HOW TO BRING FORTH GOOD SOCIAL LEARNING IN TEACHER EDUCATION THROUGH TECHNOLOGY

A CONTEXT STATEMENT SUBMITTED TO MIDDLESEX UNIVERSITY IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PROFESSIONAL STUDIES

By Public Works

HELEN ALICE CALDWELL

Middlesex University, London

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Disclaimer

The views expressed in this context statement are those of the author and do not necessarily reflect the views of the supervisory team, Middlesex University, or the examiners of this work.

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Abstract

A core theme of this context statement is the contribution that digital technology can make to social learning in online and face-to-face contexts. The work contributes to the field of educational technology across sectors, by considering some of the obstacles currently facing practitioners such as new curricula, new pedagogical approaches and the fast pace of change. I present a rationale for technology supporting social learning and discuss several significant themes, such as the role of learning communities in supporting the co-creation of knowledge, the pedagogic approaches that support computational thinking, digital literacy and mobile learning, and the potential of international projects and online courses to make purposeful connections between teachers and learners. Looking firstly with a distant lens at the forms of technology-enabled learning communities (TELCs) in my public works, and then with a closer lens at the interactions and behaviours within them, I present a characterisation of the learning landscape that involves a topology and typology of TELCs. These consist of five distinct forms of TELCs together with a set of five dualities that describe conditions for knowledge-building. This framework contributes towards an understanding of the epistemology of TELCs within the context of my public works. It offers descriptive and diagnostic tools for analysing the nature of learning, knowing and knowledge-building within TELCs, and demonstrates how some key variables are interrelated. As such, it has relevance to the design and evaluation of social online learning and makes a contribution to the debate around theories of learning in a digital age.

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Chapter 1: Introduction

1.1 Summary of the professional context

Given the pace of developments in the educational technology field, it is a challenge to maintain a stable sense of self as a practitioner. My pedagogical beliefs have been shaped by various professional challenges: as a primary teacher, subject leader, special needs teacher, writer of distance learning materials, CPD project manager, initial teacher trainer, teacher educator and researcher. Alongside these changing roles are the shifting socio-political dynamics of education in England, for example the recent introduction of the computing curriculum, the rise of school-based teacher training, and the adoption of new models of learning in the higher education context. Locally, we are amid a university-wide evaluation of pedagogical approaches predicated by a move to a new campus at the University of Northampton, with an increase in online learning, the reduction of lecture theatres, and the expectation that technology will act as a driver for active and social blended learning.

As anyone familiar with Moore's Law will know, the evolution of technology itself is exponential, making it a challenge for anyone working in the field to stay current. My career has spanned the introduction of interactive whiteboards, the internet in schools, Web2.0, mobile technologies, and more recently the rise of computer science in the national curriculum. Educators such as myself are currently evaluating the potential of developments such as the Internet of Things, wearable tech, augmented and virtual reality, and makerspaces within our learning contexts. Collaborative social learning is rising in schools, as a multimodal view of literacy begins to supersede traditional pen and paper (Jisc, 2014; Prensky, 2008).

Along the journey of professional development are key moments when one puts a stake in the ground. For me, three pivotal moments were discovering the potential to make multimodal digital artefacts on Apple computers with my special needs students in the early 2000s; my tentative first steps towards technology supporting collaboration through conference calls, webinars and online communities whilst working at the Open University around 2010; and the advent of tablet devices making ubiquitous learning a possibility at the University of Northampton in 2013. A challenge has been to ensure that these stakes remain secure against the buffeting winds of institutional and political change.

A central aim throughout my work has been enabling others to keep pace with technological change (Borko et al., 2009), and I have sought to create a range of opportunities for the professional development of my peers. In the chapters to come I will explore strands of my professional journey and consider how they have shaped my beliefs and practices.

1.2 My professional standing

I have been involved in teaching and research in education for over thirty years, specialising in educational technology, computing and primary education. I have taught in higher education since 2010 and I am currently working as a Senior Lecturer in Education at the University of Northampton. At Northampton I am the curriculum leader for Primary Computing, and the course designer and programme leader for the Postgraduate Certificate in Primary Computing and the Postgraduate Certificate in Digital Leadership. International projects on digital learning themes have been a key feature of my work since 2010.

I trained in quantitative data analysis during two years at Brigham Young University, Utah, where I undertook an MA in Education and worked on several funded education projects as a research assistant. My research in the UK has involved qualitative methods, including the analysis of multimodal data.

The focus of the works selected here began in 2011 when the new national computing curriculum was being developed in England. In 2013, I was an invited member of the Primary and Secondary National Curriculum for Computing ITT Expert Group convened by the Department for Education's Teaching Agency to produce a set of online resources to support teachers.

Since then, I have established a reputation for providing practical guidance on how to implement the computing programmes of study in primary schools and on the use of mobile technologies to promote digital literacy across sectors, with an emphasis on social learning approaches that value peer-to-peer learning. For example, I host free international online courses (known as Massive Open Online Courses or MOOCs), run teachmeets and digital playdates, and engage with educators through blended approaches combining practical and theoretical perspectives. I have been the lead bid writer and the project lead on nine funded projects and lead editor of eight practitioner-facing books since 2013.

Recently, I took a lead role in supporting a rollout of iPads for academics and students in the Faculty of Education. A core set of apps supporting staff and student digital literacy gradually emerged, as my colleagues trialled them and recorded outcomes on the project blog and online community. Through this process of sharing practice, mobile learning is becoming embedded in many of the faculty programmes. My pedagogical approach sits well with the model of active blended learning (ABL) recently adopted by the University of Northampton, based on the effective use of blended and online learning approaches. This model seeks to use technology to make strong links between on and offline activities and provide dynamic, media-rich ways for students to engage with each other and with course content.

The selected works represent the themes outlined above: technology supporting social learning in blended and online contexts, developing a pedagogy for teaching computing, and promoting digital literacy through mobile devices. They chart the development of my personal perspective alongside the evolution of the field. Some researchers propose that the changing affordances of technology amount to seismic shifts that will fundamentally transform the way we teach and learn (Collins, 2018). Others are warier, taking an 'oversold, underused' view of technology in schools (Cuban, 2001; Li, 2007). My experience suggests a role for technology as a tool to enhance our physical engagement with the world, whether it be through film-making, apps or coding, to record, reflect and share ideas, and ultimately consolidate learning.

The selected public works include books, book chapters, journal articles, conference papers, funded projects resulting in websites, online communities and MOOCs, aimed at academics, practising teachers and trainee teachers. A key aspect throughout has been to provide opportunities for educators to engage in collective knowledge building using technology as a social learning tool. This theme forms an overarching strand of the context statement, charting the metamorphosis of ideas within learning communities, expedited by technology.

1.3 Overview of the public works and the reflective themes

The selection of public works, summarised in Appendix 1, is based on my experience of developing effective pedagogy and practice in the field of educational technology. My theme takes as its premise that the best learning within the field of teacher education is social and active rather than discrete, and that it relates to authentic classroom contexts and a shared domain of pedagogic and subject knowledge (Wenger, 2011). The theory underpinning my

exploration of technology-enabled social learning in education is drawn from the large body of research on communities of practice, connectivism, social constructivism, social network theory, and situated learning. The challenge of bringing about positive change in teaching and learning is pursued throughout the context statement to determine how technology can facilitate high quality social learning.

In their systematic review of online knowledge sharing, Charband and Navimipour (2016) note that despite the significant growth of online communities supported by technology in recent years, few are successful in retaining numbers or motivating members to contribute knowledge. Active participation, they suggest, is key to building a sustainable online community and this is difficult to achieve. Yet, as Young and Tseng (2008) point out, participation in online communities is an emergent way for teachers to gain professional development. Finding ways to enable and sustain engagement in online and blended environments has been an integral part of my work, and an aim of my analysis of the public works is to identify some critical success factors to better understand the role that technology-enabled learning communities, or TELCs as I shall refer to them, can play in influencing practice. A close examination of the public works from theoretical and practical perspectives illuminates the processes by which learning occurs in such communities, and the conditions most likely to influence educators' teaching practices and beliefs, as outlined in Chapter 6. These observations have generalisability to other curricula besides computing.

I have chosen to use the term Technology-Enabled Learning Community (TELC) rather than Online Community of Practice (OCoP) to acknowledge the breadth of ways technology can promote social learning amongst groups of people with a shared domain and similar goals. Although my works have looked extensively at the attributes of online communities of practice, they also demonstrate a wider role for technology in blended learning that combines multiple delivery methods and may take place online or face-to-face. This takes account of a range of digital tools and practices that can facilitate active knowledge construction in physical and digital habitats, rather than simply seeing technology as a platform for the exchange of ideas. A second important distinction is that, within the context of my work, the TELCs are small scale compared to the very many much larger online communities. My TELCs occupy the niche of small, lively and responsive communities, often with an international membership, and with a strong sense of shared purpose. These properties mean that they can be analysed as beacons of focused collective knowledge building.

The central reflective theme for the analysis of the public works is:

> How the public works illuminate ways in which technology can facilitate high quality social learning in online and blended environments. (Chapter 6)

Additional reflective themes are:

> 1. How the public works have enhanced social learning approaches in computing via technology-enabled learning communities (TELCs). (Chapter 3)
>
> 2. How the public works have enhanced social learning approaches in digital literacy via technology-enabled learning communities (TELCs). (Chapter 4)
>
> 3. How an analysis of pedagogy and practice within TELCs can shed light on the processes of social learning. (Chapter 5)

1.4 Reflective methodologies

Below I outline how a number of methodologies have contributed to the development of my reflective themes. These consist of several overlapping qualitative approaches characterised by their social construction and subjectivity.

1.4.1 The qualitative paradigm

My analysis of the public works is firmly based in the qualitative paradigm, taking an interpretivist theoretical perspective and an inductive research approach (Gray, 2013). In common with much qualitative research, there is an overlap across several socially constructed qualitative methodologies that are characterised by subjectivity. Social constructivism suggests the potential existence of multiple realities rather than of one objective reality that can be discovered and described in a positivist way. This approach fits the defining characteristics of post-positivist research as described by Garfinkel (1967).

For example, my methodology draws from phenomenology in its focus on my own experiences, and from ethnography in its study of the cultural practices within TELCs. In addition, it draws upon participatory research methods, including autoethnography and

narrative inquiry. From a narrative enquiry perspective, the examination of the public works is a 'whole story' consisting of a chain of interwoven experiences, within which I was keen to discern common threads and patterns, and make sense out of these (Creswell, 2003). An autoethnographic perspective places me as a practitioner-researcher in the field of education, with an interest in developing dialogues between lecturers, teachers and students. As such, I am 'a member of the landscape' (Clandinin and Connelly, 2000, p63, cited in Trahar, 2009). There is a further overlap between phenomenology and narrative inquiry, in that I aimed to create a rich descriptive account of my own lived experiences over time, to better understand the functionality of the phenomenon of TELCs.

My methodology can be said to be abductive in that it moves back and forth between theory and observations to find explanations for the reflective themes, and the conclusions are derived from the process of studying the data (Smith et al., 2009). In addition, there is an inductive discovery process at work, combining the narrative threads throughout the chapters to make a connected view of the knowledge building process within TELCs. Taking a view across the works, I looked for emergent patterns and relationships between variables (Gray, 2013), and in Chapter 6, I use these to construct generalisations about knowledge building practices. By looking at numerous contextualised manifestations of TELCs in the physical and digital domains, I draw some conclusions about their essences, from the point of view of the forms they take and the nature of interactions within them. A degree of reliability is ensured in this process through the examination of multiple cases of TELCs to look for consistencies among them (Gray, 2013, p.18).

1.4.2 The autoethnographic perspective

I have drawn from autoethnography as a critical research method to take account of the specific cultures and contexts in which the public works were created. This method offers a flexible route to producing meaningful research grounded in personal experience that, by acknowledging and embracing subjectivity, can be a 'wider lens' (Ellis et al. 2011, p.2). The rationale for using an autoethnographic lens is that it seeks to 'describe and systematically analyze (*graphy*) personal experience (*auto*) in order to understand cultural experience (*ethno*)' (Ellis et al., 2011, p.1). Whilst examining my personal journey of professional development, I was also interested in the collective journeys that communities of educators made in connection with my works and how these influenced practices. I took an active role in the design and development of the learning communities that feature in my

works, and my dual identities as a researcher and a member of the communities were instrumental in helping me to understand the behaviours within them.

My method has most in common with two approaches to autoethnography identified by Ellis et al. (2011), *reflexive ethnography*, as the analysis revolves around the development of my own works that document the cultural experiences of others in TELCs, and *layered accounts*, that set my own experience alongside layers of abstract analysis and discussion of relevant literature. It also sits well with the sub-genre of *analytic autoethnography* (Anderson, 2006) that features member research, analytic reflexivity, researcher visibility, dialogue and theoretical analysis.

Ethnography is the study of people in their real-world settings, and the situated educational contexts associated with the TELCs were integral to my reflections. My aim was to gather insight into how teachers use social online learning to embed technology in their teaching and learn from each other's classroom experiences. To add the 'auto' into this, I analysed my personal experience in the field to better understand teachers' cultural experiences. The methodology can thus be described as socially constructed in that people are instrumental in uncovering the meanings (Smith et al., 2009). This approach gave me a platform from which to study the relational practices, common values and beliefs, and shared experiences within a range of TELCs, to better understand their internal cultures, identities and commonalities (Ellis et al. 2011).

The background cultural and educational contexts of my works include a climate of curriculum change in the UK between 2011 and 2018, with respect to the computing curriculum in schools and pedagogic approaches in Higher Education. They also take account of the altering technological landscape. In addition, much of my work has an international focus, and an aim has been to use technology effectively to facilitate intercultural exchanges and understandings. I have aimed to critically examine the interaction between my own actions and the cultural contexts in which they have been embedded. A constructivist analysis of these varied perspectives that is firmly rooted in my own observations of TELCs has given me an opportunity to build some models of the development of TELCs and descriptions of behaviours within them. These enabled me to firstly draw some general conclusions about how TELCs can function differently across a range of contexts, and secondly about the conditions for success in TELCs by looking at factors that remain constant.

An autoethnographic approach has overlaps with autobiography, and in telling the story of the development of my works, the works themselves acted as milestones. Viewing the works as a group puts them in a different perspective, much as a drone flying over an archaeological site enables a holistic image of an era. The observational process redefined them and offered me a chance to recalibrate them against their respective cultural contexts. In this way, the method acted as a distant lens.

Conversely, one key aspect of the method was to share 'thick descriptions' (Geertz, 1973) of the interactions within TELCs, such that a person outside can understand the social structures and the factors influencing them, and in sufficient detail so that patterns of experience within TELCs emerge. The fact that I was myself a member of the TELCs gave me an insider's perspective, and my presence in the data adds reflexive layers of observation to a simultaneous process of data gathering and analysis, a process that has similarities with grounded theory (Charmaz, 1983; Ellis, 2011). In this way, the method also acted as a close lens, enabling me to investigate the nature of interactions within the TELCs and distil my observations into a set of five dualities in Chapter 6.

1.4.3 The narrative inquiry perspective

In reflecting on my own practice, my method also has much in common with the paradigm of narrative inquiry, recognising the iterative process of research and practice evolving alongside each other (Trahar, 2009). Narrative inquiry 'characteristically begins with the researcher's autobiographically-oriented narrative associated with the research puzzle' (Clandinin & Connelly, 2000, p.40). In my case the puzzle was the nature of learning within TELCs, as evidenced by an analysis of my public works in the field of social learning.

I view evidence-led teaching as a process of personal and professional change that recognises teaching as an art as much as a science, and takes account of the complex beliefs and behaviours of teachers. In terms of the field, then, I adopt a socio-cultural perspective, seeing language as a primary tool for constructing meaning. Much of my work has involved student teachers, practising teachers and university lecturers learning through joint engagement in practice-driven social learning. My research puzzle, then, addressed the 'hows' and 'whys' of knowledge construction in such communities. By looking across the narrative landscape of the public works, I tentatively sought new levels of meaning. This approach sits well with my

emphasis on the social construction of knowledge, and on the relationships between the participants, researcher and the reader (Trahar, 2009, Ellis and Bochner, 2000). The narratives I present are stories of teachers posting and learning from each other in TELCs as captured in the public works. In my conclusion, I use their stories to generalise about knowledge and knowing in online learning communities from distant and close perspectives.

1.4.4 Methodologies used in the public works

Also relevant, are the various methodologies used in the public works themselves, which tend towards constructivisim, making use of action research and case studies to explore the development and exploitation of meaning within the learning communities. In terms of purpose, my public work reflection falls into a descriptive/interpretive category (Hedrick et al. 1993; Gray, 2013) in that it describes the phenomenon of TELCs as they naturally occur and draws conclusions about knowledge-building behaviours within them as participants co-construct their understanding of the world in line with a social constructivist theory of learning. Such an approach has been termed a mixed-methods paradigm (Cohen, Banion & Morrison (2011) or a pragmatic paradigm (Arthur et al. 2012).

Data collection methods within the works investigating behaviours within learning communities tend to be unobtrusive observations and thematic analyses of online behaviours, along with case study-style examples of teacher and student teacher uses of technologies. Taking this range of approaches into account, the qualitative mixed methods research paradigm might be considered the best description for the public works. The public works typically comprise multiple viewpoints and perspectives, and make use of multiple methods to present a triangulated description of the behaviours within TELCs (Johnson et al., 2007; Denzin, 1978). For example, the analysis of the content of interactions and of the channels of discourse within online learning communities is primarily descriptive and naturalistic in approach, using multiple case studies. It lies firmly in the exploratory domain since it is seeking to look at a relatively new area (TELCs) that is responsive to technological developments. It is open to emerging ways of exploring multi-modal communication, such as those that mix words with images, with video and with face-to-face interactions.

