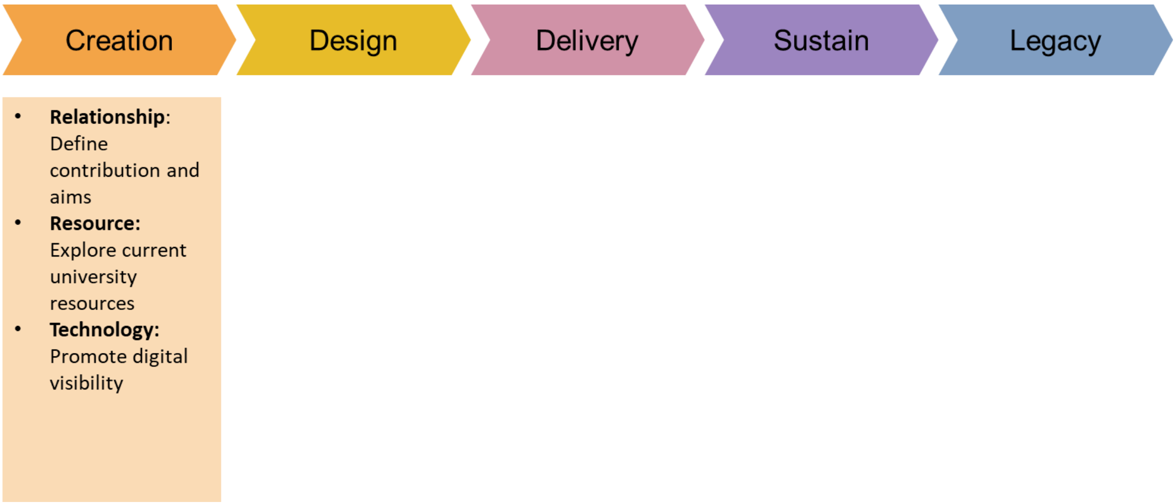


Figure 19. The Creation stage, and associated activities, of the school-university partnership process

- Relationship: Define contributions and aims

University researchers must carefully consider where their work aligns with the curriculum. When contacting schools directly with such opportunities, outlining curriculum contributions and research aims can help schools determine how such a partnership fits their own needs and development aims (e.g. (Nicholson et al. 2022). Ensuring that there is a central purpose to creating a partnership relationship can contribute to the challenge of clarity of roles, expectations and responsibilities.

- Resource: Explore current university resources

Prior to engaging in partnership activities for computing education, explore what resources are currently available within the university to support the engagement. These may exist within the department or within outreach teams, and discussions must be held with those in charge of their availability and use to ascertain how they may support school partnership activities.

- Technology: Promote digital visibility

Here is where a central, digitally-accessible repository can help to position the university as a potential partner for schools by providing an outline of potential partnership opportunities. As in Wenger et al. (2002c), a centralised digital platform (such as a web page) can provide early expectation management through the definition of roles, responsibilities and process workflows documentation that can be accessed by those involved in a partnership and those who have yet to become involved in a partnership. A further integration of a resource repository, in which resources can be held and downloaded, can also contribute to the legacy visibility of a partnership. For universities that have already participated in previous school-university partnerships, sharing previously generated resources and success stories can address school concerns about entering a partnership with a university. These address the reported challenges regarding school-university partnership participation and can provide a point of coordination amongst geographically and temporally distributed people interested in engaging in partnership activities.

6.4.3. Design of partnership content

Once a partnership has been tentatively established, the next stage in the school-university partnership process involves the design of the partnership, moving towards the development of materials. This stage should focus on developing the relationship and understanding the culture, pedagogy, and space of each participating partner. This is presented diagrammatically in Figure 20.

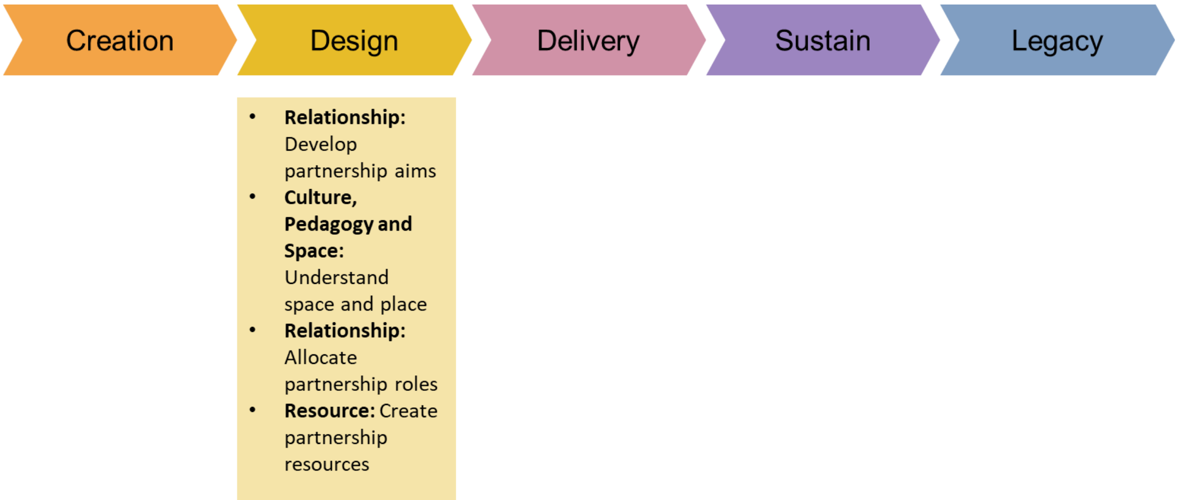


Figure 20. The Design stage of school-university partnership process

- <u>Relationship: Develop partnership aims</u>

While aims will have been discussed briefly during the creation stage of the school-university partnership process, the design stage is where a more detailed conversation must take place between partners. There must be consideration of the mutual aims and how these fit within the constraints of bounding frameworks, pedagogy, space and resource. This helps inform the partnership process across its lifecycle, with the opportunity to modify these aims as needed, as long as a conversation between partners is held. This will help inform the roles, relationships and resources that will need to be developed.

Here is where a centrally-accessible, digital record of aims and roles can provide clear communication of expectations while structuring equitable communication between partners. Literature points towards text-based discussion as the most equitable form of initial discussion between disparate groups of people working towards a common goal (Yamaguchi, Bos, and Olson 2002).

- Culture, Pedagogy and Space: Understand space and place

During the design elements of the process, both teachers and researchers need to understand the dimensions of the educational ecology in which they work – exploring the ecological domains such as bounding frameworks, relationships, culture, pedagogy, physical space and access to resource and technology. I recommend the act of physical boundary-crossing to develop a mutual understanding of space and place (Akkerman and Bakker 2011; Schenke et al. 2017), such that researchers and teachers spend some time embedded in the environment of the other where possible. This will support each actor in understanding their experiences and contributions to the aim of the project. This acclimatisation allows partners to address the disconnects between the two communities and negotiate intangible social, cultural, political, historical and pedagogical boundaries to arrive at a neutral *3rd space* in which professional relationships can begin to form independently of institutional boundaries.

- Relationship: Allocate partnership roles

Upon gaining an understanding of aims, space and place within the partnerships comes the definition of roles for those involved. Some stakeholders may have an indirect role in the day-to-day partnership activities, whereas some stakeholders may take on multiple active roles. It is important that these are defined early in the process and may include such roles as teacher, classroom support, challenge commissioner, technical expert etc. These roles may be required depending on the type of activities undertaken as part of the school-university partnership and may evolve across the lifecycle. Regular meetings across the partnership lifecycle will be needed, ideally at the transition to each subsequent stage in the lifecycle (e.g. delivery, sustainability, and legacy).

- Resource: Create partnership resources

The development of resources is highly individual to the chosen partnership aims, and partners should work to determine what activities (and therefore what resources) are necessary to undertake. Therefore, consideration of the novelty and its impact on delivery should inform the design of pupil-facing resources. If the partnership involves developing and delivering a curriculum (such as in this research), partners should discuss if the whole set of resources needs to be developed before engaging with pupils or if only critical path sessions need to be complete to allow for flexible and reactive resource development.

Furthermore, at this point in the school-university partnership process, one must consider the potential for legacy resources. These resources can support the computing community by addressing the lack of high-quality, evaluated learning materials for computing education in schools aligned to the national curriculum. Supposing a partnership chooses to develop resources for legacy impact, this entails further work to ensure that particular accountability structures (e.g. lesson plan documents, assessments) are kept as neutral as possible to allow schools with differing accountability structures to adopt the developed resources.

6.4.4. Delivery of partnership activities

Following the process stages, the next step is to engage in the delivery of materials and associated activities. The operational processes for this stage are encapsulated by Figure 21 overleaf.

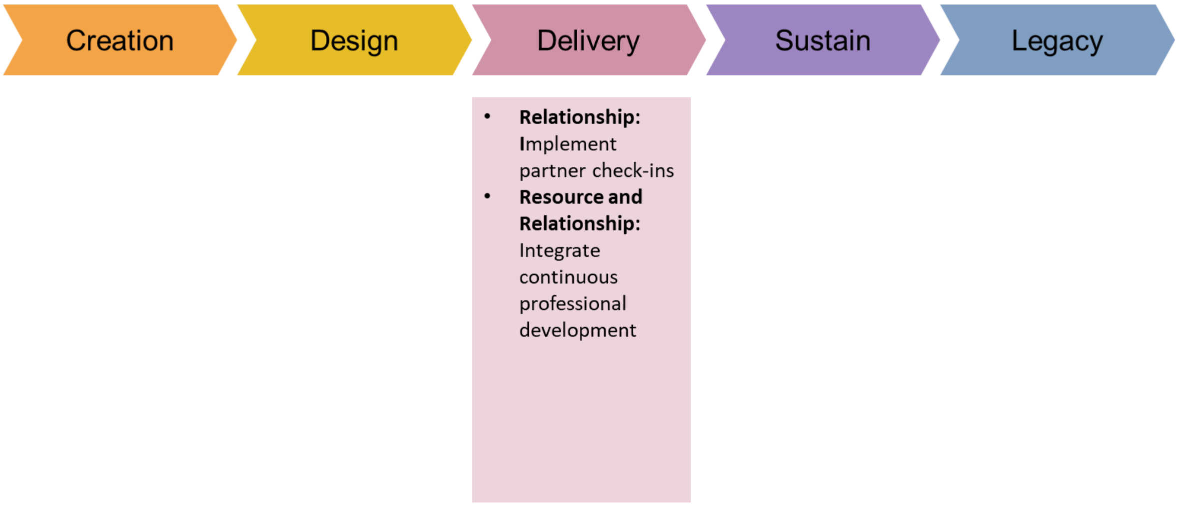


Figure 21. The Delivery stage of the school-university partnership process

- <u>Relationship: Implement partner check-ins</u>

Those involved in school-university partnership processes through a lens of brokership must acknowledge that there is a period of acclimatisation for both a researcher and their partnered school. Ensuring that the expectations of partners, assigned roles, and desired outcomes are clear in the early stages of partnership delivery activities can ensure that further communication and organisation mishaps may be avoided later in the school-university partnership lifecycle.

Despite attempting to approach the partnership with a lens of equity in my research, this could not address the entrenched position of the university as a locus of power in control in partnership with a school. Therefore, ensuring that there are several opportunities to engage in ‘check-ins’ with partners can open up space for all those involved to highlight potential opportunities, barriers, and challenges they have noticed during material delivery. These opportunities for conversation ensure that partners do not have to actively breach socially constructed boundaries resulting from the perception of partnering with a university.

This approach can help partners to understand the boundaries of what could be said and done, with further opportunities to explore how designing for mutual respect can be encouraged in the development of school-university partnerships. Ensuring these opportunities were embedded into the partnership process was vital to developing the partnership and formative in critically reflecting upon my power and positionality as a researcher aiming to challenge my underlying values and actions when working with a partnered school. This process can allow partners to achieve mutual aims, clarify incompatibilities and continuously iterate upon partnership activities, considering their capacity, flexibility and administrative support (Pollock et al. 2017; The Royal Society 2017), allowing for natural points of self-reflection, discussion, and feedback.

- Resource and Relationship: Integrate continuous professional development

Dependent on the aims of the partnership, continuous professional development activities may make up elements of the delivery of the school-university partnership for computing education. As an outcome of this research, a recommendation is to adopt a collaborative approach to CPD in which traditional didactic hierarchies of teacher and learner are dispensed with, favouring a supportive network of peers. This approach can help address the issue of deficit-oriented CPD currently available to computing teachers in the UK.

A key piece of guidance for consideration in the delivery of CPD is ensuring that the content covered applies to the practical classroom environment, such that it is immediately useful to partner teacher practices. Engaging with teachers before the session/s can ensure that content covers particularly challenging curriculum areas or areas where there is a current perceived lack of high-quality resources and training. Working collaboratively with teachers will help researchers understand the challenges, concerns, experience and expertise of computing teachers working in their partnered schools.

6.4.5. Sustainability of process

The sustainability stage entails the ongoing maintenance of school-university partnerships for computing education, as shown in Figure 22, overleaf. However, maintenance does not entail ensuring that activities continue with no room for improvement, as the ecology is under constant internal and external changes, such as potential changes in educational policy changes, staffing and resource, which can have an ongoing impact on the ways in which a school-university partnership is undertaken.

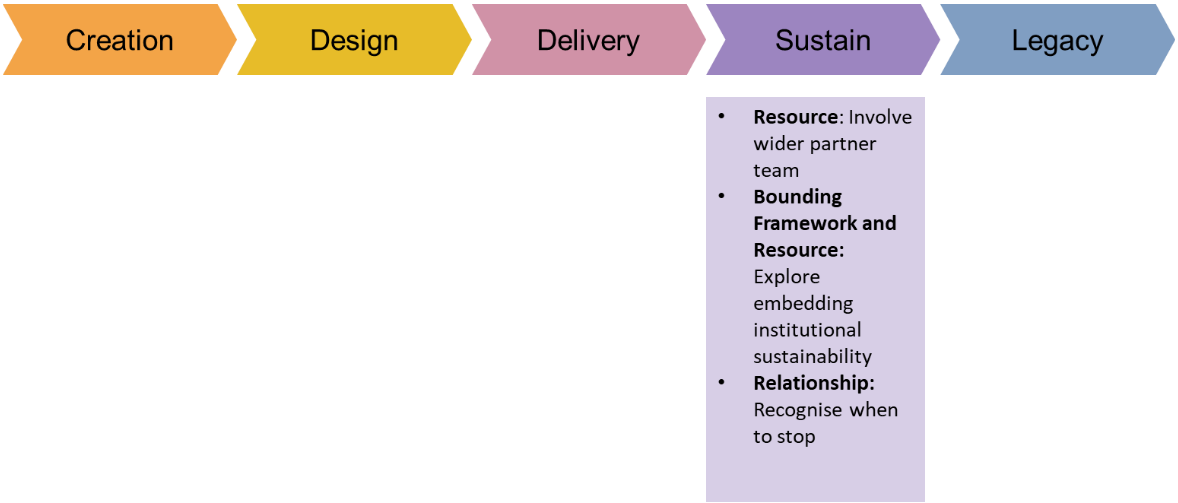


Figure 22. The Sustain stage of the school-university partnership process

- <u>Resource: Involve wider partner teams</u>

While the day-to-day activities of a partnership may rest upon a limited number of people from each participating institution, ensuring there is a wider support network who are aware of the activities being undertaken is important when considering the sustainability of a partnership. When considering the impact on the relationships between the university and school partners, this ensures that transitions between classes and teachers do not encounter misunderstandings regarding partnership aims and purpose and allows for better communication amongst participating institutions.

Additionally, when considering the impact on internal relationships, ensuring a wider partner team can help support the emotional wellbeing of those involved in coordinating the partnership activities, particularly from the risks of emotional vulnerability when engaged in challenging work.