Triangulation of data from different sources and of methods adds robustness to the conclusions within the works (Gray, 2013). As is usual with the mixed methods paradigm, the direction of travel within the works is from the particular to the general, along the way

identifying patterns to draw conclusions through a process of inductive reasoning (Imenda, 2014; Braun and Clarke, 2006). Some writers about research methods see a mixed methodology as less confining and less intellectually restrictive (Johnson & Onwuegbuzie, 2004). In my case, it has provided multiple perspectives for an analysis of the works as a whole.

The methodologies described above raise issues of reliability, generalisability and validity. An autoethnographic approach values narrative truth and narrator credibility (Ellis, 2011). In the context of the published works, the coherence of the works themselves lends credibility, as does my own lived experience of the TELCs. The work can also be said to have ecological validity in the sense that it is context specific, detailed, and accurately represents real-world settings (Charmaz, 1983). If we take Ellis and Bochner's view (2000) that generalisability is determined by reader response, a central question would be, 'does the work illuminate cultural processes within TELCs?'. As Ellis et al. put it,

'the goal (of autoethnography) is to produce analytical, accessible texts that change us and the world we live in for the better'

(Ellis et al.2011)

1.4.5 The process of preparing the Context Statement

In the sections above I outlined ways in which my reflective analysis might be aligned with qualitative methodologies such as phenomenology, autoethnography, ethnography, autobiography, and narrative inquiry to integrate my personal experience of technology facilitating high quality social learning within the context of theory and practice. This section describes how these methodologies influenced the process of writing the context statement.

Over the course of a year, I revisited a selection of my works that had communities at their heart, and used my insider knowledge alongside a critical analysis to gain insights into how their social cultures and their interactions with technologies fostered knowledge-building. Key sources of evidence were the published works, the online community postings and commentaries, and the digital artefacts and media shared within the online communities or captured during face-to-face events. Added to these, was a layer of academic literature which provided another comparative lens. This bringing together of experience and theory, resulted in a process of reframing previous knowledge (Argyris and Schon,1978). Such an approach adds coherence and formalises the reflexivity to create a scholarly personal narrative which

may lead to a contribution to the body of disciplinary knowledge in the field. (McIlveen, 2008; Bradley and Nash, 2011).

One of my first tasks was to select and assemble the works with 'hindsight', as Ellis et al. suggest (2011), considering their impact on my peers and on my professional development. I sought narrative threads within the works by stepping back and considering them as a group, and began to organise them into possible themes. The results of this initial activity can be seen in Appendix B (p.150), which sets the scene for identifying the reflective themes explored across the chapters. The next stage was to revisit the works more closely and to make detailed notes in relation to the emerging themes. Although my analysis of TELC interaction was retrospective, the fact that part of the analysis focused on online posts and comments gave it an immediacy akin to observational field notes. Indeed, many of my works represent thematic analyses carried out whilst the communities were 'live' and these could be said to be 'reflection in action' as opposed to the 'on action' reflection taking place through the context statement (Schon,1973).

The process of sifting through notes and memos comparing the works and recognising patterns within them meant that reflexivity within the context statement took the form of a deliberate rethinking and retelling. The TELC forms and dualities presented in Chapter 6 emerged through this iterative and inductive examination of the works. To give a few examples: my paper on the nature of interactions within TELCs led to a further paper on the role of visual posts, analysis of which led to the dualities digital/physical and making/talking; analysis of my work on blogs and communities led to the duality personal/collective; the MOOCs, with their c/x continuum led to the content/connectivity duality and also contributed to the digital/physical duality; and my comparison of MOOC design and delivery methods led to the synchronous/asynchronous duality.

The writing process itself led to further analysis as I crafted the chapters to include 'showing' and 'telling' (Ellis et al., 2011) with the aim of bringing the reader into a scene and helping them to view and understand the patterns of practice (for examples of this see Figures 2.4, 3.5, 3.10 and quotes from participants p.32-36), thus framing the individual stories within the context of the whole. The chapter drafting and memoing processes continued in tandem, with both contributing to the identification and refining of the commonalities and differences across the fifty or so TELCs connected with the works. Summarising these subsequently led

to the conclusions in Chapter 6 about the forms and functions of learning communities as vehicles for collective knowledge building. Thus, the act of writing can itself be described as a method of inquiry (Richardson, 2003).

1.5 Relevance of the public works to the professional field

To further define the context, most the works have been created within the field of Initial Teacher Training (ITT) and Continuing Professional Development (CPD) within primary, secondary and higher education. The target audiences are pre-service and in-service teachers in schools seeking to deliver high quality teaching and learning in computing and digital literacy, and university lecturers seeking use technology to enhance their teaching and learning. Both groups can struggle to stay current in a field that is characterised by rapid change. Developments such as the introduction of computer science into the primary curriculum, the uptake of mobile devices, and the rise of online connectivity have resulted in a need to substantially evaluate and revise their pedagogic beliefs and practice.

One outcome of my context statement is an analysis of how TELCs support the development of pedagogy and the dissemination of practice in the fields of educational technology and teacher education. Although much of my work has focused on pre- and in-service teachers, and university lecturers, there is potential for these outcomes to have a positive impact across educational sectors.

A second outcome is a consideration of how knowledge-building takes place within a TELC. This is achieved firstly through an analysis of the distinct types of learning communities that have formed part of my public works, and secondly through an analysis of the knowledge-building activities that typically take place within them. These findings are of relevance to designers and evaluators of learning environments that are predominantly online and social in nature.

The reflection is relevant and timely within the context of my organisation as a model of active blended learning (ABL) is being developed across the University of Northampton. Key features of ABL are the integration of face-to-face learning with online learning and a recognition that in both environments good learning is ongoing and social (University of Northampton, 2017).

The results are also be relevant in an international context as they inform the design and delivery of the intellectual outputs of collaborative projects such as the Erasmus + Digital Learning across Boundaries (DLaB) project.

In summary, the purpose of this context statement is to demonstrate and reflect upon how the public works have added new knowledge to the role of technology in enabling social learning across online and blended communities. This includes how it facilitates knowledge generation and transfer in social learning contexts, and how it informs the evolution of enhanced pedagogies in the field of computing and educational technology. This chapter outlines how the reflexive process of writing the context statement draws from number of qualitative methodologies to contribute to the theoretical understanding of the social phenomenon of TELCs in Chapter 6 by describing their topology and typology.

Chapter 2: Defining the reflective themes explored in the Context Statement

The overarching reflective theme is:

> How the public works illuminate ways in which technology can facilitate high quality social learning in online and blended environments. (Chapter 6)

The associated reflective themes are to investigate:

> 1. How the public works have enhanced social learning approaches in computing via technology-enabled learning communities (TELCs). (Chapter 3)
> 2. How the public works have enhanced social learning approaches in digital literacy via technology-enabled learning communities (TELCs). (Chapter 4)
> 3. How an analysis of pedagogy and practice within TELCs can shed light on the processes of social learning. (Chapter 5)

Summary of works referenced in this chapter:

Work	Reference/Source	Description
1. DLaB website, Technology Outdoors and STEM to STEAM MOOCs and online community.	http://dlaberasmus.eu/ http://dlaberasmus.eu/courses/technology-outdoors-online-course/ http://dlaberasmus.eu/courses/stem-steam-online-course/ https://plus.google.com/u/0/communities/117458443566280105364	 Digital Learning across Boundaries Erasmus+ project, comprising a website, two MOOCs and an online community. The MOOCs provide subject knowledge guidance and facilitate teachers taking ownership of what recent changes in the field mean in their own work through creating conditions for social learning and collective knowledge building.
2. Peer reviewed journal article: The interdisciplinary use of blogs and online communities in higher education	Caldwell, H. and Heaton, R. (2016). The interdisciplinary use of blogs and online communities in higher education. In: *The International Journal of Information and Learning Technology (IJILT)* 33(3) p2056-4880. https://www.emeraldinsight.com/doi/abs/10.1108/IJILT-01-2016-0006	A peer reviewed journal article on the strengths and limitations of using blogs and communities in teacher education.
3. MESH guide: Technology Enhanced Learning Communities	http://www.meshguides.org/guides/node/880	A peer-reviewed research digest published by the Education Futures Collaboration on the topic of Technology Enhanced Learning Communities. MESH stands for Mapping Educational Specialist KnowHow and the guides are designed to support teaching as an evidence-informed profession by providing research summaries to underpin educators' professional judgement. The MESH initiative comprises a community of educators from 178 countries.

Figure 2.1: Public works referenced in Chapter 2.

The above works will be referred to by number within the chapter.

2.1 Social learning and technology enabled learning communities

This chapter introduces the idea of technology-enabled learning communities (TELCs) by documenting their development in my own practice and considering their role within the field of education.

Social learning through formal and informal networks has become a cornerstone of teacher professional development, an approach that originates in Vygotsky's sociocultural theory (Vygotsky, 1978). Since then, researchers have recognised the powerful impact that developing professional knowledge through dialogue can have on pedagogic innovation (DeLaat, 2012; Vrieling et al., 2016), and the role of practice-based learning communities in supporting professional development (Twining et al., 2013; Hanraets et al., 2011).

Central to the idea of learning communities in education is an emphasis on applying knowledge to practice in a real-world context, 'united in action' as Liedka puts it (Liedka, 1995 p.5). This has strong links with theories of situated learning (Lave, 1991) and the notion of practitioners with similar aims purposefully solving authentic problems (Wick, 2000; Johnson, 2001). Many argue that applying knowledge to real situations and building upon previous understandings through dialogue and interaction successfully prepares for future practice (Coppola, 1999; Bandura, 1977).

I have chosen to use the term 'Technology-Enabled Learning' as opposed to 'Technology-Enhanced Learning', which crops up frequently in the literature. 'Enabled' puts the emphasis on technology as a facilitator but does not automatically assume that enhancement always takes place.

As Kirkwood and Price note in their literature review of technology enhanced learning, (2014), explicit statements about exactly what is meant by the term are rare. They suggest that rather than asking 'does technology enhance learning', a better question might be 'how can we design technology that enhances learning, and how can we measure that enhancement?' (Kirkwood and Price, 2014, p.7). This is a question that I have pursued throughout my practice. Section 2.2 below provides some examples.

Both Kirkwood and Price (2014) and Puentedura (2010) view the impact of technology as tiers of enhancement, with the goal of a top tier of transformational change, as opposed to simply replicating or augmenting existing practices (see Figure 2.2). However, as Kirkwood points out, there are also less radical potential gains such as efficiency. The distinction might be described as 'doing better things' as opposed to 'doing things better' (Kirkwood and Price, 2014). In effect, the impact of technology enhancements at a transformational level is difficult to analyse because of the complexity of variables involved in a substantial change in practice (Kirkwood and Price, 2014). Again, I think it more useful to think in terms of enablement and ask the question, 'what does technology add?', as in my experience, it can still have a significant influence on aspects of learning such as motivation and collaboration, even at the substitution or augmentation tiers identified by Puentedura (Figure 2.1, work 3).

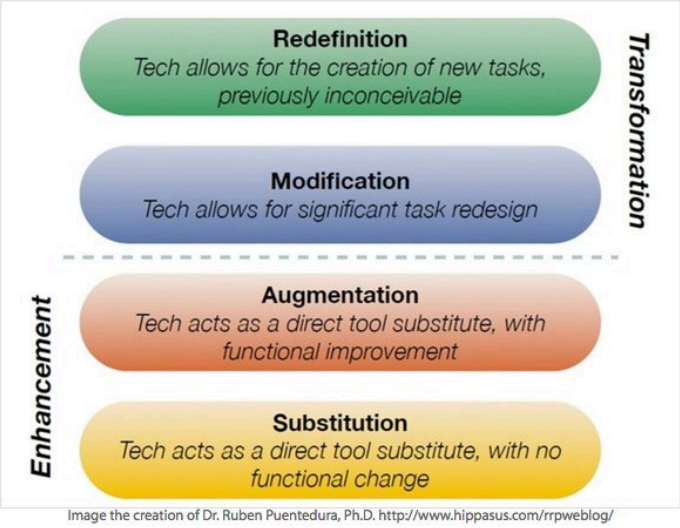


Figure 2.2: SAMR representation of technology enhanced learning (Puentedura, 2010)

2.2 Technology enabled social learning in my own practice

To give an overview of the reflective themes, the sections below illustrate some examples of social learning from my own practice, including a nationwide continuing professional development (CPD) initiative, national and international funded research projects, and internal teaching and CPD at the University of Northampton.

2.2.1 The Vital Project: the practitioner research cycle

My interest in understanding the role and impact of social learning within teacher education stems in part from my work on the Open University Vital project in 2010, which sought to

offer blended CPD in educational technology under the umbrella of an online community of practice. An aim was to reconceptualise CPD by taking an innovative 'bottom-up' approach that focused on teachers' reflective practice rather than externally-designed courses (Bradshaw, 2012; Selwood and Twining, 2005). The Vital approach was grounded in the use of learning spaces where experienced practitioners, NQTs and trainee teachers could model and share educational technology experiences and develop skills in tandem (Bradshaw, 2012):

> 'More significantly, Vital is built on the notion of a community of learners with pathways through learning. Teachers are seen as peers in the learning process rather than recipients
> of professional development.' (Bradshaw, 2012, p. 244)

A commitment to practitioners sharing knowledge through genuine online and blended collaboration rooted in practice has informed many of my public works. Observations from the Vital project were the shifting roles over the lifetime of the TELC, and the interdependence between the professional and the personal knowledge bases, as illustrated in Figure 2.3. This feedback loop helped to clarify my understanding of collective knowledge building, a theme to be developed further.

Figure 2.3: Vital's Practitioner Research Cycle (EdFutures, 2013)

Exploring a similar vein in their international literature review of 1-1 computing in schools, Islam and Gronlund (2016) note that whilst much research discusses a change in teacher's roles, there is little research defining how to achieve it. They point to the potential for online communication and social interaction to improve traditional skills, citing a study by Genlott and Gronlund (2013). Kirkwood and Price (2014) also note the difficulty of analysing complex change, and suggest moving the focus away from the physical technologies to consider the interaction between resources, and teachers and students across time and space. In this context, it seems to me, the teacher's role is as much to create and strengthen links between the right people as to recommend apps and resources.

McKnight et al.'s research (2016) also places an emphasis on audience and roles. Taking data from seven schools in the US, their work highlights that unless teaching strategies change alongside technology implementation, learning does not change, and consideration of roles is needed to support active learner centred approaches. The theme of roles and teaching strategies has been central to the analysis of the public works (work 3).

2.2.2 University of Northampton: interdisciplinary approaches

Applying knowledge of learning theories to the field of computing and digital literacy is integral to my role at the University of Northampton. I am particularly interested in authentic and interdisciplinary approaches that tap into real world issues and result in outcomes with genuine impact. As an example, the Erasmus+ Digital Learning across Boundaries (DLaB) project that I co-lead explores links between STEM and STEAM, and between computational thinking and design thinking, to foster opportunities for learners to imagine creative solutions (work 1). I have found that the addition of the arts to STEM can be a catalyst for the communication of ideas and a bridge for intercultural connections.

A key driver of my own practice, then, is that there are benefits to social learning that can be facilitated by technology. This is in line with the work of Cope and Kalantzis (2007), who draw attention to seven potentialities of ubiquitous computing that make social learning viable: *situated* as devices feature everywhere, *interactive* as we connect in more ways, *participatory* as we all become writers and readers, *spatial* and *temporal* as place and time become porous, *cognitive* as we interact with knowledge differently, and *intuitive* as technology becomes so embedded we hardly notice its presence. To this I would add an

emphasis on the potentiality of new forms of *dialogue,* such as the collaborative creation and exchange of digital artefacts as a route to collective knowledge building.

2.2.3 Blogs and communities: personal and collective spaces

My own practice has often combined media-rich spaces for personal reflection, such as blogs, with online communities to provide opportunities for social reflection on practice anchored by the exchange of concrete examples. For example, my writing on blogs and communities (work 2) documents the evolution of combining blogs and communities to give my undergraduate trainee teachers personal and public spaces through which their reflexivity might evolve. The availability of media content gave students choices over their learning pathways and means of expression. Over time, I realised that some of the most valuable digital tools are those that facilitate collaboration and interaction, extending face-to-face learning that is based on active engagement with content. A goal in combining blogs and communities was to use technology to make a more seamless connection between on and offline learning. It became clear that the presence of a commenting audience provides an incentive to write and facilitates informal peer-to-peer learning. As one student said, 'I feel that other students on the course provided me with effective feedback that helped me to improve…I liked that people could comment; it made me more aware of my audience…being able to see what other people think can be very thought-provoking' (work 2). This example highlights the interaction between personal learning in the blogs and collective learning in the associated communities (also see 4.3.2).