- <u>Bounding Framework and Resource: Explore embedding institutional sustainability</u>

A note throughout this research was of the finite nature of PhD research and the certainty that the partnership would come to an end. However, before this determined endpoint, the partnership relationship with Ivy came to an end due to staffing changes and internal decisions about the direction of the curriculum. While all potential factors for the disruption and termination of a partnership cannot be controlled, the ability to ensure sustainability through institutional process can be explored through the partnerships process. Example methods of embedding institutional sustainability include working with university outreach teams or engaging students to work with schools as part of their university education (Pollock et al. 2018; Hoxmeier and Lenk 2020)..

- Relationship: Recognise when to stop

Following these points of sustainability is the recommendation to recognise when a partnership should stop (Taylor et al. 2013). This recognition may be because a partnership has achieved the aims outlined in the create and design stages of the school-university partnership process or where there are ongoing challenges that threaten the aims of the partnership outlined in the earlier stages of the partnership process. In both cases, partners should sit together and reiterate the partnership plan from the design stage, with a detailed overview of aims achieved and potential for new and developing aims. The power of iteration, outlined in Section 6.2.1, is invaluable in identifying weaknesses and potential areas of development, to help address where a partnership can be adapted to meet the aims of its partners.

Where mutual aims are found, the partnership process begins its subsequent iteration, with design and delivery changes undertaken as necessary. Where no mutual aims are found, then a partnership can become dormant, and no active partnership activities occur. More research needs to be undertaken to explore how further processes can support the journey from active to dormant partnership relationships between schools and universities, where no active project is being undertaken, yet the possibility for future work remains.

6.4.6. Legacy of partnership outcomes

Legacy takes place outside of the direct school-university partnership process but is a by-product of this iterative lifecycle and feeds into the ‘create’ stage of the lifecycle, as seen in Figure 23, overleaf.

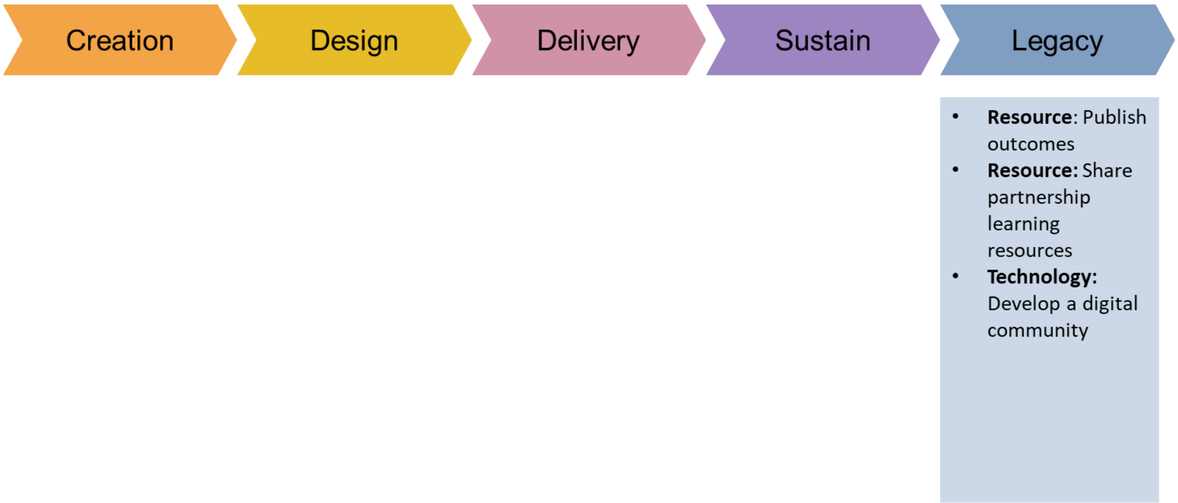


Figure 23. The Legacy stage of the school-university partnership process

- Resource: Publish outcomes

A further point in consideration of legacy in school-university partnerships is that of publishing outcomes. Researchers are more likely to consider academic venues for the publication of outcomes – this is an activity with which teachers should be involved, providing both their expertise as practitioners and developing their academic writing skills. When a key challenge of computing education in the UK is a lack of active, school-driven research into computing education pedagogy (The Royal Society, 2017), the focus on academic publication as a legacy of partnership can contribute to ongoing improvement in policy development, curriculum design and delivery practices. Positioning teachers as co-researchers has the additional benefit of promoting trust in the resource to teachers interested in adopting the research findings into their practice, as demonstrated in Case Study Four and Hendrik (2021).

Furthermore, computing teachers are seeking high-quality educational resources tied to National Curriculum requirements, and therefore practical venues such as Times Educational Supplement (TES) and the Computing at School (CAS) repository should also be considered as places to publish learning materials (e.g. lesson plans, slides, CPD materials).

- Resource: Share partnership learning resources

As a key area of development in computing education in the UK, partnerships should focus on sharing the learning resources developed as part of the school-university partnership process, particularly where educational research and practical evaluation can ensure the quality of the shared resource.

Adopting an unplatformed approach can support the sharing and engagement with learning resources through the adoption of existing technologies to sustain communication and engagement. Targeting educational resource platforms, such as TES and CAS will help promote the visibility of learning resources in places where teachers are already looking for resources. This can also be an opportunity to direct teachers to the central, digitally accessible repository developed as part of the 'digital visibility' activity in the create stage of the partnership process. Not only can this provide resource, but can also provide schools with an indication of whom they could contact about engaging in an active school-university partnership for computing education.

- Technology: Develop a digital community

In line with the cyclical nature of this lifecycle, legacy must also consider the 'digital visibility' necessary in the create stage of the process. The publication of partnership materials and outcomes can help encourage others to engage with the school-university partnership process and the learning materials. This ties to the concept of virtual communities of practice, in which a digital space for the sharing of good practice can 1) support the aims of a community (improving computing education in the UK), 2) act as repositories for good practice (partnership outcomes, legacy engagements) and 3) allow for expectation management and workflow through the publication of outcomes, materials and partnership information developed in the create stage (Wenger-Trayner and Wenger-Trayner 2015).

Furthermore, consideration must be taken to ensure the development of digital community allows for equitable communication between participants. This community should not solely be the product of universities with the perception of social and technical power and instead promote a digital space with collective ownership and community self-regulation.

Additionally, a partner must ensure that there is some level of authenticity and trust in the space – e.g. aligning this space with a trusted body, such as CAS or TES, can help address the 'inherent risk' experienced by teachers intending to adopt externally developed resources.

Finally, a digital platform must allow for users to adapt and resubmit materials to address the challenges of differentiation in the computing classroom. Further work is needed in this area to contribute toward the development of a relevant platform and the associated flow of activity. However, this research presents the groundwork for developing such a platform by sharing a chronological process for partners.

- Adopting ecologies in school-university partnerships

An ecological lens provides the reader with the tools to conceptualise complex and dynamic social systems, particularly regarding developing relationships, the flow of resources and the underpinning of social and cultural values (Leonard 2011; Mueller and Toutain 2015; Hodgson and Spours 2013; Nardi and O'Day 1999). Ecological theory in learning and education is not a novel application. It has been used as a symbolic comparison in conceptualising child development, training, education provision and pathways to work (Hodgson and Spours 2013). However, this thesis proposes ecological theory to provide a foundational element in creating and sustaining the school-university partnership process.

In the literature review, I drew attention to the variety of challenges affecting educational partnerships, including imbalance of power, conflicting culture and access to resources, which were reported to contribute to the failure of educational partnerships (Cox-Petersen 2011). However, this research demonstrates how adopting ecological theory as a lens for the creation and sustainability of university-school partnerships has the potential to surface these tensions of power, resource and culture by drawing attention to these dimensions at each stage of the proposed conceptual framework.

However, it is important to adopt an educational ecology approach with a critical eye as it is not without challenges. In particular, there may be a tendency to rely heavily on Durkheim's biological determinism (1973) as a method to explore the relationship between schools and universities at the expense of the autonomy of the individuals involved in an educational partnership (Berger and Luckmann 2016). This perspective can reinforce existing imbalances in relationships by considering they are pre-determined and cannot be challenged. However, to address this potential pitfall of adopting educational ecology theory in the creation and sustainability of school-university partnerships, those who adopt the proposed conceptual model must forefront the reflective activities to ensure that focus remains on the experiences and autonomy of the individuals involved.

- <u>Relation to existing models of educational ecology</u>

In developing the conceptual model, there were two key approaches to the conceptualisation of educational ecology – layers and dimensions. While neither was explicitly related to the infrastructuring of educational partnerships, they helped provide grounding for developing the eventual model proposed in Chapter 6.

While Bronfenbrenner had the whole child development in mind in his proposal of a layered approach to educational ecology (2000) and Hodgson and Spours (2013) were examining the wider pathways for young people's progression into work, training or education, these help situate the wider educational factors that impact upon the creation and sustainability of an educational partnership such as geography, culture, history, policy, professional networks and wider educational institutions. However, further literature critiques the dangers of these layer-based models to educational development for their potential to promote the adoption of unidirectional approaches to knowledge production as an oversimplification of a multidimensional educational ecology (Orphan and O'Meara 2016). In the case of university partnerships, where hierarchical power dynamics are a particular challenge when working with schools (as noted in Case Study One and (Slaughter and Rhoades 2009; Handscomb, Gu, and Varley 2014)), layer approaches are not an ideal form to conceptualise such relationships.

The proposed model acknowledges the wider educational ecology through a review of educational policy and encouragement for reflection upon inherent social dynamics between partners but focuses on a chronological structure of dimensional aspects drawn from layer-based theory. Dimensions such as culture, policy and networks can be considered independent elements within the proposed conceptual model without focusing on hierarchical infrastructuring. Instead, the proposed model draws from layer-based and dimensional-based approaches to conceptualise and operationalise the partnership – particularly informing the development of relationships and partnership aims, focusing on the socio-cultural makeup of the partnership and access to resource. This is embodied by the five-stage process flow of the conceptualised framework in Chapter 6 and displayed below in Figure 24, below.

Figure 24. The flow of the proposed framework

- Strengths, limitations and future work

While this is just the beginning of a framework that will need to be developed further by future researchers to explore its generalisability to new environments and educational ecologies, it presents initial guidance in the development of relationships built upon mutual aims and respect. This guidance will be of particular use to those conducting research within computing education research as a new approach to research with schools positioned as partners rather than participants.

A key strength of this proposed framework for school-university partnerships is that it is not inextricably linked to computing education and can be re-purposed for further education initiatives. Changes to the subject of the partnership will necessitate further consideration of the dimensions of a partnership, as the historical development of the subject may have impacts on the culture, pedagogy, resource, technology, bounding framework and relationships, which will influence how a partnership is created and sustained between partners. This conceptual framework stands as a starting point in the development of such partnerships. It presents contributions beyond the original realms of Computer Science Education and Human-Computer Interaction to fields such as Science, Technology, Engineering and Maths (STEM), Social Sciences, and Performing Arts.

A limitation to the proposed conceptualisation is the use of process ‘stages’ and the potential that partners may feel they need to address each dimensional aspect before moving on to the next stage. While the process has an underlying chronological flow, the recommended actions at each stage are *not a requirement* and may not need to be implemented depending on the partnership, environment or situation. Further work must be done to explore how future researchers respond to the proposed conceptualisation of the school-university partnership process, building a body of experience to further recommended actions for approaching the development of computing education in partnership.

6.5. B2: How can we appropriate and augment technologies in creating and sustaining school-university partnerships for computing education?

While the use of technology is increasingly familiar in the educational context, the following research will examine how school-appropriate technologies can address identified challenges in the process of school-university partnerships, contributing to the development of a conceptual framework of driving process and support technologies.

A significant body of research in Human-Computer Interaction (HCI) seeks to understand how existing technologies can be appropriated for use by communities in such a way that supports participation and empowerment (Celina et al. 2016; Dix 2007; Lambton-Howard et al. 2020). Drawing upon this existing body of research and the experiences of creating and sustaining a school-university partnership for computing education, I explore how existing technologies can be appropriated to support the challenges inherent to such relationships and what this means to the conceptual framework outlined in Chapter 6.

6.5.1. Technologies for the creation, adaptation and sharing of curricular resource

While the Micro:Vote curriculum developed in Case Study One through Three involved extension tasks for higher ability learners, the delivery in legacy case studies with lower ability learners was perceived to be a challenge with current resources and teachers created their own simpler versions of the resources. Providing a space for participating schools to contribute differentiated resources would allow teachers to customise their own pathway through the Micro:Vote curriculum and allow for the flexible schemes of working as highlighted in Case Study Three. This has implications for the use of technology in the design, delivery, sustainability and legacy stages of the conceptual framework.

Firstly, during the active engagement of the school-university partnership process, decisions must be made about the digital footprint of the chosen partnership activities and how produced resources will be stored, shared and edited by partnered institutions.

Secondly, when transitioning to the legacy stage of a school-university partnership process, there must be a consideration of the method of sharing resources. This must be achieved in such a way to address perceptions of risk and commitment in adopting external resources (arising from findings of Case Study Four), where digital platforms can be used to host the resources to improve their reach. However, current free digital platforms lack the collaborative create and resubmit elements adopted by platforms such as Github and Thingiverse, which can support open access to developed resources and encourage users to submit resources for remix and download by others within their community. However, neither of these platforms are particularly friendly to non-technical audiences in their use of terminology and approach. This highlights an opportunity for the exploration of a platform that provides such functionality with a focus on school-university partnership teaching and learning outputs.

In considering the processes involved in creating and sharing resources arising from direct or indirect participation in school-university partnerships, one can begin to address the challenge of limited access to high-quality resources. Ensuring that the conceptual framework encourages the adoption of a collaborative ‘create and resubmit’ approach to resources can ensure that quality is upheld while also encouraging further opportunities for engagements between schools and universities that may engage in evaluative research in this space. As such, I propose the following adaptation to the *Design* stage of the conceptual framework for school-university partnerships for computing education, outlined in Figure 25 overleaf.

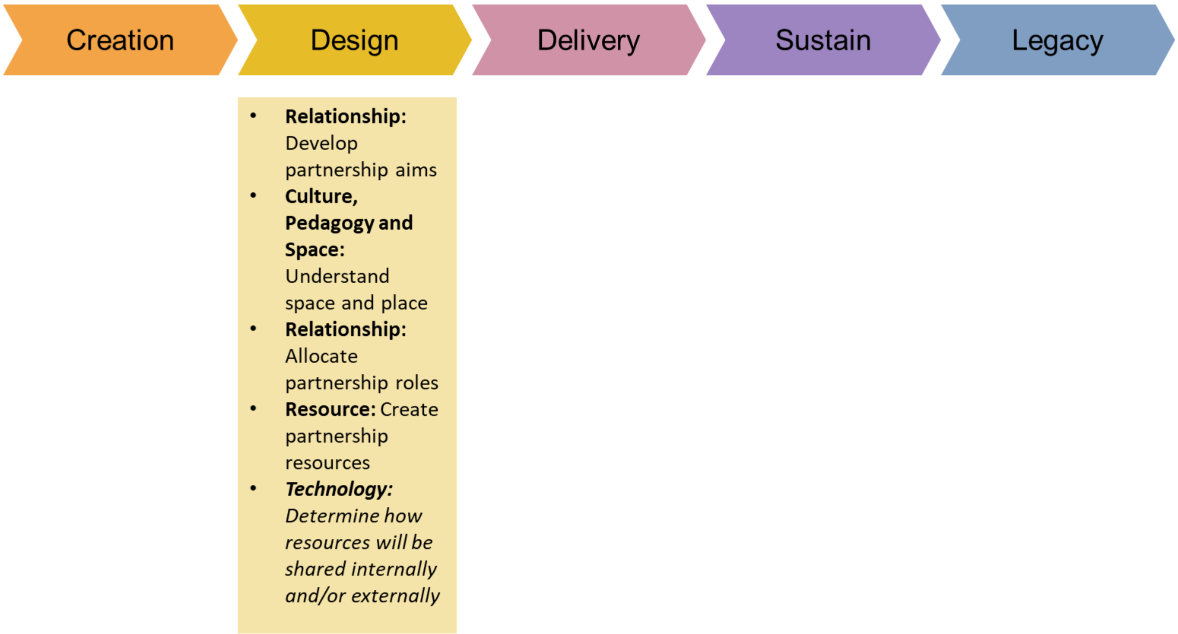


Figure 25. Reconsidering technology in the design stage

6.5.2. The use of technology in schools

A further consideration is the technological environment of the school, which acts as a space for the development of ideas, connection, knowledge and practice across organisational boundaries (Clayton 2016). Firstly, it is necessary to understand the virtual learning environment ecosystem chosen by the school and how this might impact activities centred on computing education.