2.2.4 MOOCs: combining physical and digital domains

My emphasis on capturing visual representations of practice to stimulate discussion, and mixing asynchronous with synchronous learning aligns with Trust's model of teacher learning as an iterative, multistep process that is socially constructed and situated in the contexts in which teachers work (Trust, 2016). This process can also be described as 'distributed' in that it includes a mix of delivery modes, media and methods, both electronic and traditional, and that it allows learners to learn from each other. It recognises that learning might be independent of time and place, echoing Cope and Kolantzis' seven potentialities (2007). Similarly, Cope and Kolantzis urge educators to guard against technology distancing learners from the richness of person-to-person or hands-on learning and suggest that one role of using devices is to document off-screen real-world activities. In my work with learning communities, I have placed a high value on the interplay of physical and digital activity.

Across the works, the notion of contexts where knowledge is applied and shared is extended to include professional networks, research groups, and in-service professional development opportunities as well as classrooms. In analysing learner needs, it is useful to bear in mind a continuum from externally directed learning to self-directed and/or peer-to-peer learning, based on a gradual release of scaffolding and support (Heick, 2014). For example, when analysing posts in the Technology Outdoors MOOC community (work 1), there was a distinction between posts that simply replicated ideas from the MOOC content and those that adapted or extended them, providing evidence of self-directed learning. Figure 2.4 is an example of self-directed learning leading to peer to peer learning within this online community.

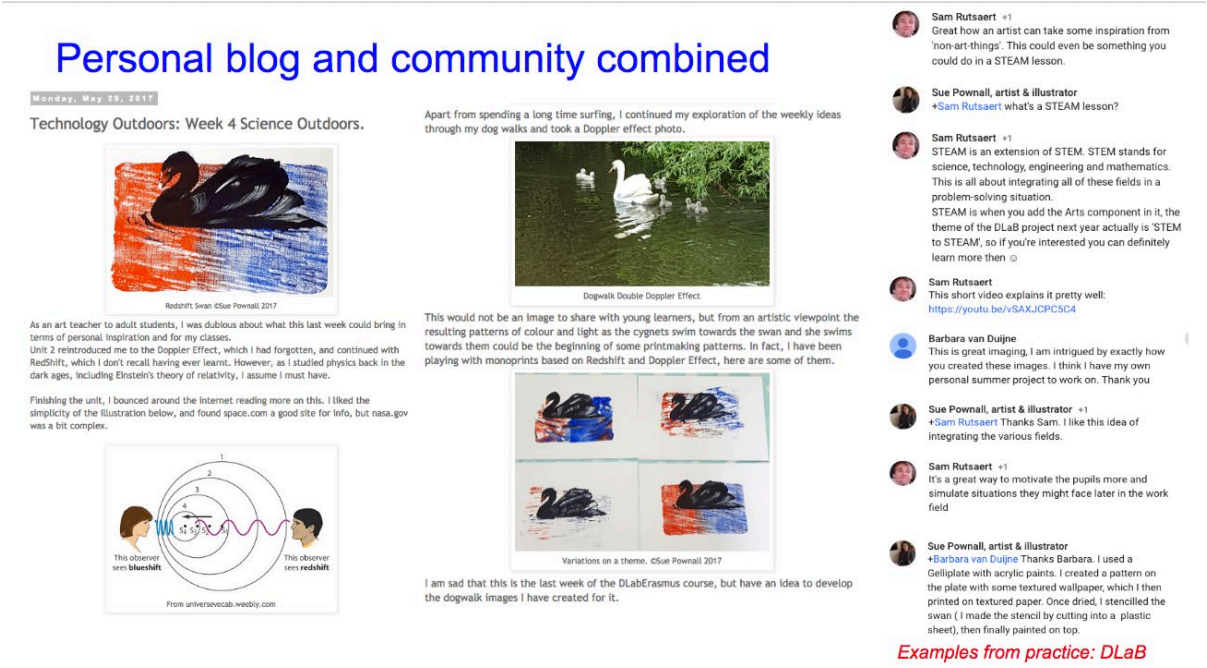


Figure 2.4: Self-directed learning in a MOOC

In the example above, a Technology Outdoors MOOC participant posts on her personal blog and in the online community about her internet research on the Doppler and RedShift effects, inspired by the outdoor science MOOC content. She develops these ideas through photography and art, and shares the results. The following commentary documents the sharing of artistic techniques and resources from learner to learner. The ideas in this post move between the digital domains of the blog and community, out into the physical domain and then back to the digital as the posted images provide the impetus for online discussion.

Peer to peer learning occurs naturally, arising out of social behaviour. There is strong evidence of self-directed learning in the way that the art teacher has applied the physics ideas to her own artwork and identified next steps in her own learning, 'I have an idea to develop the dog walk images'.

2.3 Chapter summary

Participation in TELCs is recognised by many to have the potential to produce significant value for educators across subject areas and professional roles (Sharples et al. 2016; U.S. Department of Education, 2014). However, it is also recognised that this takes time to develop and that most educators will need to adapt their working practices. This chapter has provided some examples of TELCs from my own practice that demonstrate the value of using online spaces to document and share learning that takes place in the physical world. My experience suggests that a key aspect of TELCs is to balance learning habitats. A question to answer, therefore, is 'what does good social learning with technology look like in a blended or online environment that is different from a traditional classroom?' I will address this issue in Chapters 3 and 4 on the themes of computing and digital literacy.

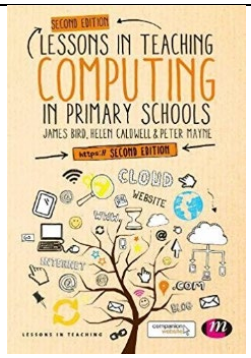
This chapter outlines two contrasting forms of communities. The Vital community is public and expansive in nature, seeking to gather its own momentum and grow in response to participant interests. In contrast, the private student communities accompanied by blogs, provide a contained environment for more structured knowledge-building within a university course. However, there are commonalities between these communities and the MOOC community described in 2.2.4 in that they all demonstrate an interplay of personal and collective learning that combines physical and digital spaces. This suggests that it is important to be aware of the changing pupil and teacher roles within online environments. Chapter 6 offers further explication of these concepts.

Chapter 3: Developing a pedagogy of computing through technology and social learning

The next two chapters consider how the works have contributed to two aspects of changing technology use in education: firstly, the emergence of primary computing and secondly, the impact on digital literacy of the uptake of mobile devices. The first theme addresses reflective theme 1:

> How the public works have enhanced social learning approaches in computing via technology-enabled learning communities (TELCs).

Summary of the works referenced in this chapter:

Work	Reference/Source	Description
1. Conference paper: Master Teachers in Computing: What have we achieved?	Smith, N., Allsop, Y., Caldwell, H., Hill, D., Dimitriadi, Y. and Csizmadia, A.P., 2015, November. Master Teachers in Computing: What have we achieved? In *Proceedings of the Workshop in Primary and Secondary Computing Education* (pp. 21-24). ACM. https://dl.acm.org/citation.cfm?id=2818332	A review of the master teacher training programme undertaken in 2015 run by the association Computing at School (CAS), in which I was a lead facilitator.
2. Online community of master teachers	https://plus.google.com/communities/116334100443162688989	A community of Master teachers attending the training programme.
3. Conference paper: Ubiquitous computing devices in the training of teacher-trainers	Smith, N. and Caldwell, H. (2015) Ubiquitous computing devices in the training of teacher-trainers. In: Morris, L., and Tsolakidis, C (eds), *The International Conference on Information Communication Technologies in Education (ICICTE 2015) Proceedings,* Southampton Solent University, pp. 42-51. http://oro.open.ac.uk/43810/	A peer-reviewed outline of techniques used in the master teacher teaching training programme, describing physical computing projects that were used in preparing teachers to deliver improved classroom lessons and tailored CPD for their peers.
4. Book: Lessons in teaching computing in primary schools	Bird, J., Caldwell, H. and Mayne, P. (1st ed. 2014, revised 2nd ed. 2017). *Lessons in Teaching Computing in Primary Schools*. London: Sage.  https://uk.sagepub.com/en-gb/eur/author/helen-caldwell	One of the first books on primary computing at the time of curriculum change. The second edition of the edited book provides an opportunity to reflect upon national and international initiatives and technological developments, to develop computing in a creative way within the primary curriculum.
5. Let's Teach Computing MOOC and community based on the Lessons in teaching computing book.	MOOC: https://openeducation.blackboard.com/mooc-catalog/courseDetails/view?course_id=_400_1 Course book: https://uk.sagepub.com/en-gb/eur/author/helen-caldwell Google+ Community: https://plus.google.com/communities/112335386477156503633	An international MOOC funded by the Department of Education and based on the book, 'Lessons in Teaching Computing in Primary Schools' and designed to develop a community of practice around the teaching of computing in primary schools.

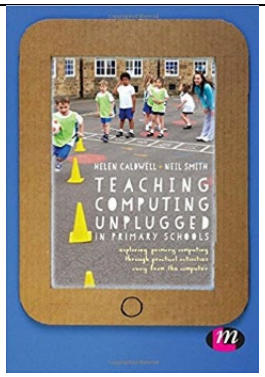
6. Online community from the PG Cert Primary Computing course	https://plus.google.com/u/0/communities/103318414174390823641	A comparison community of more experienced primary computing teachers.
7. Book: Teaching Computing Unplugged: Exploring primary computing through practical activities away from the computer	Caldwell, H. and Smith, N (2016). *Teaching Computing Unplugged: Exploring primary computing through practical activities away from the computer.* London: Sage.  https://uk.sagepub.com/en-gb/eur/author/helen-caldwell	This edited book looks at how the fundamental principles and concepts of computer science can be taught without any hardware as children analyse problems and computational terms and apply computational thinking to solve problems without turning on a computer.
8. Book chapter: Planning computing in the national curriculum	Caldwell, H. and Grantham, S. (2015). Planning Computing in the National Curriculum. In: Sewell, K and Fairley, H. *Planning the Primary National Curriculum*. London: Sage. https://uk.sagepub.com/en-gb/eur/planning-the-primary-national-curriculum/book244230	This book chapter considers factors that are specific to planning effective computing lessons. It looks at how teachers can provide the conditions to enable children to take on personally relevant and real world computing challenges, which then allow them to apply computational thinking concepts and become productive makers using technology.
9. Digital Leaders across Boundaries blog	Blog https://mypad.northampton.ac.uk/digitalleaders/ Digital Playdate https://mypad.northampton.ac.uk/digitalleaders/2016/06/11/digital-playdate-for-the-symposion-network-of-european-schools-of-education/	Pilot for the Digital Learning across Boundaries project outlined in chapter 5
10. MESH guide: Technology Enhanced Learning Communities	http://www.meshguides.org/guides/node/880	A peer-reviewed MESH Guide published by the Education Futures Collaboration on the topic of Technology Enhanced Learning Communities. MESH stands for Mapping Educational Specialist KnowHow and the guides are designed to support teaching as an evidence-informed profession by providing research summaries to underpin educators' professional judgement.

Figure 3.1: Public works referenced in Chapter 3.

3.1 Contributing to the computing field

An aim throughout my work has been to enable others to keep pace in the rapidly changing field of educational technology. With very few primary teachers in the country having any kind of background in computer science, there has been an urgent need for professional development, and this is an area where I have had an impact, through various combinations

of blended and online learning, books, presentations and papers aimed at pre-service and in-service teachers.

A distinctive contribution of my public works is the development of TELCs arising from CPD events. Examples drawn from these TELCs illustrate the emergence of a repertoire of resources and pedagogic strategies as the online community groups remix and evaluate ideas, and solve problems together. These are typical communities of practice behaviours described by Wenger (2011, pp1-6), illustrated in Figure 3.2. The online spaces provide a structured 'socio-technical framework' within which social learning can take place, cutting across boundaries and formal structures (Ozturk and Ozcinar, 2013). This chapter looks at how some of my written texts evolved into TELCs and how they contribute to the emergent field of primary computing.

Figure 3.2: A representation of Wenger's CoP elements (Wenger, 2011), taken from the MESH Guide (work 10)

3.2 Primary Computing

The works outlined in this section are aimed at an audience of teachers and student teachers. They contribute to the ongoing debate around the pedagogy of primary computing, and constitute some of the first writing on the theme to appear in higher education libraries around the country. In this section I explore how these works enabled teachers to develop and share common understandings of the national curriculum computing programmes of study introduced in 2014.

I began to develop public works on the theme of primary computing by leading the writing and editing of several books and book chapters, and this helped to consolidate my own thinking (see works 4, 7, and 8). Another key activity was to run a branch of the government funded Network of Excellence Master Teacher Training programme, and document this through conference papers (works 1 and 3). An opportunity then arose to bid with colleagues from Oxford Brookes for Department for Education funding to create a MOOC on the theme of primary computing, based on content from one of our co-authored books (work 5). Having seen the success of the TELC associated with the MOOC in giving teachers a platform for sharing ideas about this new field, I created additional communities to support other groups (works 2, 6, and 9).

The impact of this set of works is documented in part through their accompanying online communities. In effect, I have seen the book chapter monologues become dialogues through community discussions, and I have become interested in ways in which these conversations add to knowledge in the field, a process described by Hoadley and Kilner in their model of learning in a community of practice (Hoadley and Kilner, 2005). Like them, I was interested in creating online spaces where participation and conversations could flourish so that teachers could begin to take ownership over the new computing curriculum. The content of the Let's Teach Computing MOOC (work 5) was drawn in part from the book 'Lessons in Teaching Computing' (work 4), and presented with the aim of seeding activity and conversations within the accompanying community. In this way, I aimed to help the community grow its own knowledge and develop metacognitive learning strategies related to authentic contexts (Johnson, 2001).

This approach is in line with Wenger's notion of 'stewardship' to describe the way in which communities benefit from being nurtured to develop shared understandings. For example, technology stewards or moderators might play an active role in making sure that technology tools meet the needs of the community (Wenger, White and Smith, 2009). A challenge facing teachers is that they need to not only know how to use technology, but how to blend it with their pedagogical understanding and with their subject knowledge, an issue addressed by the Technological, Pedagogical Content Knowledge framework (TPACK) presented by Koehler and Mishra, 2009, building on work by Shulman (1986). The TPACK framework considers the impact of adding technology to Pedagogical Content Knowledge (PCK). In the sections below, I draw from the communities as well as the books to compare teachers' developing

confidence and competence across these aspects of their practice in the emergent field of primary computing.

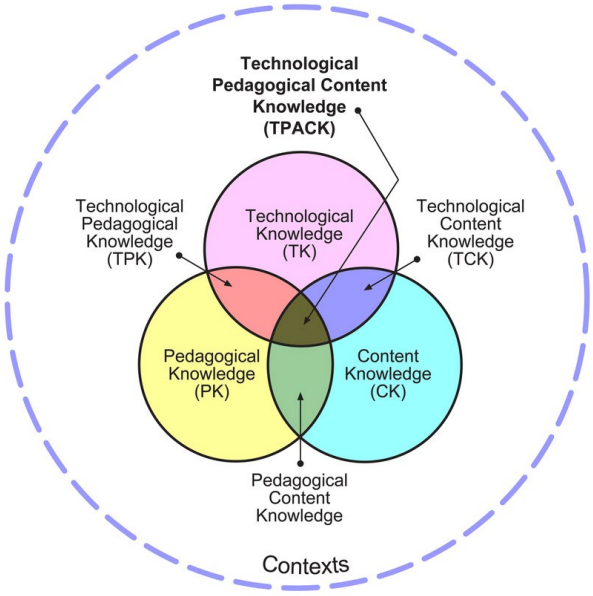


Figure 3.3: Technological Pedagogical Knowledge Framework (Koehler and Mishra, 2009).

3.2.1 National curriculum background

The period from which these public works is drawn saw profound changes in the field of computing in education. As early as 2011, at the University of Northampton I began teaching computer science with our trainee teachers, in anticipation of the national curriculum reforms. The old ICT curriculum was disapplied in September 2012, and there followed two years of consultation as the new curriculum was proposed and refined, and finally launched in September 2014. Of all the curriculum subjects, the subject of ICT saw the greatest reform, including the change of name to computing, with the expectation that pupils as young as six would 'create and debug simple programs' and 'understand what algorithms are' (Department for Education, 2014).

3.2.2 Master Teacher training

Back in 2011 Ofsted found ICT teaching to be good or outstanding in nearly two thirds of primary schools, however they identified programming or 'control technology' as an area of weakness (Ofsted, 2011). Computer science continues to daunt many teachers and student teachers, and one of my challenges has been to help them develop the confidence to teach it. I became involved with a Department for Education (DfE) funded initiative, the Computing At

School Network of Excellence programme. Representing the University of Northampton as one of 12 national programmes in 2014, I trained of a group of master teachers to deliver peer-to-peer CPD in primary and secondary computing, as outlined in works 1, 2, and 3. This CPD model was based in part on Sentance at al.'s (2013) holistic model of professional development designed to actively involve participants in constructing their own understanding through collaborative learning activities. At its core is the idea of 'grass roots' collaborative CPD within a community of practice where enthusiastic and experienced teachers work together on a sustained basis and are willing to learn from each other, supported by a website of resources (Sentance et al., 2013). My version of the training extended this idea by encouraging teachers in the group to engage in discussion and peer support through a TELC, rather than simply post resource links in a public online space.

Reflecting on this work four years later, it is clear to me that the needs of primary and secondary teachers within the master teacher group were substantially different. Although they learnt from each other, there were very few exemplars available for the primary teachers of how best to approach computational thinking in a primary context. This was a particularly pressing problem for KS1 teachers. If we browse the community postings of primary teachers in those early days of the new curriculum, we can see that, above all, they were keen to find and share classroom resources (work 2), perhaps because they needed reassurance that they were doing the right thing. In contrast, the recent postings of my Postgraduate Certificate in Primary Computing group in 2017/18 (work 6) are much more confidently focused on the need to establish sound principles of classroom practice based on research evidence (see section 3.2.4 for a more detailed exploration of this point).

3.2.3 Computational thinking in the primary classroom

It was apparent from the master teacher community postings that it was not just the subject knowledge of computing that presented a challenge for primary teachers. As mentioned above, they needed to balance subject matter knowledge (SMK) with pedagogical content knowledge (PCK), to draw from Shulman's TPACK model (Shulman, 1986). A second challenge addressed in the public works has therefore been to come to some conclusions about what the pedagogy of teaching computing looks like in the primary context, and how to help teachers to take ownership over ideas that are outlined very sparsely in the national curriculum documents. As Sentance and Csizmadia conclude from their survey of 336 primary and secondary computing teachers' challenges and strategies:

> ‘The ways in which computer science elements of Computing are taught are different to methods previously used in delivering ICT.’
> (Sentence and Csizmadia, 2017, p.489)

3.2.3.1 Computational thinking and creativity

The national computing curriculum begins with the bold claim that children will use ‘computational thinking and creativity to understand and change the world’, (Department for Education, 2014). In my view, this implies a need to develop expertise in digital making, and through this build transferable computational thinking skills such as approaches to problem solving, understanding systems and processes, generalisation, abstraction and evaluation. And the reference to creativity suggests that there may be broader benefits to computing, such as self-expression and communication.

However, if teachers are to promote these benefits through digital making, they firstly need to experience them first hand for themselves. A crucial question to explore through the public works has therefore been, ‘what do we mean by computational thinking and how can we teach it?’ Interpretations of computational thinking vary from the philosophical (Aho, 2012) to the more practical (Brackman et al., 2017; Kalelioglu et al., 2016). Many definitions are based on the seminal work of Jeanette Wing (2006, 2008), although the term was originally defined by Papert (1996).

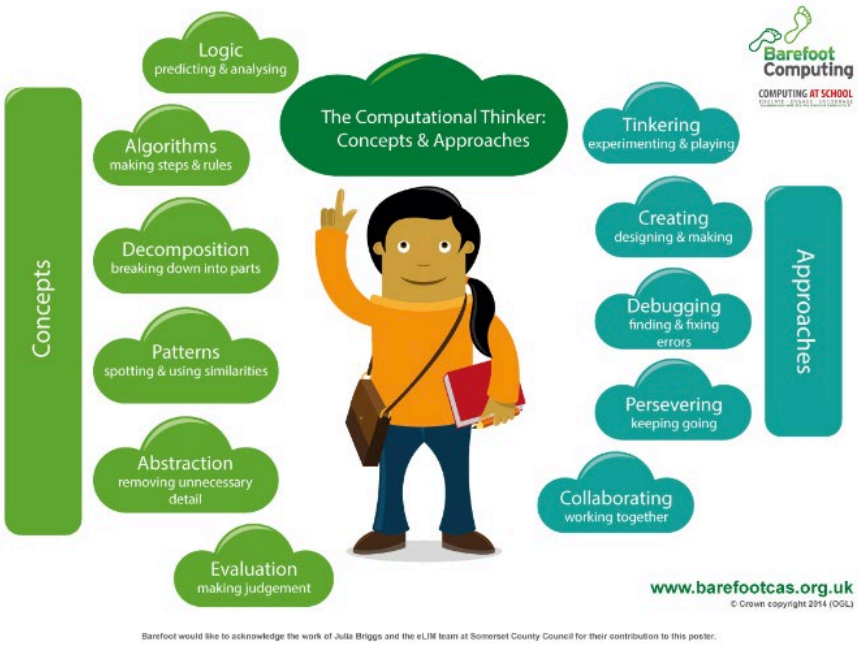


Figure 3.4: Computational Thinking diagram from Barefoot Computing

Csizmadia et al. suggest that computational thinking involves four main activities:

> 'Breaking down into component parts (decomposition), reducing the unnecessary complexity (abstraction), identifying the processes (algorithms) and seeking commonalities or patterns (generalization)' (Csizmadia et al. 2015, p.9)

My first writing on this topic was conceived at the time when the primary computing curriculum was newly defined, (works 4 and 5), and I took the view that the concepts initially needed to be related to the existing primary curriculum. There was therefore an emphasis on unpicking the unfamiliar vocabulary and demonstrating that much of the behaviour it describes already takes place in an average school day. In other words, we can reconceptualise many everyday behaviours in computational thinking terms. For example, we can generate algorithms for taking the register, stacking chairs or lining up for playtime. We can analyse dance routines, recipes and songs for sequence, selection, and repetition, and even bring in stored procedures. Through this, we can build metacognition around the concepts and recognise when we are generalising thinking strategies across situations. Works 4 and 5 describe many such examples.

3.2.3.2 Computing unplugged

Several authors acknowledge a need to separate computational thinking from the distraction of computers. So-called 'unplugged computing' has its origins in the Computer Science Unplugged project in New Zealand (Bell et al., 2009) and has been developed in this country by Curzon et al.'s CS4FN (Computer Science for Fun, 2009). My co-authored book 'Teaching Computing Unplugged' (work 7) fills a gap by providing a rationale and selection of unplugged activities that concentrate on the essence of computing. I take the view that computer science is fundamentally about learning how to think, and a key aim of teaching computing is about getting children to think about the world in a different way. Just as there is more to art and science than test tubes and paintbrushes, there is much more to computing than computers and programming. As the first chapter of Teaching Computing Unplugged (work 7) points out, we can compare coding and computational thinking to the distinction between bricklaying and architecture:

> 'Just as architecture is about understanding people's requirements and seeing how a particularly shaped pile of bricks could address them, computational thinking is about understanding a problem and seeing how a particularly shaped pile of program statements could address it.'
> (Teaching Computing Unplugged, p.2)

Across the book chapters, the activities and discussions are closely linked with each of the other primary subjects, and most are based on kinaesthetic and tangible experiences, making them easier to embed in current primary practice. The playful nature of these unplugged activities emphasises the constructivist pedagogy that underlies the approach (Papert 1996; Wing 2006, 2008).

3.2.3.3 Social computing

In the context of the public works, then, computational thinking implies that, rather than just showing children how to solve programming problems, we need to teach them applied cognitive skills. There is a tension between learning to code and learning to be creative with code, and an ambition of my public works has been to help teachers develop a vision that includes both, whilst acknowledging that they are themselves beginners in the field. The temptation for many teachers is to dip into the plethora of computing resources that merely

put children through the steps of coding a sprite to do something, without providing a wider context for applying their skills to a creative project.

Equally, there is a need for some explicit guidance on the mechanics of programming before learners can apply their skills to be creative within the medium. This calls for a balance of guidance and freedom; teachers need to engineer situations where children can be creative with code and yet are likely to achieve success. If they are to fulfil the call to develop real understanding of computational thinking, teachers need to bear in mind the twin goals of *learning through technology* and *learning how to use technology*. This means allowing time for children to become familiar with the programming strategies that will become part of their repertoire of transferable skills, and then to apply them as tools for digital making.

Various strategies have been suggested for supporting teachers in moving away from dependence on 'quick win' resources, which have low creative potential. Drawing upon Alexander's ideas about a pedagogy of principles (Alexander, 2010), Shelton (2016) suggests that we should aim to teach 'repertoire not recipes' if we want teachers to 'design the rich, open-ended learning opportunities that will most benefit their pupils and that are a feature of the practice of constructionist teachers' (Shelton, 2016, p.3).

A coding environment allied to an online community of thousands that supports this approach is Scratch, developed by MIT. In this context, the idea of remixing and reusing comes into its own; children can browse a selection of projects drawn from the Scratch community and 'backpack' pieces of code that they can then adapt to solve their own problems (Kafai and Burke, 2014; Belshaw, 2012). My books, 'Lessons in Teaching Computing' and 'Teaching Computing Unplugged' (works 4 and 7) demonstrate how teachers can build their own repertoire of strategies to ensure that children experience success.

Shelton also recognised the importance of scaffolding, and puts forward a template to support teacher planning in computing that embeds the computational thinking approaches of playing and tinkering, manipulating and remixing code, and making and evaluating. In his view, dialogic talk is an important aspect of computational thinking that merits further research (Alexander, 2006, cited in Shelton, 2016). This has similarities with Dawes and Wegerif's 'Thinking Together' approach that positions the computer as a support for social learning based on the idea of shared inquiry (2004). These ideas also resonate with Kafai and Burke's

suggestion to progress from computational thinking to 'computational participation' (2013), (see section 3.3 for further explication of this idea).

My suggested strategies for teaching computing, as outlined in works 5 and 7, have much in common with these ideas. These public works describe a learning landscape in which teachers and children jointly construct ideas by applying their problem-solving and computing skills in a purposeful way that leaves them with something to show for their endeavours. Whether they are creating media or code, I suggest that the digital products be both *objects to think with* (Papert, 1980) and *objects to share with others* (Kafai and Burke, 2013). The works describe a social process as children collaborate on the production of shareable products and pursue questions that they find interesting related to authentic contexts, rather than being presented with a set of coding challenges to solve that have little real world relevance. Teaching Computing Unplugged (work 7) describes scenarios such as learning about data transmission through teams sending coded messages across the playground, learning about abstraction and generalisation through culinary algorithms and invented recipes, and using conditional statements and repetition to program each other in a dramatic reconstruction of a hamster's playpen. These ideas assume that when children see their coding routines working in the physical world, they often reinvent more complex algorithmic structures for themselves in a natural way, and that this leads to a deeper understanding of the grammar of programming in the digital world.

3.2.3.4 Section summary

In summary, this section on computational thinking in the primary classroom has explored the idea that a key challenge for primary teachers has been to interpret the first sentence of the computing curriculum in a meaningful way (Department for Education, 2014). Through the public works, I have demonstrated that the idea of 'computational thinking and creativity' implies that children apply their coding skills with cognisance to digital making and invention projects, and that teachers create the conditions that enable them to pursue authentic creative goals.

Underpinning my writing on the computing curriculum, then, is a view of computing as a collaborative activity and the idea of belonging to a community with a shared interest in solving computational problems (Shelton 2016; Kafai and Burke 2014; Sentance and

Csizmadia 2016). The next section looks at how I supported several learning communities to embed these ideas in their own teaching.

3.2.4 Learning communities embedding primary computing

This section explores how online communities took forwards the vision of primary computing described in the edited texts and shared through teacher CPD events. It draws from a range of face-to-face CPD sessions I hosted to support local teachers, from my involvement in the training of the group of master teachers (works 1, 2 and 3) and, more recently, from the postgraduate certificate in primary computing group (work 6). These groups posted ideas about computing pedagogy and practice on their online community spaces (works 2, 5, and 6). The exploratory nature of much of this discussion is evident as teachers test different approaches.

For example, a scroll through the community postings for the master teachers' group over the course of a year shows a movement from tutor postings to student postings and a subsequent increase in commenting as students begin to support each other (work 2). An objective was to train teachers in the group to deliver some of the first CPD in the field to their peers, and we can see them seeking reassurance as they begin to take their initial steps. There is a current of sharing and evaluating resources running throughout this community, reflecting the lack of certainty about which were the best resources to use in the early days of the new curriculum. These learners moved from novice to expert through engagement and collaboration, and towards the end of the year began to run their own CPD sessions. What comes through quite clearly in their comments is a sense that they are treading new ground and supporting each other on their journey.

Master teachers 2015:

> *'Can anyone point me to a good place to go for information/ideas on embedding ICT across other subjects using the new guidelines? (if there are any)'*
> *'Does anyone have a decent year 8/9 computing exam that I could have a quick look at? I could give you one I made last year as a swap.'*
> *'I've got my first 6 places booked on my first session!! At least I won't be Billy-no-mates!'*
> *'Does anyone have experience with either web design or blogging at primary, and do you have any suggestions for software they should be using? Thanks!'*
> *'This is really useful! I am going to be delivering some training soon so I will make sure I emphasise this as part of it.'*

'Great article - quite useful to actually have a name for this 'learnt helplessness' and some good advice!'
'I did my first Barefoot presentation today. It went very well!
'Stacey and I ran an NQT day on primary computing this week. Here are our some of our resources. A big thank you to Clare Board for sharing her slides. I used a few of those at the beginning.'

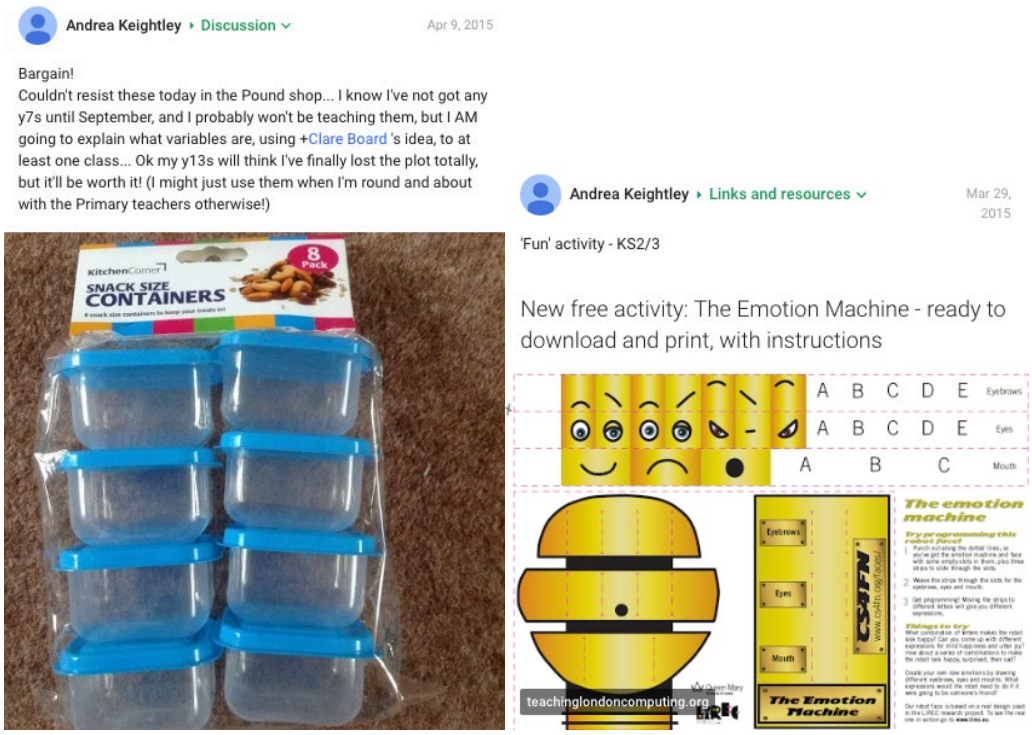


Figure 3.5: Master teachers sharing ideas in their TELC

The success of the Master Teacher community in supporting teachers implementing the new curriculum informed the development of the online community accompanying the 'Let's Teach Computing MOOC' (work 5) based on the book 'Lessons in Teaching Computing in Primary Schools' (work 4). This MOOC ran in 2015, funded by the DfE, with 570 registrations and 168 members actively posting in an online community. At this point in time, the curriculum had been in place for a year, and an intention was to model the benefits of active social learning and digital making. The MOOC was based on excerpts from the book, which were accompanied by etivities based on the work of Gilly Salmon (2013) as a framework for designing active online learning. (Salmon, 2013).

In their responses to each other's posts, we can see teachers beginning to define for themselves what computational thinking means in the primary school context. For example,

we can see numerous posts where teachers have thought about 'everyday algorithms' based on children's regular experiences:

Let's Teach Computing MOOC (2015) (work 5):

> *'Instructional writing is a good way to introduce the concept of algorithms and I was able to do so within my Literacy lessons in a Year 4 class.'*
> *'Here is my algorithm of how to plant a seed. I did this activity with my class two terms ago and they absolutely loved it.'*
> *'What surprised me and the teacher I was working with for the last half term was the number of opportunities to link algorithms to the other (non-explicitly computing) activities happening in the class.'*
> *'I think (computational thinking) has lots of potential for problem solving in maths, which we really need to work on! If I can embed this way of thinking in different areas of the curriculum, it may rub off in maths.'*

Figure 3.6: A teacher posts an algorithm for making a cup of tea.

The posts in this community have an exploratory feel as teachers are reflecting on approaches and ideas that are entirely new to them. Within this MOOC community, creating the artefacts often appears to be a catalyst for individual understanding and reflection, and then the sharing of the artefacts appears to be the springboard for more learning:

Excerpt of a post from Let's Teach Computing MOOC (2015):

> *'It has never occurred to me before that aspects of programming are actually used throughout Talk for Writing…*
> *For example, with a focus on story writing, the teacher would introduce a story to the children where they would attach actions to the key language and vocabulary throughout the story, in order to help the children to remember it.*
> *Story maps include symbols such as arrows to show the direction of the story. They also include start and end symbols such as the opening or closing of a book..... I love the fact that this scheme includes very basic aspects of coding and programming and that children are actually doing these skills without even realising.'*

Comments on the above post:

> *'I will share some photos of my children's story maps and the writing they produced very soon :)'*
> *'I like this! You could perhaps take it further, and them the story actions into literal blocks in Scratch, and use it as a structure for children to build their own animations.''*
> *'Throughout Talk for Writing, the children also go through the process of innovating their story…This is a fantastic link to debugging in programming! I love your idea of putting the story into scratch! I'm going to give that a go for definite :) Thank you!!'*
> *'An idea for showing (de)composition: create a scene and have it controlled by one script. Then make that script the body of a custom block. Do the same for another scene. Then animate the whole story by using the custom blocks in sequence.'*
> *'That's such a good idea Neil. Do you have an example script which uses a sequence of custom blocks?*
> *'Not yet, but I'll see if I can knock something up...'*

In contrast to the two communities described above, the Postgraduate Certificate in Primary Computing online community consists of a group of experienced teachers who have already been leading computing in their schools for some time (work 6). The posts from this group display a clearer grasp of computing pedagogy and a more assured evaluation of the relevant tools and devices. Within this learning community there is a strong feel of social interdependence and shared goals, and a sense of discovery when discussing strategies. There is a sense that the group values their collective voice.