Schools may be invested in a digital ecology that prevents using other platforms. For example, Microsoft 365 schools may block access to Google suite tools (or vice versa), affecting access to external resources – demonstrating one of the key digital boundaries between schools and external organisations, as noted in Case Study One. Using a VLE acts as a boundary, insomuch as the researcher cannot change the type of VLE used by a school. However, researchers could address this by working with the school to access its VLE in an admin/teacher capacity – bringing their external digital resources to the school through a familiar, approved system. Therefore, the conceptual framework must consider examining the school's digital ecology early in the partnership process to avoid such challenges to partnership activities.

In the physical realm, one must consider the role of technology resources tied to the researcher’s presence. As previously mentioned in the literature review, there is a need for external researchers to consider the introduction and removal of resources when working in schools so as not to introduce opportunities that cannot be replicated once the researcher leaves that environment. Knowing this, I still chose to introduce the ElecFreaks Tinker Kits during both Case Study One and Two, even though their purchasing through UKRI funding as part of my research budget would mean that they could not be left with the school after I finished my research. However, as my understanding developed across the time spent with the school, I pivoted the curriculum development to resources the school would continue to retain access to – the micro:bits by themselves. Considering the school's purchase of new computing equipment as a barrier due to financial constraints, researchers must consider how their work makes use of novel technologies for computing education and how this impacts the legacy of their work through school-university partnerships.

In response to the barriers of time, space and technology – these are unlikely to be within the remit of change in a researcher’s engagement with schools. Therefore, researchers should ideally work to understand the physical, social and technological environment in which they will be conducting their research prior to engaging in the research itself. This might be done through pre-visits to the school, discussions and work with partnered teachers, or potentially supporting other classes in the space to understand the barriers that must be navigated when conducting research in partnership with schools.

Therefore, I propose an amendment to the *Creation* stage of the conceptual framework from Chapter 6, encouraging future researchers to explore the digital ecology of a partnered school in the early stages of the partnership to help frame partnership activities. This is demonstrated in Figure 26 below.

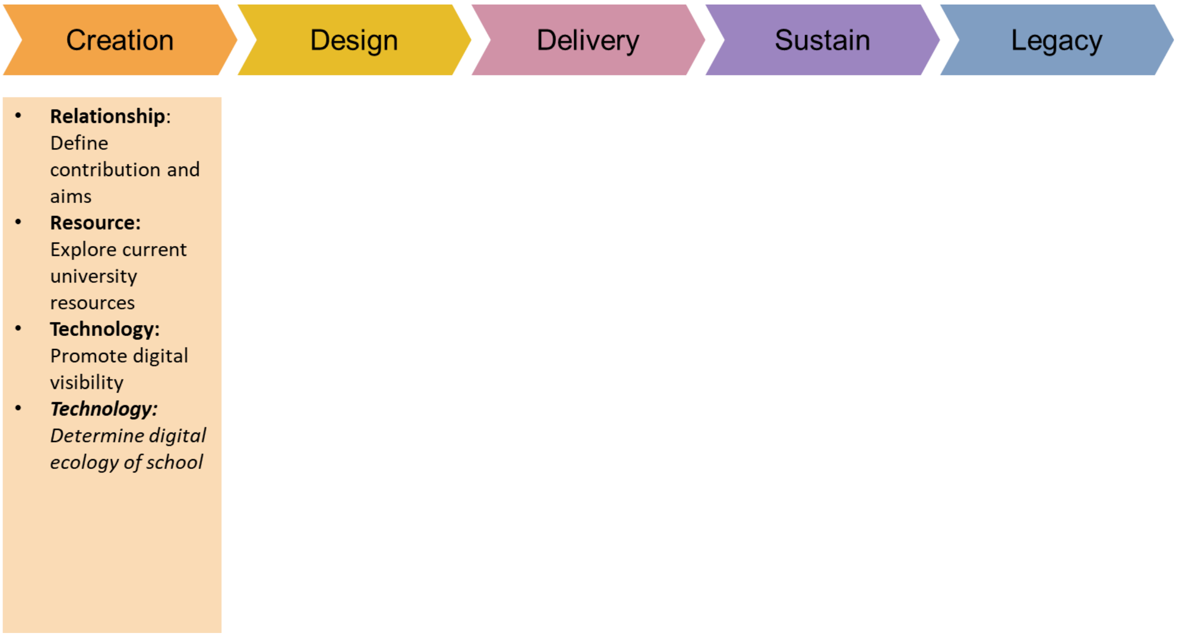


Figure 26. Reconsidering technology in the creation stage

6.6. Research Contributions

Following the discussion of this research, the contributions can be categorised as follows: 1) the documentation of the experience of participating in school-university partnerships for computing education, 2) a conceptual framework to create and sustain school-university partnerships for computing education, 3) a novel approach to computing continuous professional development and 4) a culturally-relevant approach to developing a Key Stage 3 computing curriculum.

6.6.1. The experience of participating in school-university partnerships for computing education

Engagement with computing education is declining in UK schools, attributed to poor support for teachers, limited high-quality resources and poor engagement from pupils. Partnerships were positioned as the method to inject creativity and support for the school subject. However, Chapter 2 notes how there is little understanding of how partnerships can meaningfully contribute to the development of educational practice and resources, often due to a lack of consideration of the experience of those stakeholders involved, particularly where there are social power dynamics in play.

In response, Research Aim A of this research explores the experience of those involved in creating, running and maintaining school-university partnerships and the impact of hierarchical power dynamics upon these relationships. In contributing these experiences, future researchers can utilise the areas outlined in this research throughout the development of their own educational school-university partnerships. Furthermore, this contribution also highlights opportunities and challenges for future researchers to build upon in their own research, such as the development of educational platforms to support the create and resubmit process for resource differentiation or approaches to virtual computing CPD.

6.6.2. A conceptual framework to create and sustain school-university partnerships for computing education

The second contribution of this research is to address the lack of guidance for university partners to engage with schools. While universities are well-positioned to engage schools in support of the computing curriculum due to their access to resource, this can also position them as unilateral knowledge-makers. Research Aim B presents a conceptual model of operational processes to develop equitable school-university partnerships for computing education. This also explores the role of technologies in supporting such processes from a human-computer interaction perspective. This model is split into five stages, with a series of associated activities suggested at each stage, including activities to support the equitable creation, design, delivery, sustainability and legacy of a school-university partnership.

6.6.3. A novel approach to computing continuous professional development

Although not an explicit aim of this research, findings through the Case Studies pointed towards the use of school-university partnerships to support continuous professional development opportunities for non-specialist teachers involved in computing education. Through discussions with partner teachers and findings of my literature review in Chapter 2, current approaches to teacher CPD in computing present several challenges to schools and teachers. There is often a lack of time and money to send teachers to external training, and there are limited opportunities to receive subject-specific training during delivery time. Through this research, I outline how school-university partnerships can include implicit opportunities for subject-specific professional development without a specific focus on discrete training sessions.

However, there are also future opportunities to explore collaborative CPD in school-university partnerships, with a more explicit delineation between partnership activities and professional development but with a focus on mutual exchange. Virtual CPD could provide an opportunity to address the challenge of time and space constraints in schools for teachers and presents an area for Human-Computer Interaction researchers to explore how digital technologies can mediate communication to ensure mutual, equitable learning between partners.

6.6.4. A culturally-relevant Key Stage 3 computing curriculum

Finally, a further contribution of this research is a full Key Stage 3 curriculum aligned to the National Curriculum, aimed to encourage young people to engage with computing education through creativity, digital democracy and outsider expertise.

In my introduction, I noted the challenge of computing when perceived solely as an applicable skill rather than exploring creativity, identity building and socio-political activism (e.g. (Kafai and Vasudevan 2015; Roque, Rusk, and Resnick 2016)). Furthermore, in the literature review of this research, I outlined the emerging interest in culturally-relevant pedagogies to improve engagement with computing through the lens of youth culture and exploration of youth-aligned social movements (Sentance 2021). This school-university partnership acted as a vehicle for pedagogical development, focusing on the transition of Year 8 students from block to text-based programming. This resulted in a computing curriculum with both a *personal* and *cultural* relevance for pupils, which improved engagement towards the subject while addressing key coding standards required by the National Curriculum. It also addresses Ofsted's call to develop semantic wae pedagogy across multiple lessons to infrastructure pupil's learning and engagement regarding abstract computing concepts.

A secondary contribution is a curriculum as a product for other teachers to adopt in their own classrooms. One of the core challenges to the provision of computing education in the UK is the lack of classroom-applicable, high-quality resources. Where these resources exist, they are largely focused on developing concepts and theory without considering the wider world in which these skills are situated. As a contribution to teachers and computing instructors, a product of this research is a 12-week Key Stage 3 computing curriculum focused on developing both practical and creative skills inherent to the study of computing. The developed resources have been shared as an Open Education Resource, such that they can be shared with a wider audience of teachers from a peer-reviewed platform to limit the perception of risk in their adoption.

6.7. Limitations and Future Research

This study explored the partnership between teachers and a researcher to develop a Key Stage 3 computing curriculum within the framing of a school-university partnership.

While this particular partnership focused on developing a partnership between a school and a university, with intentions to improve classroom delivery of computing materials, there is further opportunity to explore school-university partnerships for computing education with different stakeholders and intentions to explore their role in supporting computing education on a national scale. One must consider that a school-university partnership can take different forms depending on those involved from each institution, as school-university partnerships might also take the shape of "trainee computing teachers from a university working with qualified teachers at a school to develop their practices" or "senior leadership working with researchers to define computing policies within their school".

A further limitation which should be considered when interpreting the results provided is that the legacy element research was cut short by the interruption of COVID on education provision – this provides a limitation on two fronts. Firstly, I could not engage with pupils and teachers in the depth possible before the pandemic, meaning that a full saturation of data regarding the legacy of school-university partnerships would have been difficult to achieve. In future iterations, I would also engage the young people more strongly in the design of content to focus on exploring their engagement with their computing education.

Secondly, returning to the impact of coronavirus on my research, was that the pandemic led to huge shifts in the conceptualisation of education, with home learning becoming prevalent to a degree unimaginable during the design and delivery of my original plans. However, this is not only a limitation in the application of my research but also a further avenue of future research in the exploration of how the home-learning technology boom can influence how universities and schools can work together and how this influences relationships between university researchers, school teachers and pupils in a geographically displaced, temporally synchronous mode of delivery for computing education.

Furthermore, this questions the notion of scalability as an ongoing issue when considering the role of universities in supporting computing education across the UK. The ratio of universities to schools is such that a 1-to-1 relationship, like those explored in this body of this thesis, would be impractical and unmanageable across the country at scale. The increasing levels of confidence in the use of conferencing technologies may help address these scalability challenges, presenting future avenues for ongoing research in school-university partnerships for computing education.

The research outlined in this thesis focused on developing and delivering computing education at Key Stage 3. However, this is by no means the exhaustive *fix* required within the field of compulsory computing education. An issue not addressed in this body of research was the impact on young people's attainment in assessing their computing skills, as the scope of this research aimed to explore the creation of an environment to better support computing education. Exploring the impact of school-university partnerships for computing education on pupils' computing skills remains an area of future research. In addition, questions remain about the challenge of gender, race, and disability in accessing high-quality computing education and uptake beyond formal learning opportunities.

Further to these considerations, is the potential limitations due to the realities of working in the education space. In my section on ethical considerations in Chapter 3, I discussed the importance of teacher workload in the design of my research. Teachers have 10% of time allocated to the preparation, planning and assessment (PPA) of their lessons (Department for Education 2011). However, one of the key findings of this research was centred on teachers experience of struggling to find time to participate in partnership activities, influencing their participation in lesson preparation and delivery and choice in teaching materials. In this research, schools encouraged their staff to take part but no further time was allocated for the development of the resources beyond their typical PPA time, acting as a further pressure on teacher involvement. In cases where teacher workload is already high, partnership working may not be possible. During my discussion of the 'experience of schools' I highlight the role of senior leadership as a collective representation of 'The School' – future research may look to explore how senior leadership can be leveraged to address expected responsibilities and availability of partners. However, policies and practices that affect workload may be from factors beyond the control of the school and its leadership team. Researchers looking to replicate and improve upon this research are encouraged to explore the challenging realities of teacher workload and the education environment before outlining possible partnership aims and ensure teachers can be provided the space to participate without further adding to their workload pressure.

Throughout this research exploring the creation, maintenance and legacy of school-university partnerships for computing education, I adopted an Action Research approach paired with a case study methodology, observational diaries, final interviews with partner teachers, final focus groups with students and an exploration of the teaching and learning artefacts produced throughout the iterations. This approach was chosen due to its focus on

A possible improvement to the design of this research is to capture initial perspectives in interviews held at the start of a partnership – helping to contribute towards a joint understanding of the partnership process, but also to use as a point of reflection about the development of researcher-teacher relationships over the period of the partnership. In this research, these thoughts, feelings and perspectives were reported upon retroactively, and further information could be gathered about the very initial stages of the partnership relationship with data collection held earlier in the process.

Furthermore, in Section 3.4.2 I discussed the role of transferability of research, as a response to the critique of qualitative research that could not be generalised to new populations, interventions or settings (Burchett et al. 2013). Guba (1981) recommends purposive sampling, maximising the range of the data carried out. The scale of this research was limited to the North East of England, to 6 computing department staff and select year group of young people, and was not intended to be representative of all potential school-university partnerships for computing education, but provide an initial point of guidance through the formation of the framework and sharing of experience. Future research should look to explore the transferability of these findings to their own experience, contributing to the maximisation of data gathered around school-university partnerships in support of computing education development in the UK.

Earlier, in my presentation of methodology, I noted that research does not exist in a hermetically sealed environment, nor are researchers free from external biases and assumption. It is undeniable that I am a product of my community with views on computing education, with research peers and mentors focused on digital and societal inequalities and the role technology can play in disrupting these hierarchies. The embedded, reflexive, long-term nature of my case studies led to the development of emotional attachment to the research, and the place in which it was taking part. Throughout this research, I have aimed to externalise these thoughts and feelings, to ensure I provide the thick description necessary for future researchers and practitioners to understand my epistemological and methodological perspectives throughout this research.

However, this can be levelled as a critique of this form of qualitative research and revisiting my overview of data trustworthiness in interpretivist research from Section 3.4, stepwise rotation would be an important consideration for the exploration of future work regarding the potential distortion of researcher presence (Cope 2014). Stepwise rotation could see new research teams introduced between iterations to explore how the development of professional relationships between individuals impacts upon the maintenance of school-university partnerships (Onwuegbuzie and Daniel 2003), and explore how partnerships can continue to adapt after key contacts move on from their roles in a partnership, like Teacher2, Teacher3 and Teacher4 in Case Study Two. This can begin to further contribute towards research question A1 and contribute further experiences of stakeholders involved in school-university partnerships for computing education, and test assumptions of suggested processes intended to support the exploration of curricular design and delivery from research question A2.