Example posts from PG Cert Primary Computing:

> *'I've read a lot about Mitch's 4Ps of learning - the online Learning Creative Learning tasks looked at Project, Passion, Peers, Play - and I like the model of a teacher as a facilitator of collaborative learning.'*

'Thinking about what we said about subject leaders not necessarily being experts, I'm now wondering if I can extend me being a connector rather than a teacher for my class to me being a catalyst as a subject leader - asking proactive questions, exploring collaboratively, learning alongside staff in the same way as Mitch advocates teachers learning with their students.'
'I think I can accept my role as subject leader more convincingly if I actually view myself as a collaborative consultant - leading (or teaching) doesn't have to mean instructing as I don't have all the answers. But I can be a connector - sharing ideas that we explore together.'
'I think that's a really interesting strategy that could be worth adopting. It's also beneficial to embrace not knowing the answer to help others find it.'

Figure 3.7: Teachers becoming more confident with primary programming

For example, whilst participating in the Teaching with Tablets MOOC (discussed in Chapter 4) one of the students, herself a beekeeper, likened the online community to a bee colony. Her analogy acknowledges the benefits of peer-to-peer learning and sharing practice:

Bee analogy post from a MOOC participant:

'This is a complex hive for sure. The connection is very specific. A bee colony has a large community working together in a hive to achieve the same goal. Here, I've already seen many bee behaviours. Bees chipping in and helping with suggestions, a waggle dance to show others the way to good ideas and learning paths, passing resources from mouth to mouth until they become honey, encouragement for new bees and newbies, a cluster of bees together that generates warmth and security.'

3.2.4.1 Section summary

In summary, there are differences in the learning goals of these three TELCs (works 2, 5 and 6); the master teachers are working towards delivering CPD, the MOOC participants are tentatively beginning to teach the new curriculum, whereas the third group is aiming for a postgraduate qualification in leading computing. However, there is a shared sense of agency across all three in their capacity to contribute to the nascent field of primary computing through their collective voice.

These learning communities highlight the gap between the intended and the implemented curriculum and role of teachers in bridging this gap. This is a challenge noted in Finger and Houguet's study of the implementation of the first formal technology curriculum for primary schools in Queensland, Australia (Finger and Houguet, 2009), which suggests that teachers are often resistant to change (Rennie et al., 2001, cited in Finger and Houguet, 2009). It may be, then, that one function of TELCs is to build belief in learning benefits through posting and reflecting on examples from practice as they occur. This helps to build an emerging group consensus and increased group confidence as 'I' becomes 'we'. Developing shared ownership of ideas enables them to become integrated in teachers' personal beliefs. An outcome is that ideas distilled through the community engagement are subsequently transferred to individuals' practice.

The next section looks at how my later public works on the theme of primary computing develop the theme of social learning.

3.3 Developing the theme of computing and social learning in practice

In my later writing on the primary computing theme (Revised edition of work 4 and work 7), I focused more specifically on the social learning aspects of coding. I was influenced by Kafai and Burke's ideas (2013) about moving 'from computational thinking to computational participation' and by the work of Mitch Resnick (2014) on the principles underlying the Scratch community. These authors envision classroom computing as a social activity, which involves children remixing and sharing code together.

My writing on 'Computing and Digital Literacy' (work 9) considers the computational thinking approach of 'tinkering' to describe the playful nature of coding, noting that primary-aged children respond well to a problem-solving approach to beginning programming:

> ‘Tinkering is what happens when you try to do something you don’t quite know how to do, guided by whim, imagination and curiosity. When you tinker, there are no instructions – but there are also no failures, no right or wrong ways of doing things.’ (The Tinker Factory, 2012):

The creative cycle described here has much in common with Papert and Harel’s (1991) constructionist philosophy, in which children are guided to learn by doing and making in a technology-mediated environment in collaboration with their peers. This builds on the constructivist theories of Dewey (1938), Piaget (2005) and Bruner (1996), and is based on the premise that the process of constructing something meaningful creates conditions for new knowledge, as it makes space for the iterative development of ideas (Papert, 1980). Expanding on these ideas, Ben-Ari acknowledges the role of bricolage, a term coined by Levi-Strauss, to describe the process of experimenting, testing and debugging in computer science education (Ben-Ari 1998). Mitch Resnick of MIT also suggests that the development of early computing skills has much in common with play within communities of learners:

> ‘Our ultimate goal is a world full of playfully creative people who are constantly inventing new opportunities for themselves and their communities’ (Resnick, 2007. p.1).

In line with these ideas, one of my initiatives has been the development of ‘Digital Playdates’ as CPD events based on the acronym, ‘People Learning and Asking Why’. These involve groups coming together in a physical space to tinker and invent with technology. The notion of play is useful in encouraging people to suspend their disbelief and let go of preconceptions about where the learning experience will take them. Over time I have tested this concept with children, university students, visiting academics and university staff, and my experiences of running this style of event suggest that they lead to unexpected results.

Figure 3.8: A digital playdate allowing time for tinkering and experimenting

Figure 3.9: Example digital playdate from the DLaB pilot blog (work 9)

In one session, for example, one academic used the tool Thinglink to analyse a law report alongside another academic producing a guide for supporting writing.

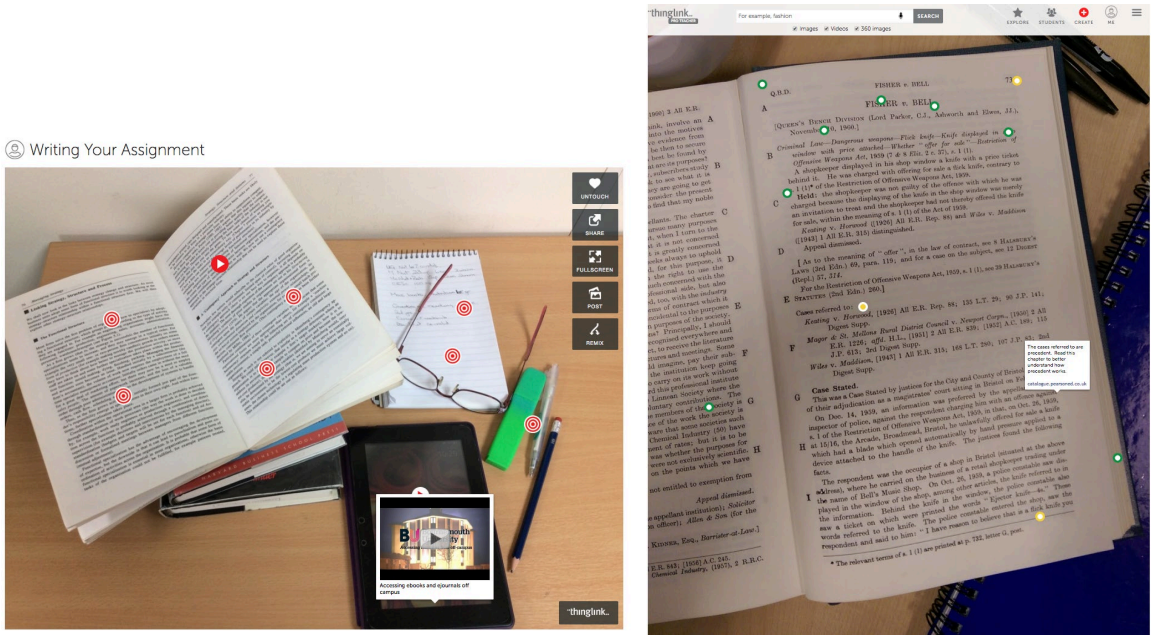


Figure 3.10: Academics using Thinglink to create interactive images on the themes of academic writing and understanding a law report. https://www.thinglink.com/scene/759762885869043714

This highlights an advantage of TELCs in that they can demonstrate how technology tools can be used in different ways across diverse groups, and that this often provides sufficient nudge for someone to apply an idea to their own context.

The playdate approach demonstrates an iterant view of knowledge construction, based on the idea that people learn in cycles and are constantly involved in refining or 'debugging' their theories of the way the world works. This has an affinity with the process of applying computational thinking to solve problems. Papert (1980) uses a similar analogy in his constructionist theory that suggests that computers provide a powerful environment for constructing and refining knowledge. If they are to tap into this potential, teachers need to understand children's social worlds to enable then to make culturally meaningful representations:

> 'Thus we are brought back to seeing the necessity for the educator to be an anthropologist. Educational innovators must be aware that in order to be successful they must be sensitive to what is happening in the surrounding culture and use dynamic cultural trends as a medium to carry their educational interventions.' (Papert, 1980, Chapter 8.)

Ben Ari echoes this need to be sensitive to learners' prior knowledge and mental models in his guide to the practical application of constructivism in computer science education (Ben Ari, 1998). He suggests that cognitive change is a result of teachers guiding their students in the modification of their mental models through individual reflection and social interaction. Two basic tenets of his theory are that models must be explicitly taught and that individuals construct knowledge in their own subjective way. Within a constructivist pedagogy, then, a good computing teacher refines students' prior models of the world through active, authentic and meaningful experiences, which, for beginner programmers at least, would be social in nature.

Wegerif and Dawes add to these ideas by defining education as 'a capacity to engage effectively in learning dialogues' (Wegerif and Dawes 2014, p.133), suggesting that new technology and spoken language are 'the two most powerful resources people have created' (p.133). They also view computing as a social activity, at its best consisting of, 'learning dialogues with focussed peers framed by technology that give real significance to the constructionist experience and create 'a climate of collaborative enterprise', (Wegerif and Dawes, 2004, p.131).

To relate these ideas to my own works, the 'Lessons in Teaching Computing' book and MOOC (works 4 and 5) and the book chapter 'Planning Computing in the National Curriculum' (work 8) posit that shared programming projects, wherein students 'make things that do things' are external representations of internal problem-solving processes, and so help them to 'think about thinking'. 'Teaching Computing Unplugged' (work 7) stresses the need to build vocabulary and metacognition around computational thinking concepts so that they become familiar strategies to draw upon, apply, discuss and then reuse in new contexts. This resonates with the ideas of Kimble, Hildreth et al. (2001), who state that it is not the artefact per se which is important but the process involved in its creation.

To sum up this section, my view of computational thinking developed through the works embraces the social nature of computing. I aim to create scenarios where learners can collaborate in digital making projects, and learn to apply and refine their computational thinking skills. A playful approach that emphasises time for exploring and tinkering has been successful for me across educational sectors. I am currently engaged in creating a physical maker space to be known as the STEAMspace for the university and the local community to continue to work together in this way.

3.4 Chapter summary

The themes that emerge from this selection of public works on primary computing broadly match the summary of five successful strategies identified by Sentence and Csizmadia (2017) in their survey of 336 computing teachers' approaches: unplugged activities, contextualisation of tasks in the real world, collaborative learning, computational thinking and scaffolding programming tasks. As these authors acknowledge, their self-selecting sample came in the main from members of the lively and supportive subject association Computing At Schools (CAS) who are already enthusiastic about teaching computing. The nature of this sample therefore suggests that the data provides strong evidence of good practice. A challenge for me within my own writing and learning communities, however, has been to build confidence and belief amongst a much less experienced audience of non-specialist primary teachers with limited experience of computer science.

These selected works were timely, in that they extended the embryonic knowledge base of pre- and in-service teachers during a period of national reform, and the conference presentations and MOOCs associated with them raised the level of national and international debate (see Appendix 3).

My public works in this field firstly helped teachers to understand the new terminology associated with curriculum change and then supported them to gain first-hand experience of computational thinking concepts and approaches so that they could transfer this to their own learners.

Building on this, the TELC platforms associated with the works gave teachers a voice so that they could state what computational thinking meant to them in a public arena. The fact that this was a collective voice engaging in sustained debate in a space where they had developed interpersonal trust empowered teachers to speak with more confidence. The TELCs cited in this section demonstrate that it is not sufficient for teachers just to assimilate new subject knowledge; they also need time for shared understandings to emerge around the delivery of a new subject. In this way, the TELCs begin to crystallise what primary computing looks like in practice from within the profession.

The TELCs associated with this chapter have informed the models presented in Chapter 6 in various ways. For example, the Master Teachers group represents a contrasting form of

community in that the members of the parent group generated new self-sufficient offspring communities with similar goals and aspirations. The resulting constellation of related communities might be described as satellite in form. There is an example of an expansive community growing in response to participant interests in the sharing of coding projects on the Scratch website. The idea that computational participation should feature in our classrooms and face-to-face CPD events suggests that the interplay of personal and collective learning can take place in physical environments as well as digital. And the Let's Teach Computing MOOC shows a community moving from being inspired by the course content to being motivated by making connections with each other as ideas are articulated through talking and making.

Chapter 4: Developing a pedagogy of digital literacy through technology and social learning

Reflective theme 2:

How the public works have enhanced social learning approaches in digital literacy via technology-enabled learning communities (TELCs).

Summary of the works referenced in this chapter:

Work	Reference/Source	Description
1. Book chapter: Computing and Digital Literacy	Caldwell, H and Honeyford, G. (2013). Computing and Digital Literacy. In: Dawes, L and Smith, P., *Subject Teaching in Primary Education*. London: Sage. https://www.amazon.co.uk/Subject-Teaching-Primary-Education-Patrick/dp/144626789X	This book chapter works towards a definition of digital literacy that involves rethinking what teaching and learning looks like in contemporary classrooms.
2. Digital Learning across Boundaries project (DLaB): Website, Technology Outdoors and STEM to STEAM MOOCs and online community:	Website http://dlaberasmus.eu Community https://plus.google.com/u/0/communities/117458443566280105364 Online course http://dlaberasmus.eu/courses/technology-outdoors-online-course/	An Erasmus+ European partnership project promoting digital learning across the boundaries of physical spaces, across curriculum subjects and across languages and cultures. Three of the project intellectual outputs of the 3 year Erasmus+ DLaB project are yearly MOOCs and online communities on the themes of Technology Outdoors, STEM to STEAM and CLiL (Content and Language Integrated Learning).
3. Book: Teaching with Tablets 	Caldwell, H. and Bird, J. (2015). *Teaching with Tablets*. London: Sage. https://uk.sagepub.com/en-gb/eur/author/helen-caldwell	This edited book looks at the teaching and learning benefits offered by mobile devices such as their portability, connectivity, accessibility and range of media, and how these present new challenges and opportunities for teaching and learning.
4. MOOC and online communities: Teaching with Tablets and Apps for Innovation	Online course https://openeducation.blackboard.com/mooc-catalog/courseDetails/view?course_id=_806_1 Teaching with Tablets Community https://plus.google.com/u/0/communities/108510780639510097712 Apps for Innovation community: https://plus.google.com/u/0/communities/110218249780833007111	The teaching with Tablets MOOC is an interactive and participatory online course on how to make effective use of iPads and tablets for teaching and learning based on the book. It offers participants the chance to share and reflect upon co-created resources with the online community of fellow practitioners. The Apps for Innovation community is a group of lecturers in Initial Teacher Training piloting the use of iPads for teaching and learning at the University of Northampton.
5. Journal article: Mobile technologies as a catalyst for pedagogic innovation within teacher education	Caldwell, H. (2017). Mobile technologies as a catalyst for pedagogic innovation within teacher education. *The International Journal of Mobile and Blended Learning* (IJMBL), 10(2).	This peer-reviewed paper explores the use of mobile technologies within teacher education at the University of Northampton. Experiences from mobile technology projects involving ITT students, primary teachers and academics are shared to illustrate how mobile technologies

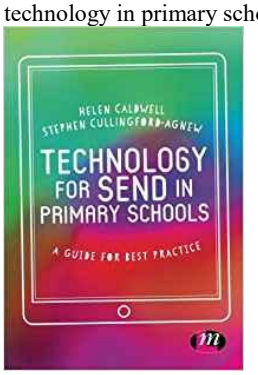
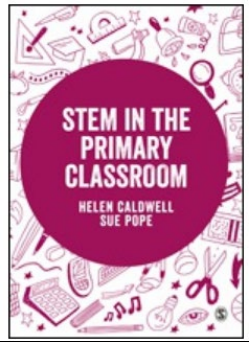
	https://www.igi-global.com/article/mobile-technologies-as-a-catalyst-for-pedagogic-innovation-within-teacher-education/201894	have been a catalyst for new approaches to teaching and learning based on a social constructivist model of learning in our teacher education programmes.
6. Book: Technology for SEND in Primary Schools and associated student communities studying an assistive technology module.	Caldwell H. and Cullingford-Agnew, S. (2017). *Technology for SEND in Primary Schools: A good practice guide.* London: Sage. https://uk.sagepub.com/en-gb/eur/author/helen-caldwell https://plus.google.com/u/0/communities/106740593214746976225 https://plus.google.com/u/0/communities/108570514394376300693 https://plus.google.com/u/0/communities/111901416660428070164	An edited book exploring the theme of assistive technology in primary schools. 
7. MESH guide: Technology Enhanced Learning Communities	http://www.meshguides.org/guides/node/880	A peer-reviewed MESH Guide published by the Education Futures Collaboration on the topic of Technology Enhanced Learning Communities. MESH stands for Mapping Educational Specialist KnowHow and the guides are designed to support teaching as an evidence-informed profession by providing research summaries to underpin educators' professional judgement.
8. Peer reviewed journal article: The interdisciplinary use of blogs and online communities in higher education	Caldwell, H. and Heaton, R. (2016). The interdisciplinary use of blogs and online communities in higher education. In: *The International Journal of Information and Learning Technology (IJILT)* 33(3) p2056-4880. https://www.emeraldinsight.com/doi/abs/10.1108/IJILT-01-2016-0006	A journal article on the strengths and limitations of using blogs and communities in teacher education. It provides a critical overview of the use of blogs and online communities to enhance interdisciplinary subject teaching, staff development and student engagement. Through a series of case studies, it puts forward the strengths and limitations of the practices adopted and demonstrates how learning can occur through the promotion of participant voice, the creation of communities of practice and reflexivity.
9. Book: STEM in the Primary Classroom	Caldwell, H and Pope, S. (2019). *STEM in the Primary Classroom.* London: Sage. https://uk.sagepub.com/en-gb/eur/stem-in-the-primary-curriculum/book265180	An edited book on the theme of STEM education. 

Figure 4.1: Public Works referenced in Chapter 4

4.1 Introducing digital literacy

This chapter addresses reflective theme 2 by focusing on how the works contribute to an understanding of digital literacy, and how this concept has been taken forwards via various associated online communities, largely facilitated by the uptake of mobile devices. Whilst the rebranding of the national curriculum puts a much greater emphasis on computer science, it continues to embrace the concept of digital literacy through the strand that calls for children to 'select, use and combine a variety of software…on a range of digital devices…to create a range of programs, systems and content'. A recent area of my work has been to seek to balance computing and digital literacy and show how both can be embedded in good practice. Much of this was achieved alongside the introduction of mobile devices for staff and students at UoN, and this group of works documents my involvement in facilitating their uptake, culminating in the Teaching with Tablets book and MOOC (works 3 and 4).

The broad theme of this chapter, then, is how the public works have contributed to a definition of digital literacy that embraces mobile learning. It begins with an overview of what digital literacy means today and considers the contribution made by mobile technologies, outlining their impact from the point of view of pupils in schools, lecturers in higher education and pre- and in-service teachers. An outcome of this focus on the pedagogy and practice of digital literacy in the works is a need to understand the success factors influencing learning with and through technology in TELCs.

4.1.1 Defining digital literacy

The process of using digital tools to apply cognitive and practical skills in a socio-cultural context can be likened to a form of literacy, and throughout my works on computing I have pursued the idea of embedding programming as one of several interconnected digital literacies, a view shared by Ng (2012), Belshaw (2012) and JISC (2014). A literate coder, Prensky suggests, will be able to:

> 'bend digital technology to one's needs, purposes…just as in the present we bend words and images.' (Prensky, 2008, p.1)

My book chapter, 'Computing and Digital Literacy' takes the view that, if they are to become digitally literate, children need to learn to manipulate the material they find or generate using technology, whether it is computer code, words, numbers, images, sound or video, and to

remix and recombine it in meaningful ways (work 1). A goal is to be able to do this across a range of devices and tools, so that they are equally at home making an eBook on a tablet as they are collaborating remotely to program an animation on a laptop. The subject association Naace use the term 'digital wisdom':

> 'Having a high level of 'Digital Wisdom' will result in learners who can make decisions about using technology in interesting, creative and productive ways and involves having a 'bigger picture' of all the aspects of ICT and being able to make connections between them.' Naace (2012. p.7)

These ideas are explored in 'Computing and Digital Literacy' (work 1) and are developed in the subsequent works in this section, which document the introduction of mobile devices for staff and students at the University of Northampton, a development that culminated in the Teaching with Tablets book and MOOC (works 3 and 4). Between 2013 and 2016, I worked on three associated projects, STEM to STEAM, Technology Outdoors and eTwinning, all of which valued the idea of learners generating digital content through active multi-modal engagement. Such a learner-centred approach, facilitated by technology, can alter the boundaries between disciplines and modify the way knowledge is represented and exchanged. Case study examples drawn from these three projects are shared in the MESH Guide (work 7).

Furthermore, an emphasis on learner generated content calls for a change in the role of the teacher by taking a different view of what is an expert (Gilbert, 2005; Bates, 2015; Laurillard, 2002). To explore these ideas further, I co-wrote a bid for an Erasmus+ funded project titled Digital Learning across Boundaries (DLaB) which sought to explore how contemporary digital literacy is redefining what and how we learn. The DLaB project explores three 'learning across boundaries' themes; physical spaces, subject disciplines, and language and culture (work 2). A final strand of this chapter (4.2.1) adds to the idea of crossing boundaries, by considering how digital literacy can support children with special educational needs and disabilities (SEND) (work 6).

4.2 Developing mobile learning and digital making

This section looks at how the works document the introduction of iPads with children, academics and teachers, and how the rise in mobile learning has prompted a redefinition of digital literacy.

4.2.1 Mobile learning in schools

The introduction of iPads along with microcontrollers such as the Raspberry Pi and Micro:Bit and robots into my university teaching has enabled me to encourage students and children to engage with technology in tandem with real world exploration. I have combined physical and digital making in various ways, including generative art projects, music using the Sonic Pi environment, and robotics. The fusion of computing, craft, engineering and electronics offers exciting possibilities, and as a member of the university STEAM steering group I am currently working towards establishing a community STEAMspace. My experience suggests that active engagement in digital making helps pupils develop solution-focused thinking skills and understand the real-world relevance of computing. Such ideas have fuelled the direction of the DLaB project work (work 2) over the last three years.

Figure 4.2: Rescue robots creating real world scenarios

A significant way in which mobile devices can support children's physical exploration of the world is to capture their learning wherever it happens and then enable them to revisit the event to reflect and build upon it through dialogic talk (Cope and Kolantzis, 2009; Wegerif, 2013). This might be through combining technologies with outdoor learning (work 2). Equally, it might take place indoors; an example is the creation of immersive multisensory spaces that particularly lend themselves to Early Years or SEND teaching. In my

interpretation, such spaces can combine tangible and digital objects by using devices such as projected images, sensory apps, torches in dark dens, robots, green screening or virtual reality combined with tangible materials. Building on the work of Preece (2015) and Pagliano (2012), students at the University of Northampton developed this idea through an assistive technology module I co-wrote, with an associated online community, and created sensory spaces for local children with special needs (work 6). One child described their immersive sensory story experience, 'We're not just reading it, we're in it!'. This work has been disseminated through the book 'Technology for SEND in Primary Schools' (work 6) and a conference presentation (Appendix 3).

Figure 4.3: Students creating multisensory environments for storytelling (work 6)

4.2.2 Mobile learning in Higher Education

A recent challenge has been to support my colleagues in the Faculty of Education and Humanities in using iPads for teaching. In 2014, I took a lead part in a pilot project, 'Apps for Innovation' in which a group of lecturers explored the use of iPads for teaching and learning, to prepare for a rollout of iPads across the faculty. This work is discussed in the journal article, 'The interdisciplinary use of blogs and online communities in higher education' (work 8). The pilot group shared ideas through face-to-face meetings, a blog and an online community as a platform for sharing their expertise. Through these regular sharing opportunities, the project provided support for novice users who could gain exemplars and

advice from a collaborative team with a common purpose. A core set of apps evolved over the course of a year, with tools being reused to meet a range of learning objectives across different subject areas within the group.

A shared consensus emerged that apps can help make students' learning more visible. Over time, a core set of open-ended content-creation apps that facilitate the *creation*, *collaboration*, *curation*, and *capture* of content emerged as users trialled them for different purposes and recorded successes as mini case studies on the project blog. In this way, the group provides an example of collective knowledge building around a common purpose (Wenger, 2011). Figure 4.4 shows an interactive image made by members of the Apps for Innovation group summarising some of their reflections on the use of mobiles in their practice through text and film. This was shared with the wider education and humanities faculty team and at a UoN conference (Appendix 3). Figure 4.5 illustrates a Haiku Deck shared at a faculty forum and via the MESH Guide sharing the project (work 7).

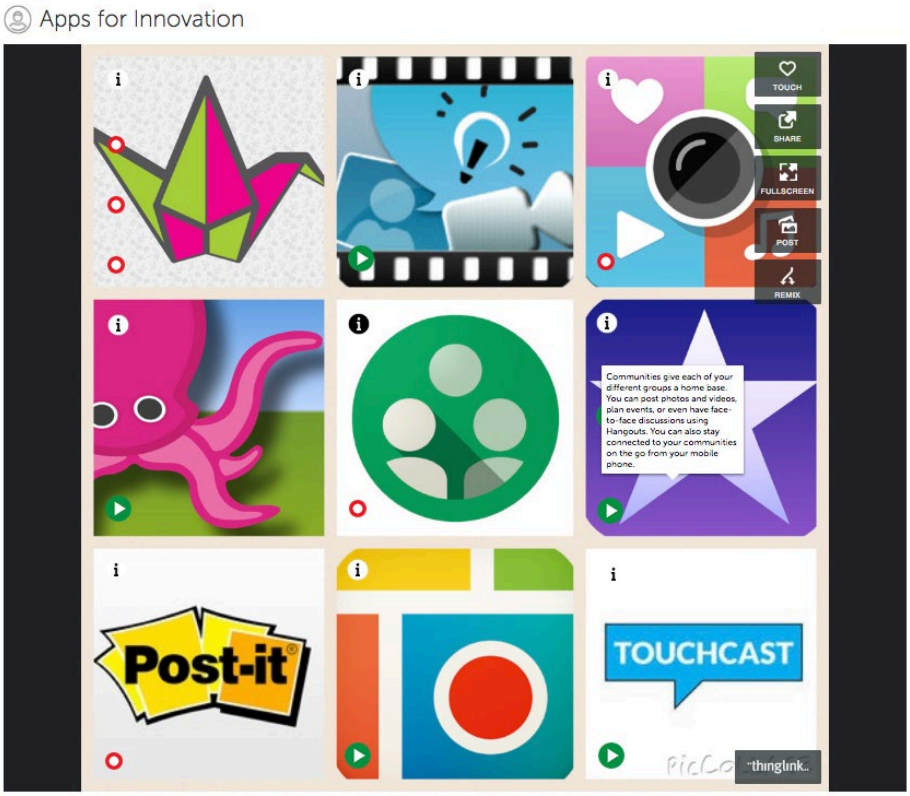


Figure 4.4: Collaborative Thinglink made by the Apps for Innovation team for staff CPD. Available at https://www.thinglink.com/scene/655712508119613441 Sourced from the MESH Guide (work 7).

Figure 4.5: A Haiku Deck drawing together ideas on mobile learning for the faculty. Available at https://haikudeck.com/p/9suurg2cOj Sourced from the MESH Guide (work 7).

4.2.3 Mobile learning for pre- and in-service teachers

Whilst developing the theme of mobile learning for an audience of pre- and in-service teachers in the book Teaching with Tablets (work 3), I sought to inspire creative experimentation, believing that if learners engage with content in active dynamic ways that result in shareable products they are more likely to develop a positive attitude towards technology. Through discussion of case studies from practice, the book demonstrates ways in which concrete doing and making can drive and consolidate learning. Taking these ideas further, the Teaching with Tablets MOOC (work 4) shares examples from the book (work 3). MOOC participants are invited to try out ideas in their own practice, and then reflect and post within an online community. In the example below, a teacher has been reading about the theme of visible learning in the MOOC materials. She chooses to test Socrative as an assessment tool in her own classroom and reflects on the success of this in the comments. Another participant gives her some positive feedback and is inspired to look at the tool herself.

Example MOOC online community post on the theme of tools for visible learning:

> *'I've been looking at Socrative and I think I'm going to experiment with it today. I have 4 classes of Y4 pupils who are doing scratch and I like the interface a lot. So I'm going to see if I can use it. In two weeks I'm doing a maths inset workshop too so may well include some of the things I've learned here.'*

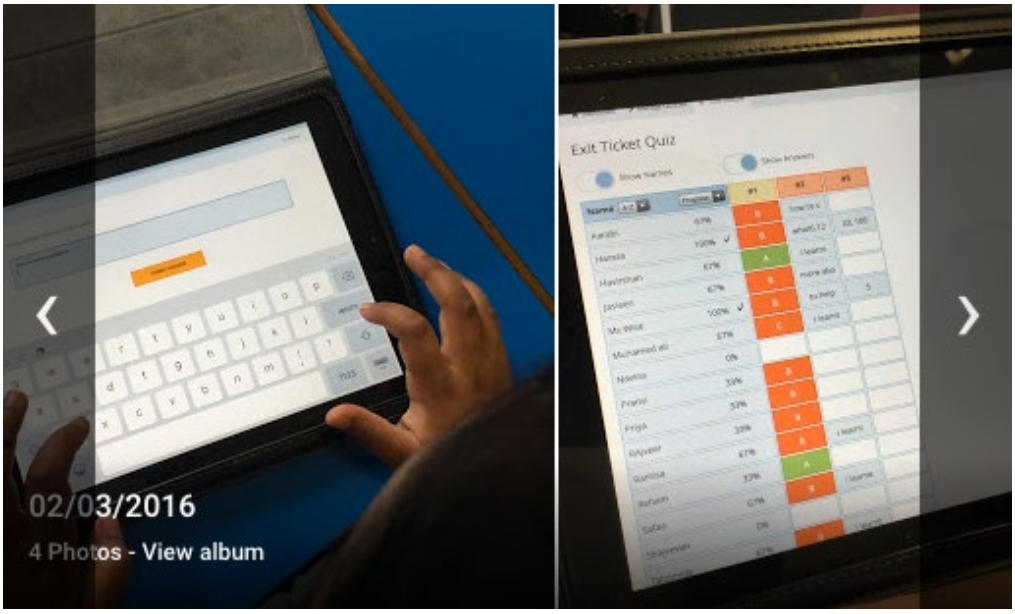


Figure 4.6: Photo album illustrating participant's use of Socrative

Commentary on the Socrative post:

> *'Socrative is awesome!*
> *'So I decided to use Socrative with Year 4 today to evaluate how they were getting on with our new Scratch project. We used the 'exit pass' tool. I did it successfully with all four classes today.'*
> *'In visible learning terms, it was great because every child did their own. There was no competition or comparison between students. It was very personal.'*
> *'In assessment terms, I liked the snapshot it gives. The immediacy. The output.'*
> *'In the future I will use it to track understanding again. The children will need more guidance in how to reflect on their learning in this way but I'm happy to do that.'*
> *'My four colleagues whose classes I was teaching also liked it. (It's a way of sharing this type of tool for their work too). All in all, I'd recommend it thoroughly.'*
> *'Thanks for the recommendation. I tried Socrative out a long time ago but haven't used it with students. I'll have to have another look at it again.'*
> *'I think I did too but it was before we had enough confidence with and access to tablets and devices.'*

4.3 Exploring models of mobile learning in teacher education

My work on introducing mobiles with pre- and in-service teachers and university academics has led me to think that they can be a force for change in education, and I have sought to compare my work with models from the academic literature. The example above on the tool Socrative illustrates that there can be a shift in the relationship between learners, learning and knowledge when mobiles provide ubiquitous access, not only to information, but to like-minded peers within a community of practice with shared goals. The resulting increase in the

agency of learners and their ability to co-create knowledge independently of their teachers is a dominant theme of the MESH guide (work 7). According to Royle et al., 'Use of (mobile) devices changes the nature of knowing and knowledge.' (2014, p.32). Others agree that technology can elicit a shift in the way we learn (Siemens, 2006; Luckin, 2010; Royle et al, 2014; Burden et al; 2016; Hoadley and Kilner, 2005; Cope and Kalantzis, 2009). Within my own work, the paradigm shift between learners, learning and knowledge predicated by technology change became a dominant theme of the MESH guide (work 7) and of the DLaB project (work 2).

A result of the decentralization of knowledge and the instability of the information climate, Siemens suggests, is that the learner has more agency in creating connections between new ideas and experiences, and learning becomes an active process of recognising patterns, gathering, adapting and creating knowledge (Siemens, 2006). In the reflection on the tool Socrative above, we can see technology facilitating this process by providing a social space for learners to connect with each other's experiences of technology tools. In this context, it could be said that technology allows the learner to switch between consuming and producing knowledge, and the learning context moves in and out of the virtual and physical worlds. This dynamic process is accelerated by the inclusion of visual images that encapsulate technology use (Figure 4.6).