A further methodological limitation underpinning the fabric of this research is that the nature of a PhD necessitates the work to be completed by an individual in fulfilment of their PhD program, preventing a truly collaborative process of data analysis and interpretation by all partners involved. The presentation of this research and framework was completed by myself as an individual and lacked the pluralist inputs of my partner teachers as equals, where I was granted the final decision in the presentation of interpretations and the places in which these findings are shared. Future work in this area should consider the bounding factors of the academic research process – including data collection, analysis and presentation, as well as . a future area of development, which is the evaluation of the proposed framework with school partners to ensure a mutually beneficial process.

Regarding the role of ecological theory throughout the design of this research, it has been used as a tool to conceptualise, frame and discuss the complex and dynamic influence of actors, environment on the development of knowledge throughout the development, maintenance and legacy of this school-university partnership. It has provided a theoretical basis for the proposed conceptual framework, drawing attention to the elements that can cause tension or be adopted as fulcrum and levers for the benefit of involved partners. However, it is important to acknowledge that an educational ecology is fluid, with varying dimensions that will attract more attention in response to wider political, economic or educational climate. The produced framework is a product of the time, place and space in which it was generated – in providing thick descriptions it is my hope that this initial framework becomes transferable, with the language of ecological theory being a lynch pin to provide continuity in flux. This can begin to further contribute towards research question B1, and further explore how future researchers and practitioners adopt and adapt the proposed model for school-university partnerships for computing education, as well as the role of appropriating and augmenting technologies to support these relationships from research question B2.

With this is mind, I come to the importance and bounding nature of educational policy on computing education design and delivery within an educational ecology. Whilst a school-university partnership may be able to address identified challenges of compulsory computing education in the UK, it will be necessary to examine the political structures and governance which allowed for the introduction and propagation of the subject at a national level. While my research may not offer direct implications for policy discussions, it can offer a much-needed starting point in discussions of ecological resources and relationships which impinge upon the successful delivery of computing education in schools, and the potential for improved pupil outcomes. The framework can offer opportunities for political bodies to work in partnership with schools to gain a realistic understanding of their policy in practice and how these might be best changed to ensure high-quality delivery of computing education in schools, with adequate access to resources and support at a national scale.

6.8. Final Remarks

The research presented in this thesis has proposed an initial conceptual framework for creating, sustaining, and legacy school-university partnerships in support of computing education in the UK. By synthesising existing literature, I have drawn upon educational partnership and HCI research to offer a new approach for universities and schools to address current challenges of computing education, such as lack of engagement and poor support for teachers. Through four distinct case studies, this research presents the beginnings of a conceptual framework to support universities in developing and participating in equitable school-university partnerships for computing education.

Case Study One covers the creation of the partnership with teachers at a local secondary school who approached the university to explore methods of supporting Year 8 pupils to transition from block-based to text-based programming. Through the lens of project-based learning, we jointly developed an initial curriculum that saw young people design and deliver computing projects to deliver back to the university. The findings of this case study demonstrated the challenges of early partnership working, the restrictions imposed by accountability in educational delivery and the constraints of working in a school environment. However, this case study also demonstrates how the school-university partnership process could contribute to subject-specific upskilling for partner teachers that could be practically applied in the classroom, addressing the current critique of computing continuous professional development (Neutens and Wyffels 2018).

Case Study Two saw a further exploration into the pedagogical design of the initial curriculum, building upon the insights gained from the first iteration. Adopting a design studio approach, pupils were required to respond to a chosen challenge area and continuously develop a computing portfolio across the project's duration. Pre-existing perceptions and wider school culture led to the termination of this iteration in the classroom, yet contributed important findings regarding the challenge of complacency in maintaining partnerships, the importance of ongoing communication and the impact of an existing environment on behaviours and attitudes in partnership activities. It also began to contribute novel pedagogical approaches to compulsory computing education in schools, drawing upon research and practice in higher education to encourage creativity and confidence for computing pupils (Reimer and Douglas 2003; Koutsabasis et al. 2018).

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Appendices

Appendix A. Information and consent sheets

A1. Pupil information and consent sheets for Case Study One

The "Computing of the Future" Challenge

Open Lab, Urban Sciences Building,
1 Science Square,
Newcastle upon Tyne,
NE4 5TG
Tel: 0191 277 7849

Dear Parents/Guardians,

My name is Megan Venn-Wycherley, and I am the lead researcher for the "Computing of the Future" Challenge between Newcastle University and Ivy Community College. As part of the Year 8 computing curriculum, your child is working towards creating a project that responds to the challenge "*How can we use the BBC Micro:bit and your computing skills to help disabled people in everyday life*?".
The research project looks to understand how the role of the university impacts student engagement and enjoyment of computing. Therefore, we are asking for your consent to:

- Access the outcomes of your child's baseline, formative and exit test which assesses improvement of understanding of computing concepts
- Allow your child to participate in a focus group at the end of the course, which will help redesign the process for the next group of students who will take part in the challenge.

The data will be used to help the university to learn about how we can continue to improve this process. The data will be anonymized and stored on a secure server at Newcastle University, and used to inform our ongoing research into improving computing education in Newcastle.
If at any point during or after the process, you or your child wish to withdraw your data, please contact the researcher at m.venn-wycherley@ncl.ac.uk. You do not have to provide a reason for wanting to withdraw the data and no questions will be asked about your reasons for withdrawal. The data will be deleted and will not affect your child's participation in the challenge.
Warm regards,
Megan Venn-Wycherley
Lead Researcher of the Computing of the Future Research Project
m.venn-wycherley@ncl.ac.uk
If you **do not** wish your child to participate in this research study, please sign and return this form.

Name of Child (Print): ……………………………………………………………………………………………………

Parent/Guardian Signature:………………………………………………………………………………………….

A2. Amended Pupil Information and Consent Sheets for Case Study Three

The Micro:Vote Research Project

Open Lab, Urban Sciences Building,
1 Science Square,
Newcastle upon Tyne
NE4 5TG
Tel: 0191 277 7849

Dear Parent/Guardian,

My name is Megan Venn-Wycherley, and I am the lead researcher for the "MicroVote Research Project" between Newcastle University and Ivy Community College. As part of the Year 8 computing curriculum, your child is working towards creating a digital poster to engage the school community around local issues and challenges.

The research project looks to understand how the role of the university impacts student engagement and enjoyment of computing. Therefore, we are asking for your consent to:

- Access the outcomes of your child's baseline, formative and exit test which assesses improvement of understanding of computing concepts
- Allow your child to participate in a focus group at the end of the course, to redesign the process for the next group of students who will take part in the challenge.

The data will be anonymized and stored on a secure server at Newcastle University, and used to inform our ongoing research into improving computing education in Newcastle. If at any point during or after the process, you or your child wish to withdraw your data, please contact the researcher at m.venn-wycherley@ncl.ac.uk. You do not have to provide a reason for wanting to withdraw the data and no questions will be asked about your reasons for withdrawal. The data will be deleted and will not affect your child's participation in the challenge.

Warm regards,
Megan Venn-Wycherley
Computer Science Education Researcher, Newcastle University
m.venn-wycherley@ncl.ac.uk

Please sign and return this form if you are happy for your child to participate in this research study.

Child's Name (Print): ………

Your Name (Print): ………

Signature:……

Date: ……

A3. Teacher Information and Consent Sheets (all case studies)

My name is Megan Venn-Wycherley, and I am requesting your consent to be involved in my current research project, which aims to explore how the university can participate in meaningful educational partnerships for computing education, and explore how technology might facilitate this process. These aims will be addressed through the following research questions:

1. How can universities and schools work in partnership to explore curricular design and delivery for computing education?
2. What are the experiences of the stakeholders involved in university-school partnerships for computing education?
3. How can we use digital technologies and resources to create and sustain meaningful university-school partnerships for computing education?

There are three elements to this study: 1) An initial chat, to understand your current experience of the computing curriculum, support strategies and intended outcome for the partnership, 2) a journal-keeping exercise to understand your experiences of participating in the university-school partnership for curricular design and 3) an individual exit interview to discuss your experiences in the project, and your thoughts towards the redesign of the process for future iterations.

All collected data will be anonymized and stored on a secure server at Newcastle University, and used to inform our ongoing research into improving computing education in the North East. The overall, anonymised results of this research may be used in future research publications.

If at any point during or after the process, you wish to withdraw your data, please contact the researcher at m.venn-wycherley@ncl.ac.uk. You do not have to provide a reason for wanting to withdraw the data and no questions will be asked about your reasons for withdrawal. The data will be deleted and not used for any future publication. This will not affect your access to the curriculum materials designed or developed as part of this process, as they are to be considered Open Educational Resources.

Warm regards,
Megan Venn-Wycherley
Computing Education Researcher
m.venn-wycherley@ncl.ac.uk

Please read the information below and provide information where required. Print and sign your name at the bottom to demonstrate that you have understood taking part in this research.

1. I voluntarily to participate in this research
2. I understand that I can withdraw my consent at any point. There will be no penalisation for my withdrawal and I will not be asked why I have withdrawn. All my data will then be removed from the study.
3. The use of the data in research and publications has been explained to me.
4. I understand that other researchers may have access to this anonymised data if they agree to preserve the confidentiality of the data and if they agree to the terms specified in this form.
5. I understand that the data will be stored on a secure server at Newcastle University
6. I understand that the data will be anonymised

Name (Print):
……

Signature:…….

Date:
……….

Appendix B. Ivy Community College Background Materials

B1. Initial wish list

Project Based Learning Plan

Course, unit & topics:	Key Stage 3 Computer Science
Year group & approx amount of students:	Year 8: 190 students approx.
Timeframe:	12 weeks - Carousel basis (2 classes each rotation) 2 x bottom sets withdrawn and follow alternate SOW
Lesson per week:	1
Project:	Student led

The Big Issue
Teaching staff are unfamiliar with Computing knowledge and struggle to deliver activities beyond block based programming. Year 8 requires text based programming. Many members of the department are not confident in delivering Computer Science, particularly those that did not previously specialise in ICT, but Business instead. Students in Year 8 only have one lesson of Computer Science per week which doesn't offer much scope for in depth learning of programming.

The Big Picture
Students will develop their algorithmic thinking and programming skills while focussing on a solution to a real world problem. The key focus will be on the development of a program using the BBC Microbit that focuses on a real world problem that the students will decide, with some input from Newcastle University. They will work collectively and independently throughout the project to develop programming skills in Python (text based) using the BBC Microbit with support from members of Newcastle University R&D. *Staff will also be supported in the delivery of content for a number of lessons to improve their confidence and abilities.*

Links to the Curriculum	
Unit.Topic	**Delivery Content**
	A. Abstraction B. Algorithmic thinking a. Sort

	b. Search C. Design Programs including flow diagram and algorithms D. Understand Boolean logic H. Use two or more programming languages (1 must be text based) I. Arrays J. Functions K. Create complex programs L. Use Boolean logic M. Use data types

Project Outline Idea
At the start of the 12 week program students will visit Newcastle University to build the foundations of the project and work with members of the NU R&D team to consider possible real world problems that could be solved using the BBC Microbit and establish a plan for what they will program in the upcoming lessons. The following 10 weeks will focus on developing a solution to their problem using the BBC Microbits while learning to code and understand key programming terms such as input, output, variable, constant, data types, constructs (selection, iteration, sequence) and arrays. At the end of the program students will showcase their work in a celebratory event at the University where parents/carers of the students will be invited.

Appendix C. Data Collection Materials

C1. Teacher interview schedule

Tell me a little bit about your experiences in taking part in this project. What do you feel was the most beneficial part of taking part of this project? What motivated you to take part initially? What would you change about the project?

Did you have previous experience with the BBC Micro:bit? How do you feel about them now? What are your thoughts about using them in the classroom to teach computing?

How involved did you feel throughout the project? Did you feel like you had influence over your school's involvement in the scheme? How do you feel about this? Would you like to have more input on your school's involvement?

How do you think your pupils felt about the project? Were there any noticeable differences in their behaviour/engagement during/after the lesson? Did you feel like you were able to support the pupils?

What is your typical process of designing or implementing a computing curriculum? What factors impact your curricular design or implementation (e.g. space, time, place, number of students) and why?

Have you ever worked with any external parties in curriculum design or delivery? This might be an external company, organisation, school or teacher. How and why were these parties chosen?

What are you previous experiences in interacting with a university around computing education? This might have been CPD, outreach, assemblies etc. What was the content delivered? What impact did this have? How were these experiences set-up, and were they sustained? Why? Why not?

What *should* the university be doing to support computing education in its local community? How can it help in ways it currently does not? How might it approve on its current approach?

Have you conducted any other form of training with the introduction of the new computing curriculum? This could be online in your own time, in CPD sessions, or formal training. If so, please describe

What are your current experience of the national computing curriculum? What are the challenges, benefits and opportunities it provides? Do you think these factors differ between pupils and teachers? How?

What forms of support do you use in teaching? These might be colleagues, online forums, technologies, books etc. What are the benefits of accessing support in this way? What are the challenges?

What are you hoping the outcome of implementing the micro:bit curriculum will be? What would "success" look like to you personally in participating in this work?

C2. Teacher interview schedule – Case Study Four

What are your current experiences of teaching the micro:vote computing curriculum? What are the challenges, benefits and opportunities it provides?

If you noted any challenges, how might these be addressed?

Have your perceptions of the micro:vote curriculum changed since you were first introduced to this research? How? Why?

Have you changed any areas of the materials? If so, provide some further details. This might have been to differentiate materials for different abilities, or update materials to be in line with school policies.

Do you feel this curriculum currently meets the needs and standards expected of school policy and the national curriculum? How might this be improved?

How have pupils engaged with micro:vote? Have there been any observed changes in their classroom behaviour?

What forms of support do you use in teaching the micro:vite curriculum? These might be colleagues, online forums, technologies, books etc. What are the benefits of accessing support in this way? What are the challenges?

What would be the challenges in scaling this curriculum to new schools What advice would you provide to them on adopting these materials and approach?

What would your advice be to universities on becoming engaged in supporting computing curriculum development, resources and materials?

C2. Pupil survey – Case Study One

What did you find most fun about taking part in the project? Give as much detail as you can.

Did you ever take a micro:bit or Tinker Kit home? What did you think about it?

Do you think we should keep offering students the opportunity to borrow the kits? Why?

What would you recommend for us to change about the project? Explain why.

Do you have any suggestions about what you would like to see as part of the project? (e.g. Is there something in particular you would like to learn?)

If you could recommend one thing to completely remove from the project, what would it be and why?

Do you think computing skills will be useful to you in the future? Why?

Do you have any other thoughts or comments about your computing lessons that you would like to share?

If you have time, Megan would really like you to share a few of your experiences in more detail. She can either use your answers above, or you can write another paragraph. This is optional! Write a short paragraph about your experiences on the School Observatory project. What did you love? What would you change? What has it been like to work with the university? Do you have any suggestions for the types of computing projects the university should offer next?

C3. Pupil focus group question schedule – Case Study Two

1. What did you enjoy about the project
    a. What are the benefits? The important things you want to keep? What was your favourite thing you learned?
2. How did you feel taking part?
    a. What emotions did you feel?
3. What is one thing you learned?
    a. What have you learned from taking part?
4. If you could add or change something to the project, what would it be and why?
5. What was one thing that went wrong with the project?
6. If you had to sum up the challenge we completed, how would you describe it?
7. What do you think about taking part in this focus group?

C4. Pupil survey – Case Study Three

Note: pupils were asked what they thought of each if the following elements of the Micro:Vote project: Idea Creation, Micro:bits, Tinker Kits, Posters, Visit

a What did you enjoy about this stage? Think about: benefits, value, positive aspects, strengths

b How did you feel taking part in this stage? Think about: feelings, emotions

c What did you learn from this stage? Think about: facts, information, data, computing concepts

d What would you add or change about this stage? Think about: creativity, alternatives, possibilities, opportunities, recommendations

e. What was difficult about this stage? Think about: difficulties, risks, weaknesses

What did you think about the research challenge: "MicroVote for improving your school environment"?

What was it like to work with the university? What did you enjoy? What could be improved?

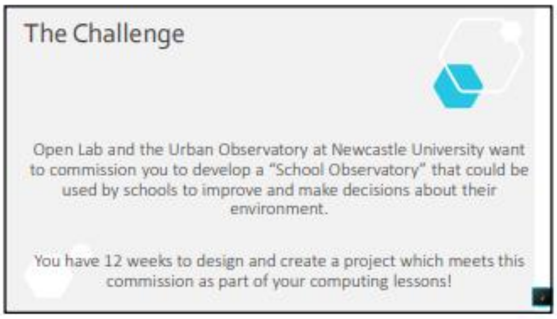
Appendix D. Teaching and Learning Artefacts

D1. Excerpt of Visit Day Slides

1

2

3



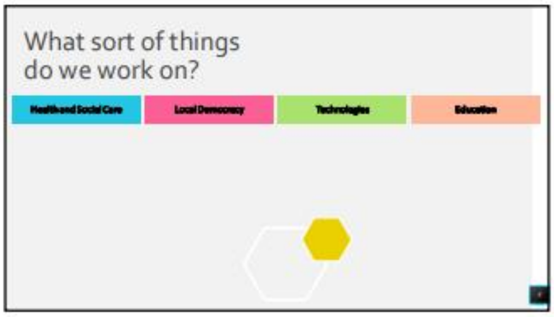
4

5

6


What is Open Lab?
We are a computing research group, and our work focuses on how we can use computing and technology to respond to challenges in society.
We look at how we can use our computing skills to help citizens and communities improve the quality of life.

7


What sort of things do we work on?
Health and Social Care
Local Democracy
Technologies
Education

8


What sort of things do we work on?
Health and Social Care
Local Democracy
Technologies
Education
Dementia VR – Create a virtual reality experience for people with Dementia, helping them to remember past memories

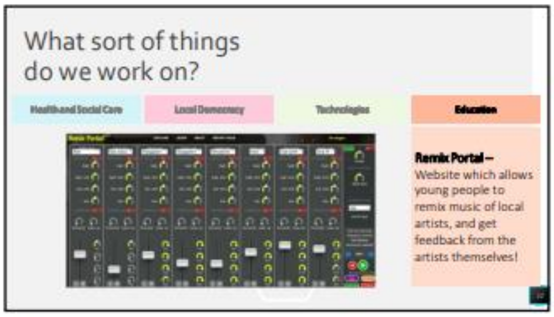
9


What sort of things do we work on?
Health and Social Care
Local Democracy
Technologies
Education
PosterVote – community voting system, with 5 lights and 5 buttons, to understand what a community thought about an issue

10


What sort of things do we work on?
Health and Social Care
Local Democracy
Technologies
Education
AppMovement – Website which allowed a community, with no technical skills, to create location based apps

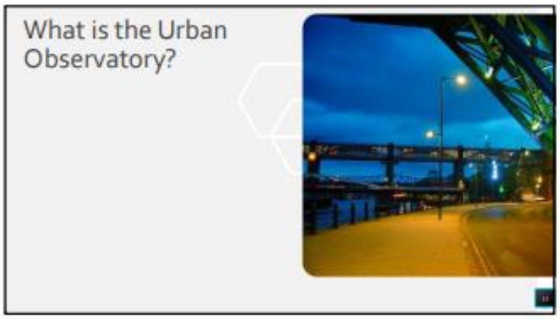
11


What sort of things do we work on?
Health and Social Care
Local Democracy
Technologies
Education
Remix Portal – Website which allows young people to remix music of local artists, and get feedback from the artists themselves!

12

13

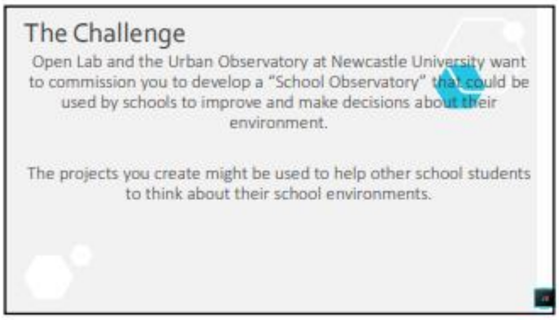
14



15

16

17



18

The Challenge

Observatory:

"a room or building housing an astronomical telescope or other scientific equipment for the study of natural phenomena"

"especially a place equipped with a powerful telescope for observing the planets and stars."

19

The Challenge

Observatory:

"a school housing lots of different micro:bit projects to help improve school environments and communities"

20

1. Develop a proposal

- What problem are you going to tackle? How did you decide on this problem?
- What elements of the micro:bit are you planning to use? Which accessories?
- What kind of knowledge are you going to need to implement your project?
- Keep a record of your code, with comments explain your decisions!

21

2. Develop a project

Basic

- Be developed using the python programming language
- Use the BBC micro:bit as a central part of the project
- Be able to read in data from the environment (this could be sensed data, or from interaction from a user) and provide some kind of response to this data
- Keep a record of your design and code decisions.

22

2. Develop a project

Intermediate

- Provide a way to sort the stored data
- Search the stored data
- React to the stored data

23

2. Develop a project

Advanced

- Provide networking between micro:bits

24

3. Panel of experts - November

Each team will present their project ideas to a panel of experts for five minutes. These will be members of the community, the University, and local businesses. You will explain how your design meets the brief given by Newcastle University and the experts will give feedback on your designs and your project pitch.

25

4. Exhibition - December

The final part of the project will involve presenting your ideas back to Open Lab and the Urban Observatory at a trade fair based at the Urban Science Building. You will present your project to a range of interested members of the community, local businesses and researchers at the university

26

D2. Excerpt from Case Study One Slides

The School Observatory Challenge
Week 4: Starting the project

1

Proposal Section – **DONE!**

Week	Topic
Week 1	Starting the proposal
Week 2	Finishing the proposal
Week 3	**Baseline Test**

2

Starting our projects

Week	Topic
Week 4	Project Time
Week 5	Project Time
Week 6	Project Time
Week 7	**Present your projects to a different pair and get feedback (not finished!)**

3

Responding to feedback

Week	Topic
Week 8	Project Time
	Holiday!
Week 9	Project Time
Week 10	Project Time
Week 11	**Coding test**

4

Make sure all tests are done!

Week	Topic
Week 12	Project Time
Week 13	Must have tested your project and responded to test outcomes
Week 14	**Panel of experts**

5

Showing off your projects!

Week	Topic
Week 15	Redesign the School Observatory Project!
Week 16	**University Trade Fair**

6

Documenter

In charge of keeping track of your project.

What happened in the lesson, did you follow your plan? What did you achieve? What did you enjoy most? Who did what in your team? Were there any problems? Why?

Important life skill!

19

Tutorials

Project tutorial sheets will be available on google classroom, starting on 3rd October. Each week we will release more tutorial sheets. You get to decide which tutorial sheets you want to follow, and will help support your project.

20

Tutorials

topic 1 "Display": premade images

ABOUT	SKILLS	YOU NEED
Program your micro:bit to show a sequences of pre-made images	• Displaying images • Sequencing • Pauses	• A micro:bit

What the tutorial is about, what skills you learn, and what equipment you need

21

Tutorials

1. What are premade images?

The micro:bit can use its screen to display premade images. These images were created by other programmers, and we can access them by using `from micro:bit import *`.

We might use premade images to display what the micro:bit is completing an action, or create simple animation. Sometimes it's easier to use something that's already made!

Information about the tutorial, where and how the topic can be used

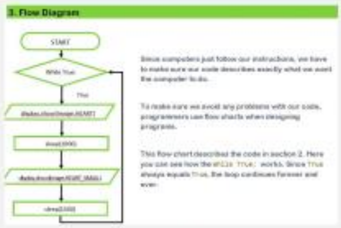
22

Tutorials

Code example, with step by step instructions and a downloadable python version of the code

23

Tutorials



Flow diagram of the example code, and a description of any interesting code choices

24

3. Testing

Testing is the process that allows us to make sure our solution does the job it has been designed to do and to think about how it could be improved.

Use your flow diagrams to help you test!

13

4. Marketing!

At the trade fair there'll be lots of projects, how are you going to show off what you've done?

You should design an A4 poster that you'll show off at the trade fair at the University. It should communicate what your project does and why. How do you use your project? How did you test it?

14

Programmer

Writes and comments the code.

Both of you should be in charge of programming different elements of the project!

Important coding skills, but also helps you think about things in a more logical way, and helps you solve problems (even when problems not involved!)

15

Designer

Designs the flow diagram for the project.

Responsibilities also include preparing the trade fair poster.

Important skills if you're interested in design! Similar skills used in marketing, fashion design, product design

16

Test Writer

Using the developed flow diagram and proposal, writes a series of tests to prove your project does not have any bugs, and works as you expected.

A **very** important skill if you're interested in developing video games!

17

Code Evaluator

Follows the test plan and writes down the outcomes for the programmer to be able to fix.

Also a **very** important skill if you're interested in developing video games!

18

Where we are now:

Week	Topic
Week 4	**Project Time**
Week 5	Project Time
Week 6	Project Time
Week 7	**Present your projects to a different pair and get feedback**

7

What are you doing for the rest of this lesson?

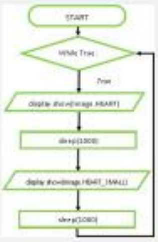
Go to the "Project Overview" document on Classroom, and use it to:

- Plan your project (doesn't have to be perfect, you can change as you go along!)
- Decide on your roles in the project
- Start coding!

8

1. Design a project flow diagram

Programmers use flow diagrams to outline what their programs will do, but also help people like testers and users understand the program they have made.



9

2. Develop a project

Basic

- Be developed using the python programming language
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10

2. Develop a project

Intermediate

- Provide a way to sort the stored data
- Search the stored data
- React to the stored data

11

2. Develop a project

Advanced

- Provide networking between micro:bits

12

topic 3 "Input": Buttons

ABOUT	SKILLS	YOU NEED
Program your micro:bit to respond to A and B button presses	• Inputs • Conditionals • Boolean Logic	• A micro:bit

1. How do we code the buttons on the micro:bit?

The buttons on the micro:bit are a form of **input**. Inputs are a way to supply information to the computing system, and are usually a way of deciding what actions a program will take. Inputs which help use decide the flow of our program are called **conditionals.**

2. Code - "buttons.py"

Here we have three **conditions** the micro:bit can follow. We check to see if: 1) The A button has been pressed, 2) The B button has been pressed 3) No buttons have been pressed. Then the program has been programmed to respond, depending on which input was chosen. In plain English, this code says:

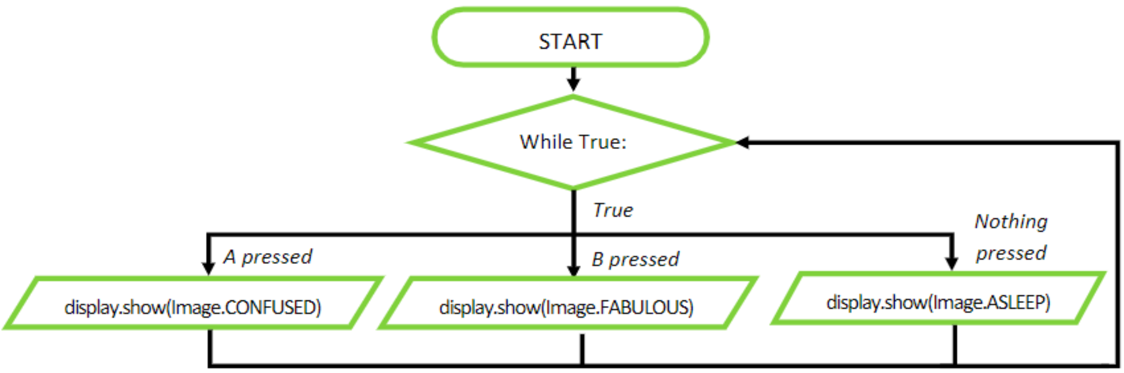
```
1  from microbit import *
2
3  #Loop forever
4  while True:
5      #If button a is pressed
6      if button_a.is_pressed():
7          #Show a confused face
8          display.show(Image.CONFUSED)
9      #else if button b is pressed
10     elif button_b.is_pressed():
11         #Show a fabulous face
12         display.show(Image.FABULOUS)
13     #else if nothing is pressed, show an
14     #asleep face
15     else:
16         display.show(Image.ASLEEP)
17
```

"If button A is pressed, show a confused face.

Else if (`elif` on line 10 is the way the micro:bit understands else if!) button B is pressed, show a fabulous face.

If no buttons are pressed, then the micro:bit will show an asleep face".

3. Flow Diagram



Here our flow diagram is really useful! We can trace through each of the outcomes of the program, depending on which input is chosen, or if no inputs are chosen at all.

4. Extra Code “if_and.py” “if_or.py” “if_not.py”

`is_pressed` can only produce two results: either the button has been pressed (which the micro:bit understand that `is_pressed` is True) or the button hasn't been pressed (and `is_pressed` is False). So, if you're pressing one of the buttons it returns True, otherwise it returns False.

So what happens if we want the micro:bit to respond to two buttons at the same time?

Python uses special programming keywords to check multiple conditions, which can produce True or False results:

```
while True:
    #If button a and button b are pressed
    if button_a.is_pressed() and button_b.is_pressed():
        #show a confused face
        display.show(Image.CONFUSED)
    else:
        #show an asleep face
        display.show(Image.ASLEEP)
```

1) and

Using this keywords means that both A and B buttons have to be pressed for the confused face to show up on the micro:bit. We use this is we want two conditions to be True before making a decision.

```
while True:
    #If button a or button b are pressed
    if button_a.is_pressed() or button_b.is_pressed():
        #show a confused face
        display.show(Image.CONFUSED)
    else:
        #show an asleep face
        display.show(Image.ASLEEP)
```

2) or

Here, either A or B can be pressed to show the confused face. We use this if we want multiple ways to trigger the same line of code inside an if statement.

```
while True:
    #If button a or button b are pressed
    if not button_a.is_pressed():
        #show a confused face
        display.show(Image.CONFUSED)
    else:
        #show an asleep face
        display.show(Image.ASLEEP)
```

3) not

We use `not` to flip what the if statement is asking. Here, if the A button is `not` pressed, *then* we see the confused face. We use `not` if we want the micro:bit to `not` respond to an input.

4. Activities

Copy out the code in section 2.

1. What happens if you press both A and B buttons very quickly?
2. Can you add an option to the end of the “if.py” code that will let you press A and B to show a different image?
3. What happens if you add more if statements to your code? Add one for `or` and one for `not`, and decide on what your micro:bit will show. Make sure each image or output you choose is different, so you can see how your micro:bit reacts. Remember to use `elif`!

topic: three "Outputs": LEDS

3. Dimming Lights - "dim.py"

```
1 # Add your Python code here. E.g.
2 from microbit import *
3
4
5 while True:
6     #Read in the angle of the
7     #rotation switch (which can be
8     #0 to 1023) and store it in a variable
9     #called brightness
10     brightness = pin3.read_analog()
11     #Send the value of the brightness variable
12     #to the LED attached at pin1
13     pin1.write_analog(brightness)
14
```

Keep your LED attached to pin 1, and attach the rotation switch to pin 3. Copy this code, download it to your micro:bit. What happens when you turn the rotation switch?