These ideas sit well with Luckin et al.'s learner-centric framework of Learner Generated Contexts (Luckin et al. 2010), which suggests that learners gain control through interacting around a common learning goal. As highlighted in the MESH guide (work 7), Luckin et al.'s model (2010) makes a key distinction between more traditional organisation-centric educational models and the potential for communicative learner-centric models of learning. In Luckin et al.'s view, technology changes the boundaries 'between learners and teachers, formal and informal education and the producers and consumers of knowledge' (p.72). Seen in this way, the learning context is less a physical location, and more the combination of interactions the learner experiences across multiple physical and digital spaces and times. Drawing from activity theory, Luckin et al. describe context as 'a constant, dynamic interaction between internal and external sources' (2010, p.74). Luckin et al. apply their model to the context of Web 2.0, stating that it provides a platform for an 'architecture of participation' (2010, p.80). In my view, re-visioning our relationship to learning, knowledge and pedagogic practice is even more relevant eight years later, given the rise of mobile

devices with their range of apps, affordances, and their impact on continuous connectivity. This is a theme I have pursued through the MESH guide (work 7) and the DLaB project with its associated MOOCs and online communities (work 2). An aim of my work is to create more open, creative and participatory learning experiences through technology.

In line with this idea, other researchers recognise that mobiles have the potential to 'contribute simultaneously to pedagogical innovation and to transformed practice' (Danaher et al. 2009, p.1; Song, 2014; Kong & Song, 2015). In their discussion of 'seamless flipped learning', Hwang et al. (2015 p.1) suggest that a classroom enhanced with mobile technology can facilitate across learning contexts, times, and social settings. They note that good use of multimedia is a key feature of successful flipped learning and that multimedia apps on mobile devices make it easier to engage with, revise and share content. And Royle et al., (2014) draw attention to the opportunities for more agile learning using personal connected mobile devices. My experience of TELCs (works 2, 4 and 6) demonstrates that a key feature is the speed with which connections can be made and experiences shared across contexts.

In my own work, I have observed interplay between personal and collective stances influencing learning within TELCs, an idea that is explored in work 8, wherein blogs and communities complement each other as online spaces with different purposes (see section 4.3.2). This has resonance with the work of Burden et al. (2016) who adopt a socio-cultural perspective on the intersection of the changing nature of knowledge and the emerging capabilities of technologies. Acknowledging the continuous flux of epistemological change, and drawing from the work of Barnett (2012), Burden et al. put forward an argument for an ontological shift in the nature of knowledge to take account of the impact of mobiles in enabling students to construct individualised knowledge bases and customised learning opportunities independent of their teachers. This work led to the development of the Mobile Learning Toolkit (Burden and Kearney, 2018), which embeds three constructs of mobile learning, personalisation, authenticity and collaboration, in the time-space context of mobile learning. In this framework, situated social learning is mediated by tool use:

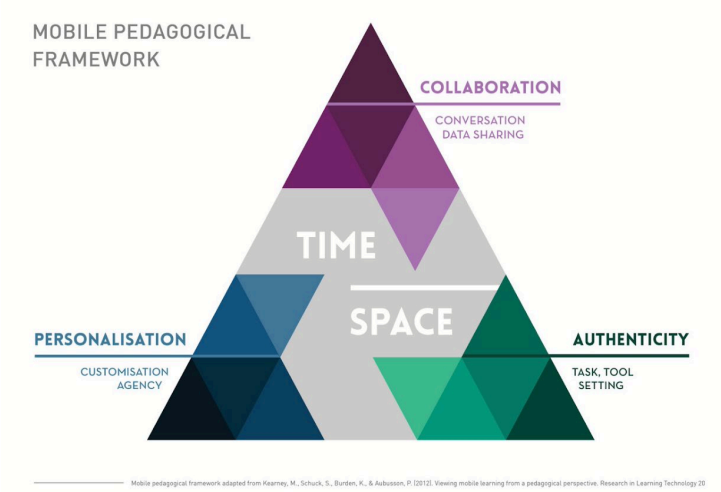


Figure 4.7: The mobile pedagogical framework (Burden et al., 2018)

The ongoing discussion about the changing nature of learning and the potential for mobiles to create timely, distributed and situated learning opportunities is echoed by a reflection from one of my MOOC students (work 4). She benefitted from the flexible nature of the course and the fact that she could engage at any time and place. The online community meant that she could 'join in' and 'apply to practice' at the same time, blending talking and doing, or 'participation and reification', to use Wenger's terms (2009). Her reflection also highlights the way in which online social online learning blurs the boundaries between formal and informal learning.

Student reflection on the Teaching with Tablets MOOC (work 4):

> '*This course has been a veritable Teacher's Centre for me. Something I've missed since moving to an international context. I'm very impressed with the range of benefits and the way that the collaboration has worked. Meanwhile I've found new enthusiasms as a result of joining.*
> *Learning on your own has never been very successful for me before. I can sit down and do an assignment but it's always hard to get stuck in. With Teaching with Tablets the fluid and flexible nature of this course has been a real transformation. Of course, this means that I've learned more about learning too. I'll be exploring how to take that to my colleagues and students.*
> *It's been really interesting to find a medium that feels truly 21st Century and about as far removed from the Victorian classroom setting as I can get… to be able to participate during the day in lots of different settings was a great way for me to work.'*

Figure 4.8: Participant reflection on the Teaching with Tablets MOOC
Available at: https://www.thinglink.com/scene/771282009031966721

In summary, my exploration of models of mobile learning in teacher education led me to look for evidence within the public works of how TELCs support collective-knowledge building. I looked at the evolution of the various forms of TELCs within the works and I also sought to describe the conditions for learning within them. These ideas are presented in Chapter 6.

4.3.1 Technology facilitating social learning in face-to-face and virtual environments

The learning frameworks described in the section above highlight reflection and doing as part of online learning, suggesting that blended learning spaces should be collaborative, active and authentic. This ties in with the Read, Reflect, Display and Do model (R2D2) (Bonk and Zhang, 2006) that takes a constructivist approach to the design of online learning, drawing from an array of technology options and media for accessing information and expressing ideas (Cartner and Hallas, 2009).

Similarly, in their systematic literature review of the literature on K-12 teacher preparation for teaching online, Moore-Adams refer to 'hybrid' teaching environments, suggesting that, given the prevalence of 1-1 devices;

> '..it seems likely that, in the near future, all teachers will be required to teach in both (virtual and face-to-face) environments, and be able to seamlessly switch between environments to maximize the affordances of each.'
> (Moore-Adams et al., 2016, p.346)

In 2017, I reflected on my seven years of using mobile technologies with children and pre- and in-service teachers in the paper, 'Mobile technologies as a catalyst for pedagogic innovation within teacher education' (work 5). This paper acknowledges the need to embed the use of technology in education through interdisciplinary approaches mixing social learning spaces. It provides examples from practice of how some of the affordances of iPads, such as increased connectivity, mobility, ubiquitous access and combining media, have prompted learning initiatives among our academics, pre- and in-service teachers. I agree with Bonk and Zhang (2006) that we should draw from the wealth of apps and tools available for both accessing and expressing ideas, a view that is a cornerstone of the Universal Design for Learning (UDL) approach for inclusion using technology (Rose, 2002) (work 6). I would add that we should also make explicit our uses and contexts of technology so that they are replicable, as this is a key factor influencing learning outcomes.

This highlights the difficulty of evidencing the role of technology in bringing about pedagogic innovation (work 5). As noted by Kirkwood and Price (2014), it is a challenge to analyse the many modes in which communities interact, such as virtual meetings mixed with physical meetings, synchronous interactions mixed with asynchronous interactions, and text-based posts mixed with multimedia posts. In my experience, mobile technologies have functioned as the glue cementing synchronous and asynchronous activities in the digital and physical spheres. To give an example drawn from the MESH Guide (work 7), in Figure 4.8 a student posts a Prezi she created in response to a pre face-to-face task and invites comments from her peers. A second student reflects on how Prezi could be used in the classroom and then in a face-to-face session a group of students synchronously post their ideas about visible learning. I suggest that this level of detail is necessary to draw conclusions about the nature of learning within TELCs, an idea that is further explicated in Chapter 5.

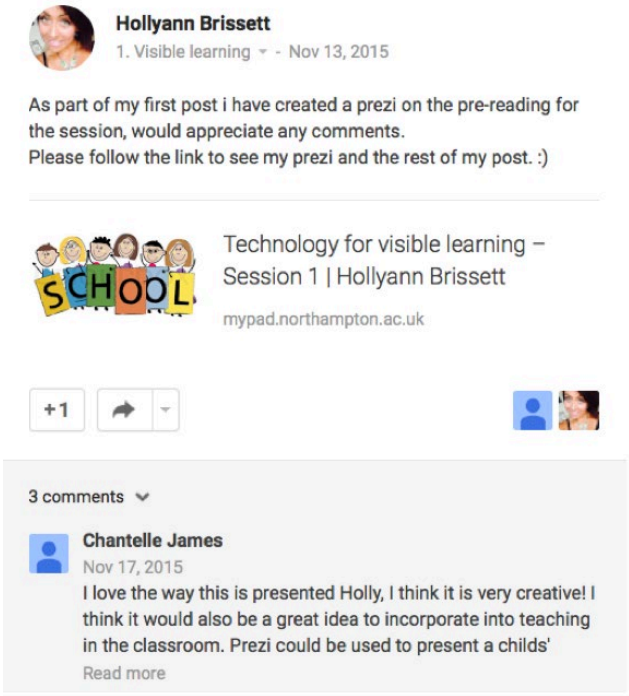


Figure 4.9: Students posting on their online community, taken from the MESH Guide (work 7).

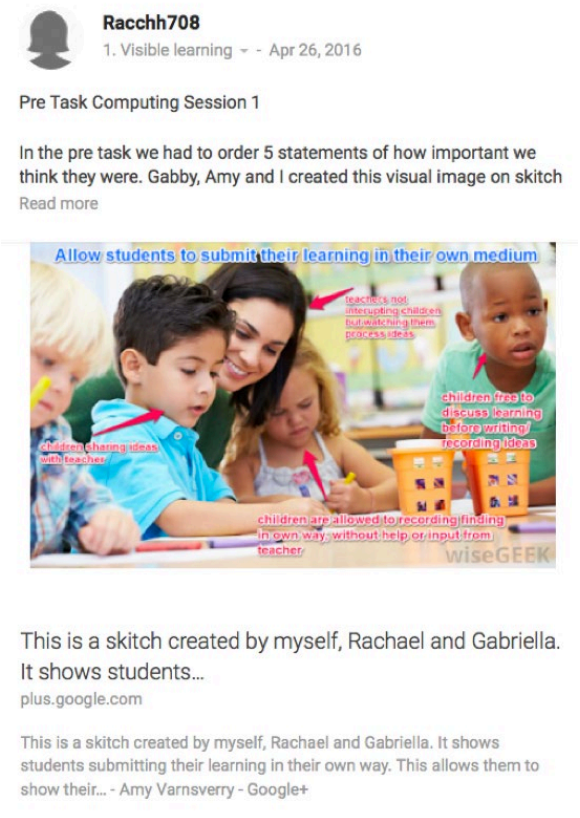


Figure 4.10: Three students collaborate to produce an annotated visual image, taken from the MESH Guide (work 7).

In summary, the examples from practice outlined in the mobile technologies paper (work 5) conclude that mobile technologies can act as a catalyst for pedagogic innovation by providing opportunities to develop shared understandings based on captured events, a bridge between informal and formal learning across disciplines, and contextualised experiential learning opportunities that combine real world interaction with the creation of digital artefacts.

4.3.2 Technology facilitating social learning in physical and digital environments

Technologies such as mobiles can provide a platform for hybrid social learning environments that facilitate interaction within physical and digital spaces. To draw an example from work 8, 'The interdisciplinary use of blogs and online communities in teacher education' (Caldwell & Heaton, 2016), group blogs were used as an assessment tool to demonstrate how Primary PGCE students applied a Learning Outside the Classroom (LOC) approach to study foundation subjects in the UK National Curriculum. Students created blogs in groups of four over the course of an academic year documenting reflection on their own learning experiences of LOC practices. Over time, the students' reflection occurred both *in action*, *on action* and *for action* (Schon, 1983) as they refined their ideas in various physical environments: site visits, on campus and during school placements. Figure 4.10 demonstrates that the structure of the blog, by combining pages and posts, allowed for reflection before, during and after the collaborative work. In this way, the finished digital artefact provided evidence of how the collective competence of the group grew over time as they built a shared repertoire of strategies for teaching foundation subjects through LOC. This example highlights the value of mixing physical, digital and social learning spaces. It also demonstrates the value of documenting learning 'as it happens' rather than demonstrating mastery of a field through a text-based assignment at the end of a module (Ovens, 2003). Chapter 6 recognises these physical/digital and personal/collective dualities as conditions for learning within TELCs as presented in the works.

Figure 4.11: Student group blog on learning outside the classroom
http://mypad.northampton.ac.uk/parkrangers/

The next section considers ways in which the Digital Learning across Boundaries (DLaB) project has contributed to an understanding of digital literacy (work 2) through the project website and the MOOCs, together with their associated online communities.

4.4 DLaB project building digital literacy through international collaboration

In its first year, the DLaB project aimed to promote digital learning across the boundaries of physical spaces through the theme of technology outdoors. In the second year, the theme was to cross boundaries of curriculum subjects by integrating the arts into STEM subjects through an interdisciplinary approach, described as STEM to STEAM. Again, use was made of mobile devices to support physical making activities. In addition to this, the project drew on design thinking ideas to support the pedagogical approach. In year 3 (2018/19) the project aimed to cross languages and cultures through CLIL (Content and Language-Integrated Learning) using technology to break down barriers of language and culture by connecting learners within media-supported and visual exchanges. These three project themes are interdependent.

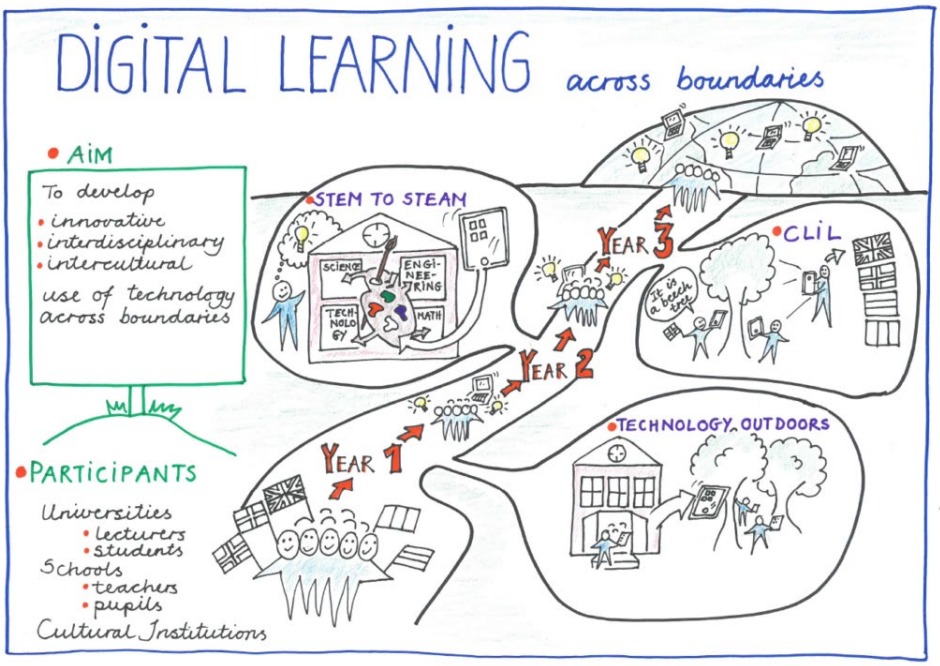


Figure 4.13: Representation of the DLaB project taken from work 2, the project website

An idea that has preoccupied me throughout the DLaB project is how to describe the ways in which the various affordances of the technologies support learning. Diana Laurillard's Conversational Framework based on Pask's analysis of learning as a form of conversation (Pask, 1976) offers one approach. It combines theories of learning to represent conditions for learning, and then offers a way of categorising the potential of different collaborative technologies to determine whether learning is genuinely enhanced. Laurillard suggests that a strong theoretical statement about learning is a prerequisite in deciding how learning is augmented by technology (Laurillard, 2009). Once this is in place, she suggests that we can map technologies onto it to evaluate their learning potential, comparing conventional and technology-based methods. Laurillard's framework puts an emphasis on an 'iterative flow' of active social learning that includes 'attending, questioning, adapting, experimenting, analysing, sharing, commenting, reflecting, articulating' as learners use technologies to define, refine and redefine their ideas (Laurillard, 2007 p162). Of relevance to the DLaB work, is her suggestion that the articulation and sharing of a final product makes for a much richer learning experience, giving students ownership over the outcomes.