This code uses `while True:` to create a program which loops forever and ever. The code that's pushed in slightly (indented), is the code which is going to get repeated—the code that controls our LED.

Line 10 asks if anything is plugged into pin 3 (using the yellow wire), and to store the number in a variable called "brightness". We can imagine "brightness" to be like a box, with a label, which will store numbers we can use in our program.

Since we ask to `read_analog()`, pin 3 can send a number between 0 and 1023 depending on the angle of the rotation switch. We use **Analog** to send data which continuously changes, like levels of light or music.

On Line 13 we take whatever is in our "box called brightness", and we send it to our LED at pin 1 by using `write_analog(brightness).`

Since these instructions are in a loop, you can increase the brightness and decrease the brightness of the LED as often as you like!.

4. Dimming Lights—Activities

Now we can control our lights, and get them to dim! How about trying:

- To replace the word "brightness" on line 13 with a number between 0 and 1023? Try a small number, then try a big number!
- Change all "brightness" to say "tomato" instead. What happens?

topic: three “Outputs”: LEDS

ABOUT

Control your Tinker Kit LEDs

SKILLS

- Analog vs Digital
- Outputs
- Variables

YOU NEED

- A micro:bit
- A Tinker Kit board
- A Tinker Kit LED (in a colour of your choice)
- Tinker Kit Rotation Switch

1. Light Switches—are they magic?

How do light switches actually work?

We know we press a button, and they turn a light on and off. Sometimes we twist a switch and we can gradually make the light brighter or dimmer.

But how does the light bulb know what to do?

2. The Simple On/Off— “digital.py”

```
1  from microbit import *
2  #Forever
3  while True:
4      #Turn the light on
5      pin1.write_digital(1)
6      #Wait 1 second
7      sleep(1000)
8      #Turn the light off
9      pin1.write_digital(0)
10     #Wait 1 second
11     sleep(1000)
12
```

Attach your LED to pin 1, and then copy this code. Download it on to your micro:bit. What does it do?

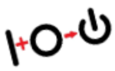
This code uses `while True:` to create a program which loops forever and ever. The code that’s pushed in slightly (indented), is the code which is going to get repeated—the code that controls our LED.

Line 5 - `pin1.write_digital(1)` - tells the micro:bit what kind of information to send and where we send it to.

`Pin1` tells the micro:bit to send the information to Pin 1 on the Tinker Board, where your LED should be plugged in.

`write_digital` is the way we send information - **Digital** only lets us send 0 or 1s, and we use them if we want to send lots of information with a low risk of error. We use digital signals to program computers, phones and other digital devices.

Digital signals can only ever be 0 (off) or 1 (on). Take a look at an on/off button symbol, they’re actually made up of a ‘1’ and a ‘0’ representing on/off option of a computer!



`1` tells the light it needs to turn on - `1` acts like an instructions for “full power”. On line 9, when we send `0`, we tell the LED to turn off.

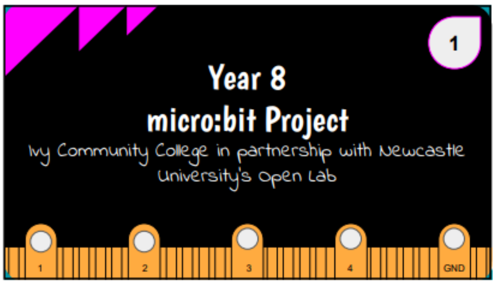
Since these instructions are in a loop, the light will keep turning on and off forever (or until the micro:bit is turned off)

3. The Simple On/Off Activities

If your lights blinked on and off forever, it would probably get irritating very quickly! So how can we control them?

How about adding in an ‘if statement’ which checks for an “a button press” to turn the light on, and another “if statement” which checks for a “b button press” to turn the light off?

D4. Excerpt from Case Study Two lesson slides



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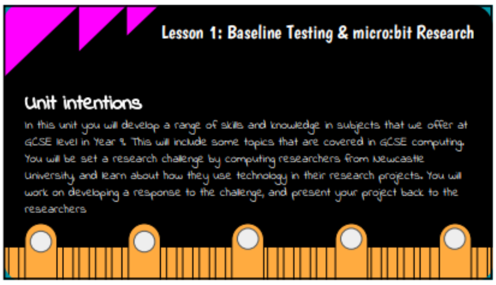

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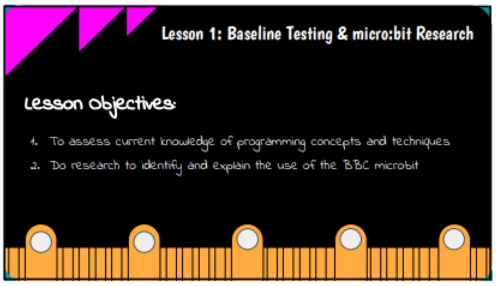

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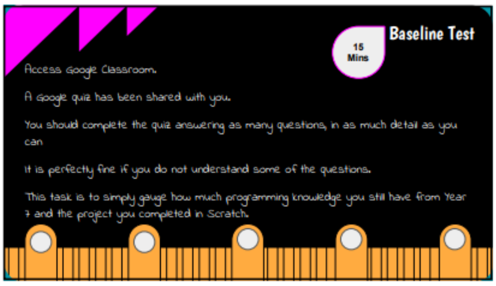

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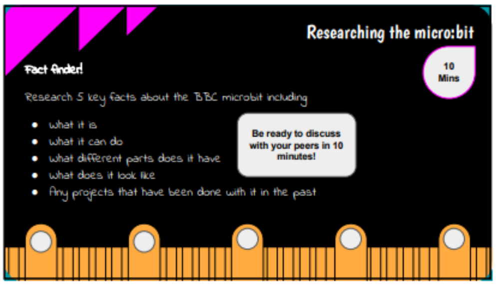

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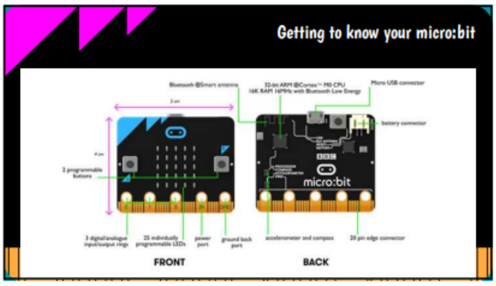

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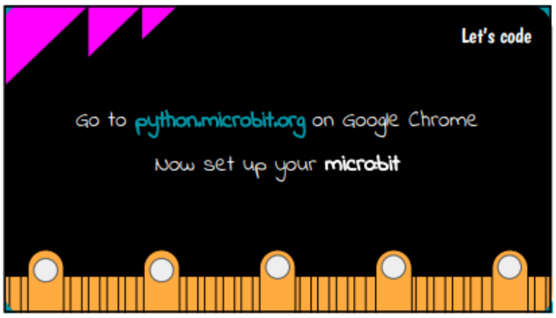
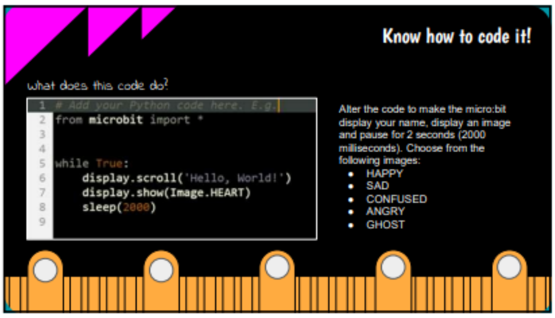
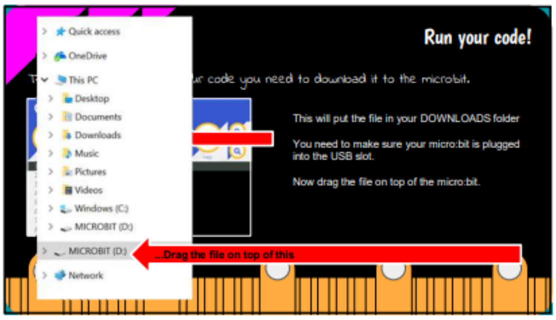

Let's code
Go to python.microbit.org on Google Chrome
Now set up your microbit

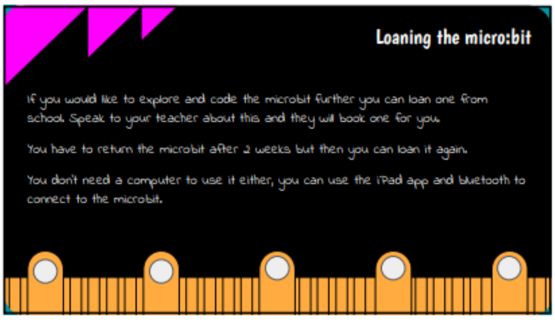
7


Know how to code it!
what does this code do?
# Add your Python code here. E.g.
from microbit import *
while True:
display.scroll('Hello, World!')
display.show(Image.HEART)
sleep(2000)
Alter the code to make the micro:bit display your name, display an image and pause for 2 seconds (2000 milliseconds). Choose from the following images:
HAPPY
SAD
CONFUSED
ANGRY
GHOST

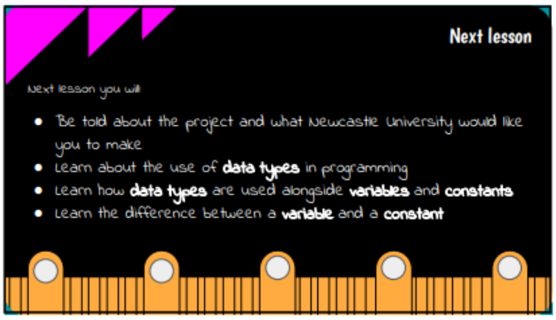
8


Run your code!
Quick access
OneDrive
This PC
Desktop
Documents
Downloads
Music
Pictures
Videos
Windows (C:)
MICROBIT (D:)
ur code you need to download it to the microbit.
This will put the file in your DOWNLOADS folder
You need to make sure your micro:bit is plugged into the USB slot.
Now drag the file on top of the micro:bit.
MICROBIT (D:)
...Drag the file on top of this
Network

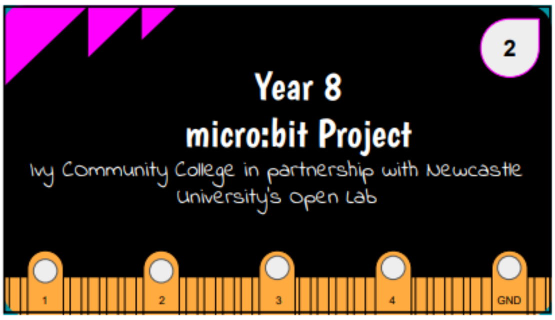
9


Loaning the micro:bit
If you would like to explore and code the microbit further you can loan one from school. Speak to your teacher about this and they will book one for you.
You have to return the microbit after 2 weeks but then you can loan it again.
You don't need a computer to use it either, you can use the iPad app and bluetooth to connect to the microbit.

10

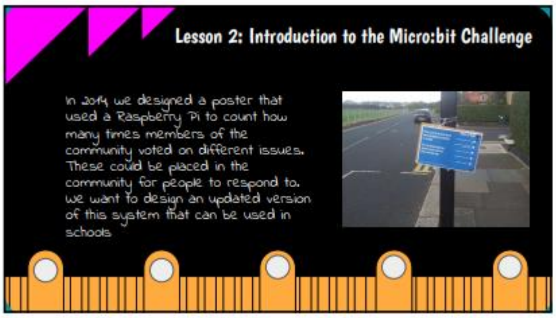

Next lesson
Next lesson you will
Be told about the project and what Newcastle University would like you to make
Learn about the use of data types in programming
Learn how data types are used alongside variables and constants
Learn the difference between a variable and a constant

11


2
Year 8
micro:bit Project
Ivy Community College in partnership with Newcastle University's Open Lab
1
2
3
4
GND

12

13



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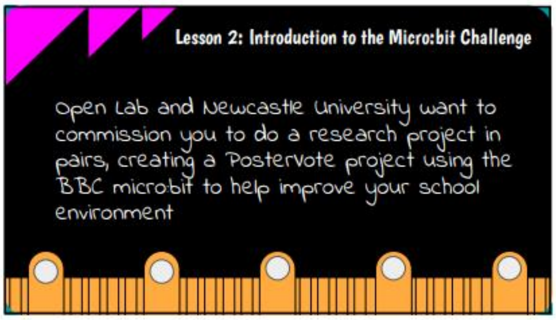

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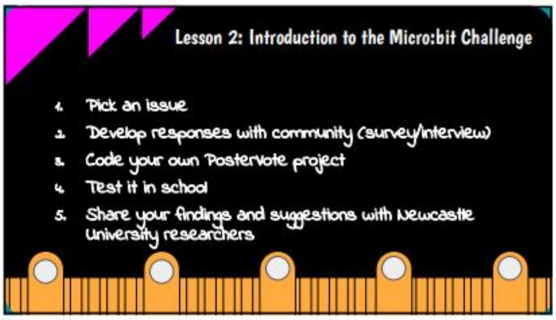

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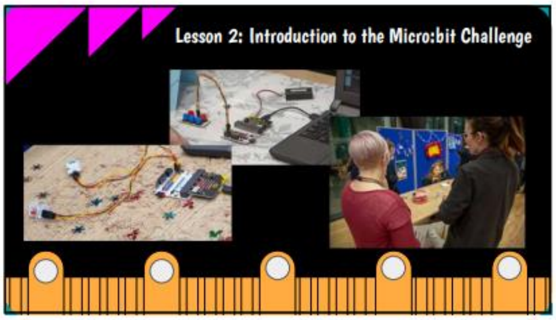

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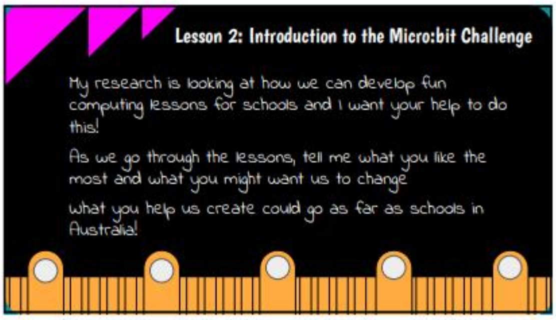

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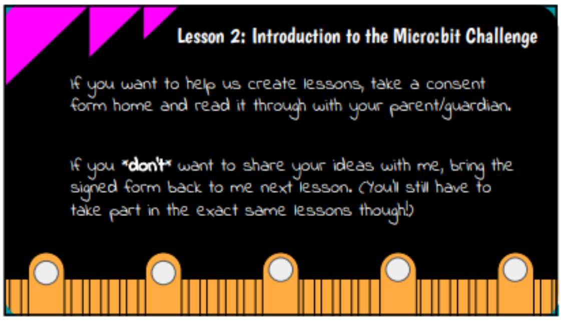

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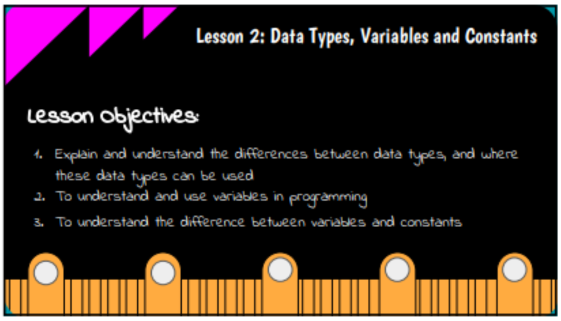

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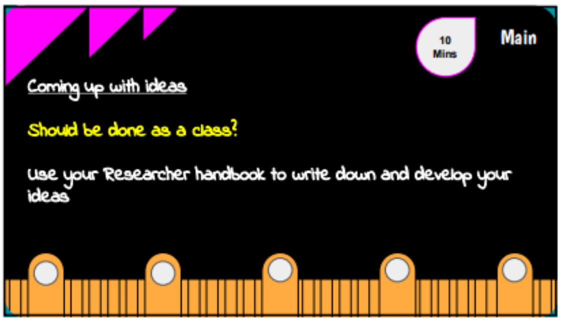

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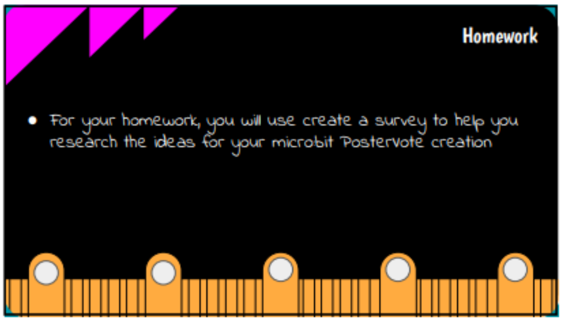

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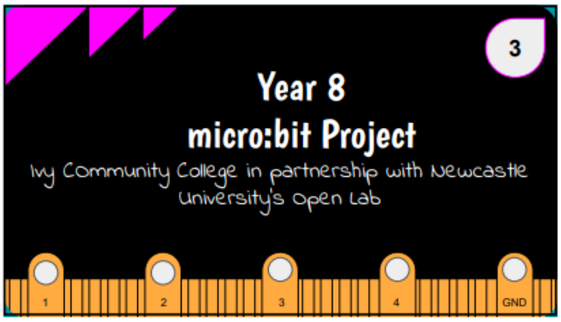

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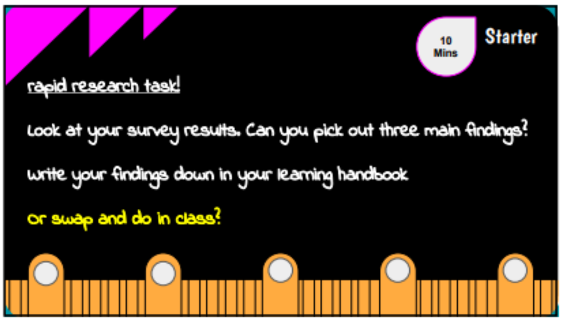

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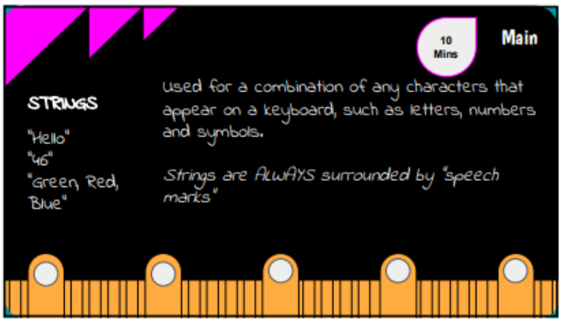

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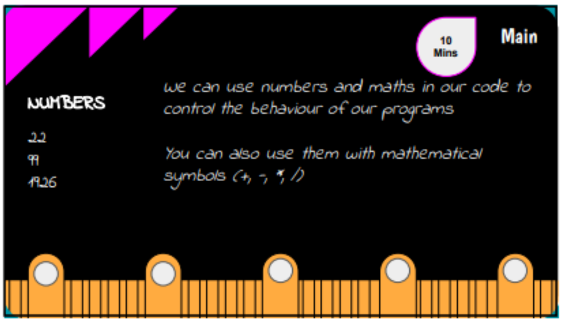

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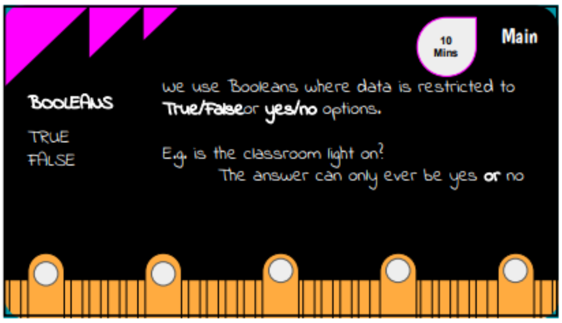

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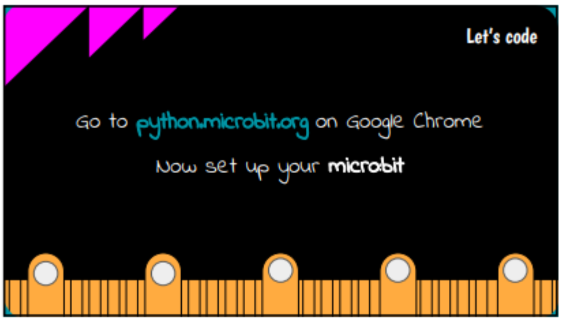

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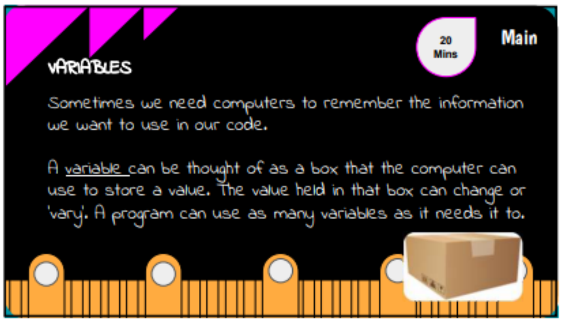

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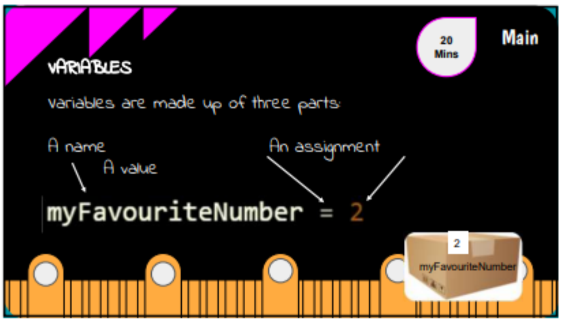

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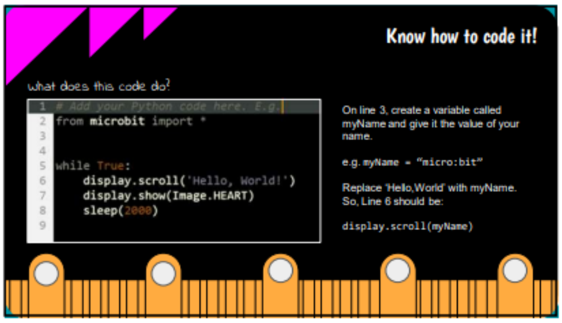

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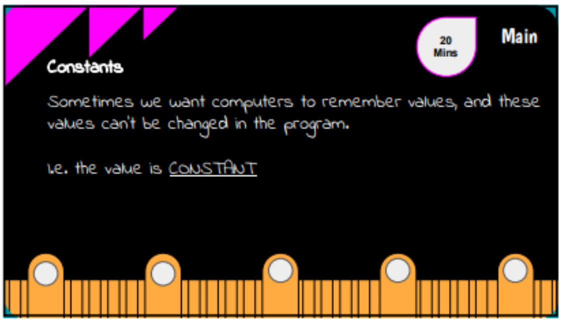

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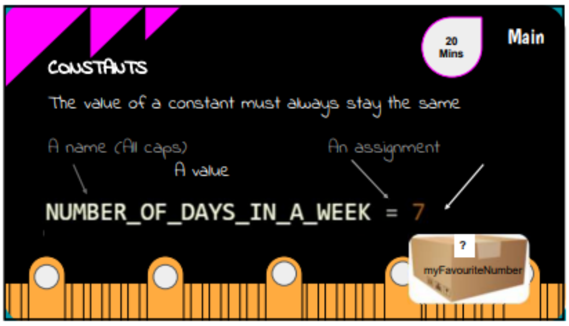

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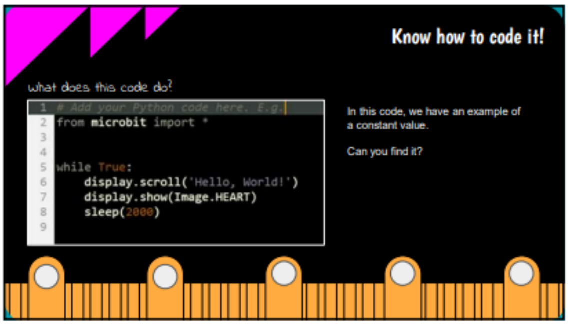

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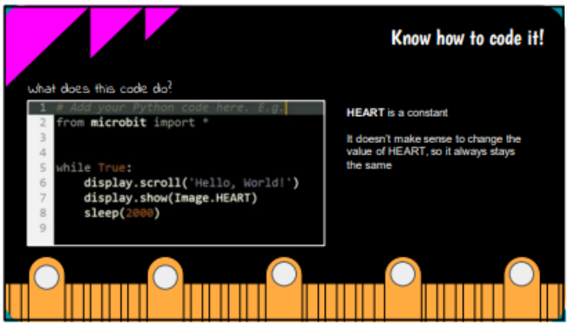

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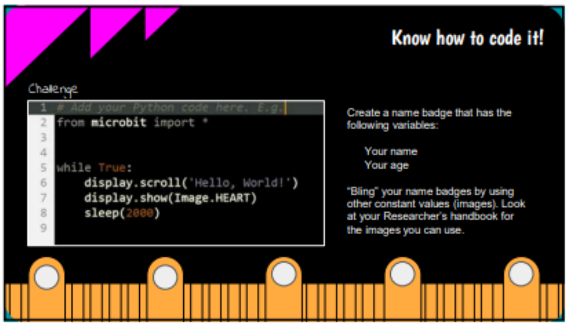

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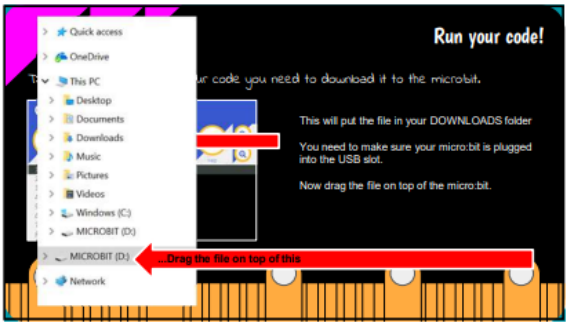

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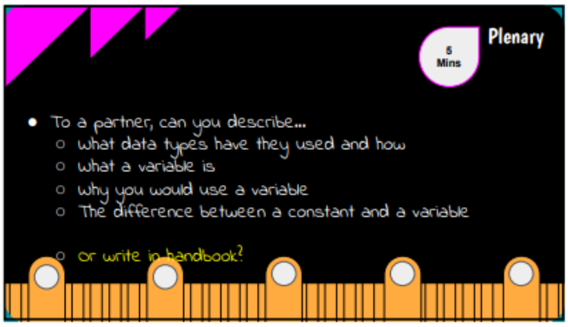

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D5. Excerpt of Case Study Three lesson slides

Micro:Vote

Lesson 1: Micro:bit Research

1

Lesson 1: What do you remember?

Unit intentions
In this unit you will develop a range of skills and knowledge in subjects that we offer at GCSE. This will include some topics that are covered in GCSE computing. You will be set a research challenge by computing researchers from Newcastle University, and learn about how they use technology in their research projects. You will work on developing a response to the challenge, and present your project back to the researchers.

2

Lesson 1: What do you remember?

Lesson Objectives: (at the end of the lesson you should be able to)

- Demonstrate your current knowledge of programming concepts
- Summarise your understanding of a Micro:bit

3

Lesson 1: What do you remember?

A Google quiz has been shared with you.

You should complete the quiz answering as many questions, in as much detail as you can

Don't worry if you do not understand some of the questions, this task is so we know how much programming knowledge you still have from Year 7 and Primary School - we don't want to teach you things you already know!.

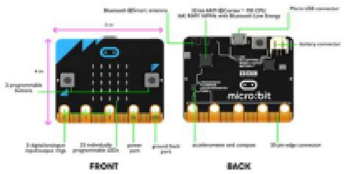
4

Lesson 1: What do you remember?

- You will be given a challenge by computing researchers based at the university.
- You will respond and present your research to the university researchers.

5

Lesson 1: Getting to know the micro:bit



6

Task 1.1: Fact Finder

Research the BBC micro:bit to find out facts about it. This might include:

- What it is
- What it can do
- What does it look like
- What projects that have been done with it in the past

Record your findings in your Workbook

Be prepared to discuss your findings with the class!

7

Plenary

Share what you found out with the person next to you

Tell the class what the person next to you found out

8

Micro:Vote

Lesson 2: Learning to code the BBC micro:bit

1

Lesson 2: Objectives

- Learn how to program and use the BBC micro:bit
- How to create simple program using the BBC micro:bit
- How to download programs on to the BBC micro:bit

2

Task 2.1: What do your friends know?

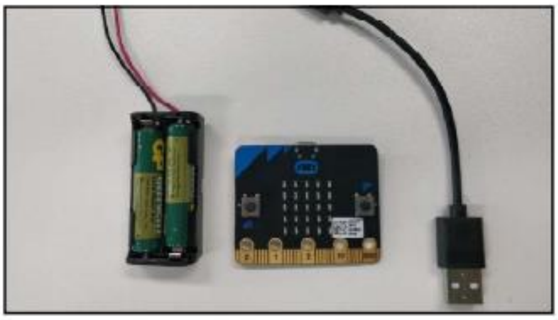
- Last week we researched the micro:bit
- In pairs, tell each other as many facts as you can remember about the micro:bit and record them in your researcher's workbook

3

Lesson 2: Let's look at the micro:bit

- In pairs, you should have a micro:bit
- Take it out and put it on the desk, and we'll talk through what the micro:bit is and what it can do

4



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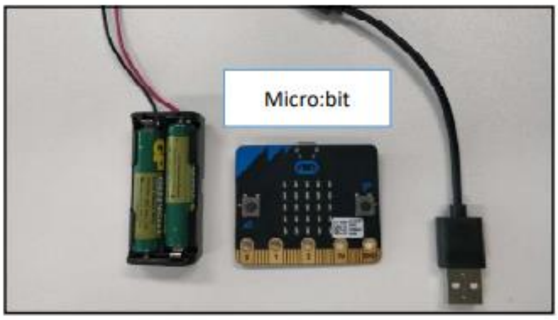

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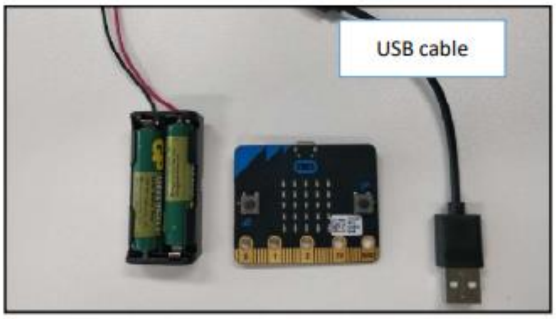
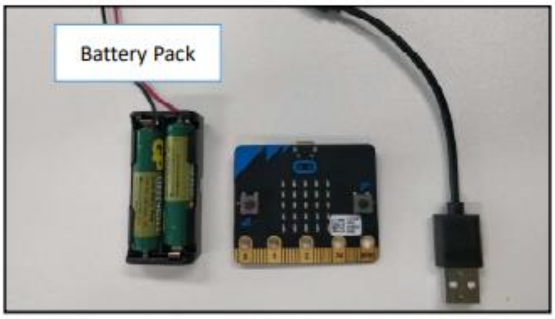
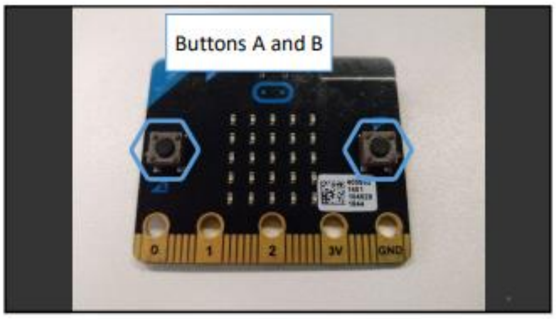

USB cable

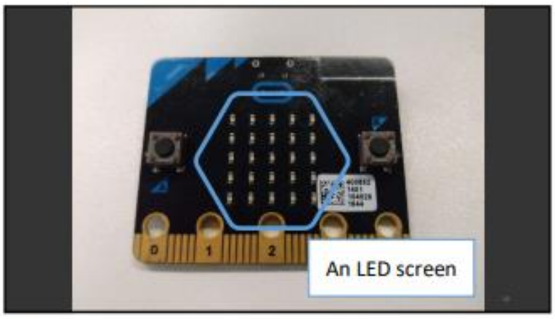
7


Battery Pack

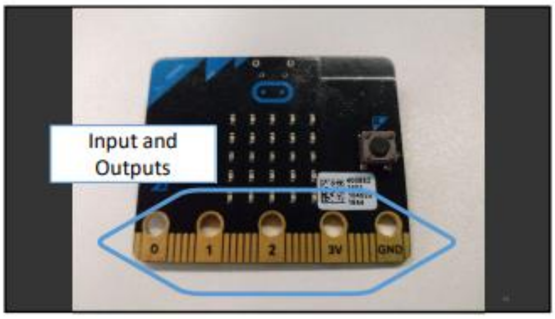
8


Buttons A and B

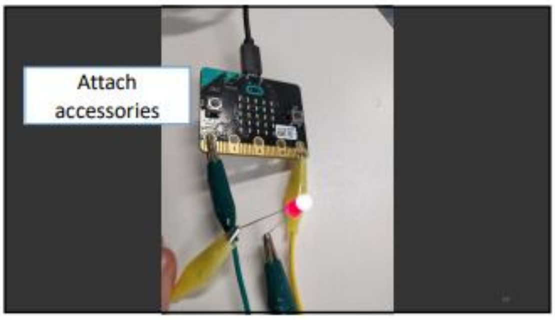
9


An LED screen

10


Input and
Outputs

11


Attach
accessories

12

Lesson 2: Let's Code!

- Go to python.microbit.org on Google Chrome
- Now set up your micro:bit, remember to plug in the small end of the USB to the top of the micro:bit and the larger end into your computer

13

Lesson 2: Know how to code it!

```
# Add your Python code here. E.g.
from microbit import *


while True:
    display.scroll('Hello, World!')
    display.show(Image.HEART)
    sleep(2000)
```

What do you think this code does?

14

Task 2.2: Creating a Name Badge

```
# Add your Python code here. E.g.
from microbit import *


while True:
    display.scroll('Hello, World!')
    display.show(Image.HEART)
    sleep(2000)
```

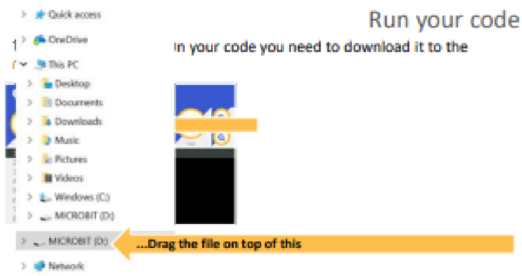
Alter the code to make the micro:bit display your name, display an image and pause for 3 seconds (2000 milliseconds).

Choose from the following images:
HAPPY
SAD
CONFUSED
ANGRY
GHOST

15

Run your code!

In your code you need to download it to the



16

Task 2.3: Improving your name badge

```
# Add your Python code here. E.g.
from microbit import *


while True:
    display.scroll('Hello, World!')
    display.show(Image.HEART)
    sleep(2000)
```

Change the code to make the micro:bit display your name, then an image, then a pause, then your age, then a different image then pause for 2 seconds (2000 milliseconds).

17

Plenary

```
# Add your Python code here. E.g.
from microbit import *


while True:
    display.scroll('Hello, World!')
    display.show(Image.HEART)
    sleep(2000)
```

What happens if we remove sleep?

What does the '2000' measure?

18

D4. Excerpt from case study tutorials

topic 1 "Display": custom images

ABOUT

Program your micro:bit to show your own custom images

SKILLS

- Arrays
- Constants
- Sequences

YOU NEED

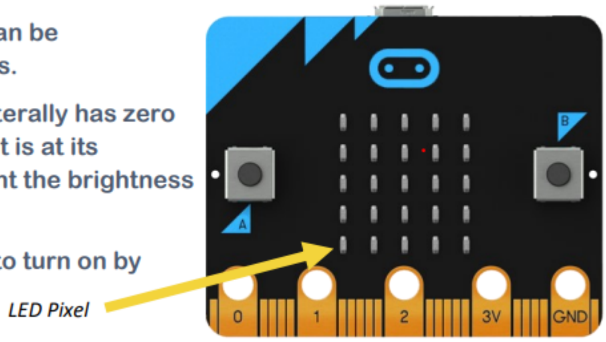
- A micro:bit

1. How do we create custom images?

Each LED pixel on the micro:bit display can be programmed to be set at one of ten values.

If a pixel is set to 0 (zero) then it's off. It literally has zero brightness. However, if it is set to 9 then it is at its brightest level. The values 1 to 8 represent the brightness levels between off (0) and full on (9).

We can instruct the micro:bit which LED to turn on by giving a command for each LED pixel.



2. Code - "custom_images.py"

```
1  #Import our microbit code
2  from microbit import *
3
4  #Creating an Image called flower
5  FLOWER = Image("99099:"
6                 "90909:"
7                 "09090:"
8                 "90909:"
9                 "99099")
10
11 #getting the micro:bit to display flower
12 display.show(FLOWER)
13
```

Here our code is going to create an Image called "`FLOWER`" and they display it on the micro:bit. The most important bit of this program is on line 5, so let's go through it in stages!

1. Why is `FLOWER` in all capital letters?

`FLOWER` is what's known as a constant value. These are values that aren't changed through the course of the code. When we give a constant a name, we make sure they're in ALL CAPS, to show that they are different from a variable (variables "vary", or change, throughout the course of the code). We might use a constant for the names of the days of the week (MONDAY, TUESDAY…) because they won't change.

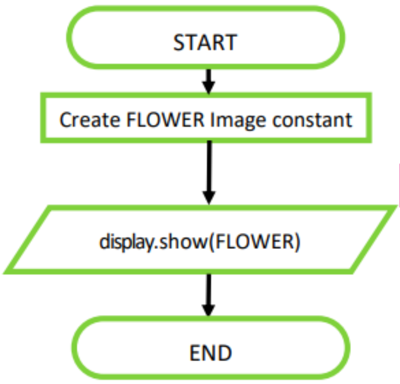
2. What does `Image(…)` do?

Think back to your premade images, and how you had to type `Image.HEART` to display an image on the micro:bit. If we had just typed `HEART`, the micro:bit wouldn't have understood our instruction. We had to tell it the type of the thing we had to display. By making sure we add `Image(…) around the value for FLOWER`, we tell the micro:bit it should expect a value of type `Image.`

2. What do each of the lines of numbers do?

Have you noticed that each line of the physical display is represented by a line of numbers ending in : and enclosed between "double quotes"? Each number specifies a brightness of one of the LED pixels. There are five lines of five numbers so it's possible to set the brightness of each pixel on each line of the display. That's how to create a new image!

3. Flow Diagram



The flow diagram for this program is simple, and just follows a sequence of steps from beginning to end. We create our FLOWER Image constant, and then we get the micro:bit to display the Image.

4. Extra Code

You don't have to a new line of code for each of the lines of LEDs on the micro:bits. If you think you can keep track of each line, you can write:

```
FLOWER = Image("99099:90909:09090:90909:99099")
```

It's the "`:`" which tells the micro:bit to move to the next line of pixels!

5. Activities

Download the code from section 2.

1. What happens if you delete `Image(…)` from around your constant value code? Why do you think that happens?

Lesson 1: Micro:bit Research

Task 1.1 - Research the Microbit

Research the micro:bit and see what it can do.

Explain your findings in the box below

Lesson 2: Introduction to the micro:bit

Task 2.1 - What do your friends know?

You have just heard your classmates explain some of the facts they researched last week. Write two of them in the box below ….. they must be different to the facts you have above.

Task 2.2 - Creating a Name Badge with the Micro:bit

Open the code editing web page
https://python.microbit.org/v/1.1

Change the code to make the micro:bit display your name, display an image and pause for 2 seconds (2000 milliseconds). Choose from the following images:

- HAPPY
- SAD
- CONFUSED
- ANGRY
- GHOST

Copy the code that you used and you know works and paste it in the box. This means you can refer back to it later if you need to.

Task 2.3 - Improving your name badge
Change the code to make the micro:bit display your name, then an image, then a pause, then your age, then a different image then pause for 2 seconds (2000 milliseconds).

You have improved your name badge for your Micro:bit and included an image. Copy the code that you used for your improved name badge and paste it in the box. This means you can refer back to it later if you need to.

Lesson 2a: Creating custom images

Task 2a.1 - Custom Images
When you have an image you are happy with take a photo of your micro:bit showing the image.

Insert the photo and copy the code into the table below

Lesson 3: Thinking of ideas

Task 3.1 - Using computers to help people
Using the university researcher website to help you list three research projects that are going on in the university.

-
-
-

Task 3.2 - Ideation Square
The university researchers use “Ideation Squares” to help them think of ideas for projects. You’re going to create your own Ideation Square to help you think of project ideas for your version of MicroVote.

In each yellow square, write a location in school (lunch hall, corridor, classroom etc.)

In each blue square, write a type of people that you find in school (Students, teachers, friends etc.)

In each orange square, write a type of output that's possible on a micro:bit (lights, sound, movement etc.)

	1	**2**	**3**
A			
B			
C			

Now look at every row and column, each one should have a location, a group of people, and a micro:bit output. From these different options, pick the top two options that you think are most interesting. (e.g. classroom, students, lights)

1.

2.

My Final Idea

My problem is going to be…
The location the poster will be found is…
The group of people it will help is…

D7. The Open Educational Resources of the produced artefacts

The produced resources can be located at https://www.engage-csedu.org/find-resources/microvote-introduction-python-using-bbc-microbit

Appendix E. Conceptual Framework for School-University Partnerships for Computing education

E1. Revised conceptual framework for School-University Partnerships for Computing Education

Creation	Design	Delivery	Sustain	Legacy
• **Relationship**: Define contribution and aims • **Resource:** Explore current university resources • **Technology:** Promote digital visibility • ***Technology:*** *Determine digital ecology of school*	• **Relationship:** Develop partnership aims • **Culture, Pedagogy and Space:** Understand space and place • **Relationship:** Allocate partnership roles • **Resource:** Create partnership resources • ***Technology:*** *Determine how resources will be shared internally and/or externally*	• **Relationship:** Implement partner check-ins • **Resource and Relationship:** Integrate continuous professional development	• **Resource**: Involve wider partner team • **Bounding Framework and Resource:** Explore embedding institutional sustainability • **Relationship:** Recognise when to stop	• **Resource**: Publish outcomes • **Resource:** Share partnership learning resources • **Technology:** Develop a digital community

Appendix F. Ethical Approval Certificates

F1. Case Study One Ethical Approval Certificate

18-VEN-042

SAgE Faculty Ethics Committee
Ethics Application Pro-forma

Applicant Name:	Megan Venn-Wycherley
Applicant email:	*m.venn-wycherley@newcastle.ac.uk*
Academic Unit	Computing
Supervisor email (if available)	Ahmed Kharrufa
Category	PGT
Project Title:	The School Observatory
Start / End Date	01/10/2018-31/12/2018
MyProjects Reference (if available)	
Reviewer 1 Name: Date sent: Date comments received:	 Phil Hyde 16/10/2018 01/11/2018
Reviewer 2 Name: Date sent: Date comments received:	 Lindsay Marshall 17/09/2018 03/10/2018
Date comments provided to researcher:	16/10/2018
Date researcher confirmed amendments made:	17/10/2018
Faculty final approval date:	05/11/'18
Notes	
Follow-up queries	
Later amendments requested from applicant: Details: Date requested: Approved? Date approved:	

Approved / Not Approved by the SAgE Faculty Ethics Committee

Signed by Dr Patrick Degenaar (Chair)

Patrick Degenaar .... **Date:** 05/11/2018

1

F2. Case Study Two Ethical Approval Certificate

18-VEN-019 Amendment

SAgE Faculty Ethics Committee
Ethics Application Pro-forma

Applicant Name:	Megan Venn-Wycherley
Applicant email:	*m.venn-wycherley@newcastle.ac.uk*
Academic Unit	Computing
Supervisor email (if available)	Ahmed.kharrufa@ncl.ac.uk
Category	PGR
Project Title:	Creating a sustainable learning ecology between local schools and the university
Start / End Date	10.12.18-31.01.19
MyProjects Reference (if available)	
Reviewers	Phil Hyde; Lindsay Marshall; Anil Namdeo
Original approval date:	18.05.18
Notes	
Follow-up queries	
Later amendments requested from applicant:	
Details:	Applicant wishes to work with a different partner and change the focus of the original study.
Date requested:	03.12.18
Approved?	**Informal approval granted 10.12.18**

Approved / ~~Not Approved~~ by the SAgE Faculty Ethics Committee

Signed by Dr Patrick Degenaar (Chair)

....

Date: ...10th Jan 2019...

F3. Case Study Three Ethical Approval Certificate

Faculty of Science, Agriculture & Engineering — Newcastle University

CERTIFICATE OF ETHICAL APPROVAL

Project #: 18-VEN-019 **AMENDMENT**

Project Title: Creating a sustainable learning ecology between local schools and the university

This certificate confirms that the amendment application made by **Megan Venn-Wycherley (PGR student in Computing), supervised by Ahmed Kharrufa,** was **APPROVED SUBJECT TO CONDITIONS** on 26/03/2020.

Conditions of approval (If applicable):

i. Ensure that you have explicit parental consent and child assent for any pupils' data that you use for the purposes of your research
ii. Ensure that pupils know how they can complain/raise any issues without consequence to their grades/daily classroom activities

It is the responsibility of the applicant to ensure that any conditions of approval are fully met before proceeding with the research. Applicants are also required to notify the Faculty Ethics Committee (sage.ethics@ncl.ac.uk) if they wish to make any changes to the design/methods/participants of the study ***before*** *commencing with any changes.*

If you receive any complaints or encounter any issues during the implementation of your research study, please contact the Ethics Committee via SAGE.Ethics@newcastle.ac.uk. Please **do not** *respond directly to the complaint.*

Signed:

Date: **26.03.2020**

On behalf of Patrick Degenaar due to Covid-19 restrictions

F4. Case Study Four Ethical Approval Certificate

Faculty of Science, Agriculture & Engineering

Newcastle University

CERTIFICATE OF ETHICAL APPROVAL

Project #: 18-VEN-042 **AMENDMENT**

Project Title: The School Observatory

This certificate confirms that the application made by **Megan Venn-Wycherley (PGR student in Computing)** was **APPROVED SUBJECT TO CONDITIONS** on 03/06/2019

Conditions of approval (If applicable):

i. You must seek **opt-in** consent from parents and verbal assent from all pupils taking part

*It is the responsibility of the applicant to ensure that any conditions of approval are fully met before proceeding with the research. Applicants are also required to notify the Faculty Ethics Committee (sage.ethics@ncl.ac.uk) if they wish to make any changes to the design/methods/participants of the study **before** commencing with any changes.*

Signed: [signature] 3rd June 2019