The DLaB approach has an affinity with the idea of learning involving 'flow' and 'articulation' that is further explored in Chapter 6. The international partnership was organised so that every participant belonged to a sub-theme, and within sub-themes each

classroom was paired with a class in another country. Pairs of classes collaborated closely around designated international days to create shareable digital artefacts that had built-in interdependence. Collaboration was intrinsic to these outcomes so that there was a planned flow of ideas as each country was dependent on another to make the digital product that represented their work. Scrolling Twitter walls and Skype sessions were built into the international collaboration days so that there was continuous interaction and a sense of purpose as each class could see images of the progress being made elsewhere through synchronous and asynchronous interactions. To give some examples from the website (work 2):

- *Inspired by the trigger question 'what if our senses changed?', four classes in 'Experiencing STEAM' in year 2 worked on different aspects of the theme of the super senses of the animal world, swapping their research on mammals, fish, birds and reptiles, and creating a combined media presentation.*

- *Exploring the theme of 'Wild Writing' in year 1, classes used an interactive image of a set of 'in' and 'out' drawers to post media inspirations and responses for each other.*

Figure 4.14: Interactive Thinglink image of a set of drawers

- *Investigating environmental issues in their countries through 'Science Outdoors' in year one, the partner classes used infographic tools to post information and then swapped them to suggest solutions for each other, combining the results into an eBook.*

- *Thinking about the theme of 'Art in the Environment' in year 1, classes used an app to capture the colour palettes of their countries for each other to use as a basis for digital art swaps; virtual sculptures were also exchanged and green screened into each other's environments. The results of all the art exchanges captured as tags on a digital art map.*

Figure 4.15: Virtual sculptures on the fourth plinth in Trafalgar Square, taken from the MESH Guide (Work 7)

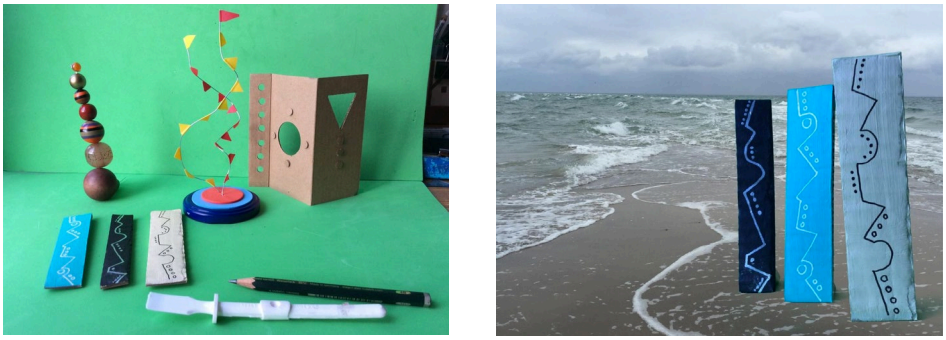


Figure 4.16: Virtual sculptures from England placed on the confluence of seas in Denmark, taken from the MESH Guide (Work 7)

For me, these examples highlight ways in which technology has impacted on language and literacy practices, and the rich choice of authoring technologies children can now choose from in their production of multimodal texts. In this way of working, physical and digital ways of exploring and representing experience seem inseparable, as is the use of technology

for collaboration and connectivity. One digital artefact inspires the creation of another, and through swapping and responding to artefacts, learners are corresponding through visual media as well as words. The posted images made the twitter wall a powerful window into the other classrooms during the international days.

This process can be likened to multimodal literacy approaches that recognise how shared meanings can develop across time, space and modalities. A key idea for me was how the multimodality of the exchanges facilitated joint meaning making. Through the DLaB MOOCs (work 2) this was extended to work with international groupings across sectors, subject areas and levels. This echoes the work of Mercer et al. (2003) investigating the value of talk and digital activities for promoting children's literacy development. The DLaB works demonstrate that contemporary literacy is a much broader field than just encoding and decoding written text, and that the process of making, reading and learning from multimodal texts is much more complex. A distinction between traditional literacy and multimodal literacy is the degree to which the creative process is social and participatory. Meaning-making today typically combines several communication modes and often involves the remixing of content in a non-linear fashion. Access to the internet and social media means that dialogic interaction can be taking place in several spaces simultaneously.

Figure 4.17: Children using multimodal ways of working collaboratively

The Technology for SEND book (work 6), also makes a case for multimodal learning, on the grounds that a choice of visual and auditory modes of access and expression alongside text can enrich learning and help to meet learner needs, making learning personally meaningful and inclusive (Rose, 2002). A multimodal approach for collaboration and feedback can

therefore make learning more dynamic and responsive, and this needs to be considered when defining digital literacy.

4.4.1 DLaB integrating subjects through STEAM

In its second year, the DLaB project sought to bridge traditional subject boundaries by exploring the theme of STEM to STEAM, adding the arts to science, technology, engineering and maths. Our pedagogical approach was based on an interpretation of 'design thinking' (Kimbell, 2015) that begins with empathising with an end user, and puts an emphasis on defining a key question and then framing a problem. This makes it more akin to problem finding than problem solving. This model was relevant, as we wanted to highlight creativity alongside the criticality of the scientific process. We used a 'double diamond' model to describe divergent and convergent stages of a design thinking process that aims to build up ideas through a combination of empathising, defining, ideating, prototyping and testing. Several possible ideas are created (divergent thinking) before refining and narrowing down to the best idea (convergent thinking). The double diamond indicates that this happens twice, once to discover and define the problem and secondly to develop and deliver the solution. Central to the process are three stages: a trigger, a vision and plan, and a creative solution. In the context of the DLaB international days, learners moved from design thinking to design doing.

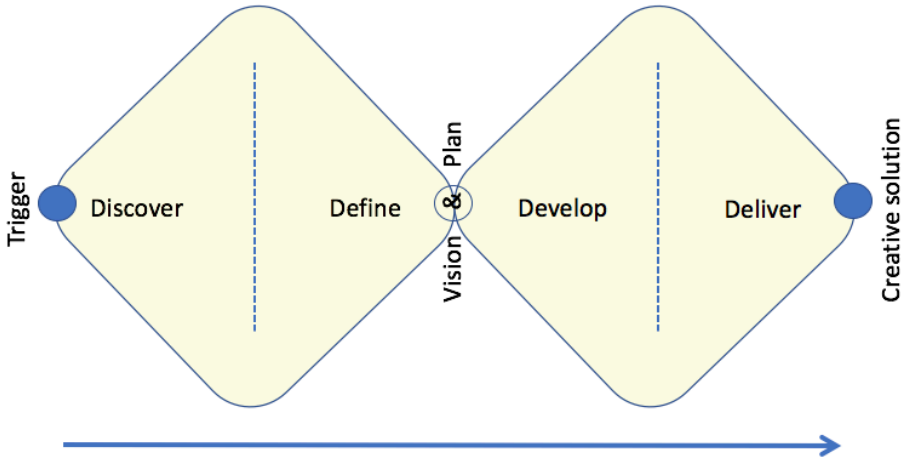


Figure 4.18: Adaptation of the UK Design Council's 'Double Diamond' model (https://www.ebi.ac.uk/training/online/course/user-experience-design/phases-design)

In the example project below from one of our local schools engaged in the DLaB project, the trigger takes the form of a video produced by the class teacher combining several different apps to produce a movie which ended with a virtual Gru from the film Despicable Me becoming a physical Gru walking into the school hall.

Figure 4.19: The trigger and ideation phases of design thinking in practice at Duston Eldean School

The DLaB project has shown that the arts can offer an additional impetus to design thinking by being part of the trigger prompting learning. We also wanted to use the arts to connect with others and communicate the outcomes of the STEAM activities. For example, during one activity a group was inspired by an installation at the Barbican's Digital Revolution exhibition (2014) based on interactive bird sculptures made from parts of mobile phones. In response to this, children took defunct technologies apart, surmised their functions, and reconstructed their own singing sculptures using a musical composition app and QR codes. This culminated in a group dawn chorus (Figure 4.2).

A second example was inspired by artists working with materials such as ice, found objects, condensation, snow, and light to create ephemeral art. Children made their own transient art pieces and thought about the scientific process behind the changes of state: decay, freezing and melting, evaporation, colour pallets and light. These examples were posted and taken forwards by the learning communities associated with the project (Figure 4.2.1).

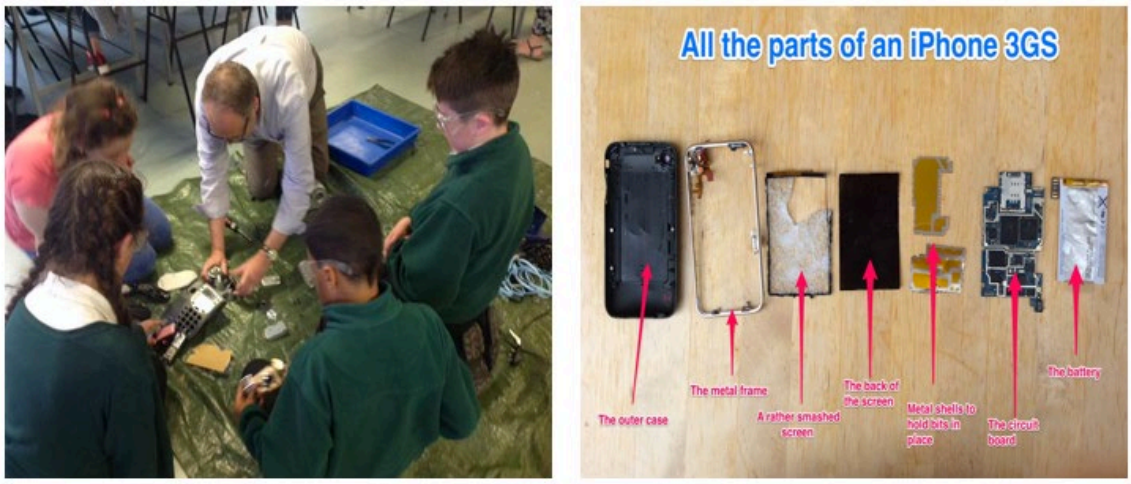


Figure 4.20: Deconstructing and reconstructing technologies

In the context of the DLaB international project work, digital art has acted as a communication tool bypassing language barriers and building intercultural understandings. Collaborations based on the arts provided a context for intercultural exchanges supported by technology. In work of this nature, technology often becomes a lens for looking at the world and manipulated media represents new viewpoints that constitute a response inviting feedback rather than merely a representation.

Figure 4.21: Swapping colour palettes to inspire artwork as part of the DLaB project

The DLaB STEAM work ties in with a growing trend around the world in using STEAM approaches across educational sectors to create a fertile environment for inquiry-based learning, which involves learners in setting their own goals. For example, Connor et al., (2016) in New Zealand, outline five HE engineering student-centric STEAM projects designed to promote active, curious learning; in the US, Radziwill et al. (2015) describe a collaboration on a piece of participatory art between science and technology and arts, and design students; Land (2013) describes a number of STEAM curricula initiatives developed across the US; and Saddiqui and Marcus (2017) suggest that their STEAMpunk Girls Co-Design program can prompt secondary-aged young women to pursue STEM study and careers in Australia.

A recurring theme across these papers is the need to mirror the complexity and interconnectedness of work-based STEM professional environments and to prepare graduates for the challenges of real world problem solving, which often needs to draw upon inductive thinking and applying knowledge in a practical way. A second theme is that the approaches need to see uncertainty and failure as positive learning opportunities, and that it is acceptable not to have all the answers. These examples also lean towards the dialogic networked model of learning, which allows for iterative knowledge flows such as I have discussed above in section 4.0. The book STEM in the Primary Classroom (work 9) links these themes from the

perspective of each of the other areas of the curriculum, and refers to STEM literacy as an ability to engage with understanding scientific and technological debate as a responsible citizen of our interconnected global society. Like digital literacy, STEM literacy puts children at the centre of learning and aims to embed coherent and connected learning experiences in meaningful and authentic ways.

4.5 Chapter summary

The selected works in this chapter have explored how technology can enhance the pedagogy and practice of digital literacy. They shed light on the complex relationship between pedagogical beliefs and technology innovations, demonstrating that the integration of technology in education requires beliefs and actions to evolve in turn and in tandem, as noted by Tondeur et al. (2016). A multidimensional approach is needed for successful technology use in practice. (Ertmer, 2010)

A theme throughout the works in the last two chapters has been to unite computing and digital literacy so that there is an appropriate curriculum balance going forwards within the educational climate. This is emerging as an issue now that the furore about the introduction of coding in primary schools has abated. My works demonstrate that if a balanced approach is taken within cross-curricular planning, coding becomes another embedded creative tool to turn to when making digital artefacts that demonstrate understanding about any subject, rather than an 'add-on' skill taught in a discrete way.

The DLaB project has shown that the arts integrated with STEM can enhance different stages of the learning process. At the beginning of a project it can offer an inspirational impetus by being part of the learning trigger or prompt. Whilst work is ongoing, it can help to make connections between learners. Towards the end of a project it can engage an audience and communicate the results of STEM investigations. In the context of my international project work, digital art collaborations and exchanges helped to bypass language barriers and build intercultural understandings.

I have suggested that a digitally literate learner will have a stock of skills to draw upon that includes competence with a range of tools, but will also comprise familiarity with strategies for learning in today's socio-technical learning landscape. The works highlight that digitally literate learners develop the ability to navigate a shifting network of resources, social

connections and learning habitats across times and spaces. The resulting sense of agency makes for cycles of personalised learning propelled by authentic contexts and dialogic interaction in a social community. In this context, it is important to make links between people and apps, and helpful to understand how the process of interaction between people, digital and physical spaces and technologies can impact on learning. I examine this process in more detail in the next two chapters.

This chapter contributes to the emergence of the models in Chapter 6 by sharing two communities that could be described as 'nested' in that established core communities evolve over time into a second larger community. This took place within the DLaB group each time they ran their yearly MOOCs and within the Apps for Innvation pilot group as they supported the wider introduction of iPads in their HE context. Consideration of Luckin et al.'s work (2010) highlights the multidimensional nature of learning with technology and the need for re-visioning to describe the complex dynamic learning processes and shifting roles at play as communities mature. This chapter contributes to this debate by finding a parallel between the duality of talking and making in Chapter 6 with Wenger's duality of participation and reification, and offering a detailed example of dialogue supporting knowledge building in the Teaching with Tablets MOOC. It also describes immersive sensory spaces bringing together digital and physical making with an emphasis on digital technologies enhancing children's physical exploration of the world. And the DLaB International days highlight how a combination of asynchronous and synchronous interaction supports collaborative learning.

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Chapter 5: TELCs influencing practice: the design and delivery of online learning

Reflective theme 3:

How an analysis of pedagogy and practice within TELCs can shed light on the processes of social learning.

Summary of the works referenced in this chapter:

Work	Reference/Source	Description
1.Peer-reviewed journal article: A comparison of MOOC development and delivery approaches	Smith, N., Caldwell, H., Richards, M., and Bandura, A., 2017. A comparison of MOOC development and delivery approaches. *The International Journal of Information and Learning Technology*, *34*(2), pp.152-164. http://oro.open.ac.uk/49137/	This work compares two ways of designing and delivering MOOCs.
2. Peer-reviewed conference paper: The online learning hive: transfer to practice within a MOOC community of educators	Caldwell, H. and Smith, N. (2017). The online learning hive: transfer to practice within a MOOC community of educators. In: *The International Conference on Information Communication Technologies in Education (ICICTE 2017) Proceedings, Southampton Solent University.* http://nectar.northampton.ac.uk/10175/	This paper examines the nature of the interactions within a community of practice associated with the online hybrid MOOC, 'Teaching with Tablets' to see whether the learning environment facilitates a more effective transfer of skills to practice. The analysis indicates that MOOC participants moved towards peer-to-peer interactions, wherein they shared expertise and suggestions, showing clear indications of socially constructed knowledge processes.
3. Book chapter and online community: The use of technology to build digital communities	Bugby, M. and Caldwell, H. (2018) The use of technology to build digital communities. In: Sykes, G and Teszenyi E. *Young Children and their Communities: Understanding Collective Social Responsibility.* Routledge. https://www.routledge.com/Young-Children-and-Their-Communities-Understanding-Collective-Social-Responsibility/Sykes-Teszenyi-Eunice/p/book/9781138558526 Associated community: https://plus.google.com/u/0/communities/116686472878126744345	This book chapter explores the potential for digital communities to support learning in the Early Years.
4. Book, MOOC and online community: Teaching with Tablets  	Caldwell, H. and Bird, J. (2015). *Teaching with Tablets*. London: Sage. https://us.sagepub.com/en-us/nam/author/helen-caldwell Online course https://openeducation.blackboard.com/mooc-catalog/courseDetails/view?course_id=_806_1 Online community https://plus.google.com/u/0/communities/108510780639510097712	MOOC and online community based on content from the Teaching with Tablets book.

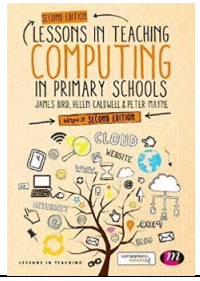
5. DLaB website, Technology Outdoors and STEM to STEAM MOOCs and online community.	Website http://dlaberasmus.eu/ Online course http://dlaberasmus.eu/courses/technology-outdoors-online-course/ Online course http://dlaberasmus.eu/courses/stem-steam-online-course/ Online community https://plus.google.com/u/0/communities/117458443566280105364	Digital Learning across Boundaries project, comprising a website, two MOOCs and an online community.
6. Book, MOOC and online community: Let's Teach Computing	Bird, J., Caldwell, H. and Mayne, P. (1st ed. 2014, revised 2nd ed. 2017). *Lessons in Teaching Computing in Primary Schools*. London: Sage. https://openeducation.blackboard.com/mooc-catalog/courseDetails/view?course_id=_400_1 Online community https://plus.google.com/u/0/communities/112335386477156503633	A MOOC and online community inspired by a book: Lessons in Teaching Computing 
7. MESH guide: Technology Enhanced Learning Communities	http://www.meshguides.org/guides/node/880	A peer-reviewed MESH Guide published by the Education Futures Collaboration on the topic of Technology Enhanced Learning Communities. MESH stands for Mapping Educational Specialist KnowHow and the guides are designed to support teaching as an evidence-informed profession by providing research summaries to underpin educators' professional judgement.
8. How do visual postings impact the evolution of pedagogical beliefs and practice in a MOOC online community?	Paper presented at the MiTE International conference on mobile technology in teacher education. http://www.gratek.ie/mite2018/	Co-authored research paper.
9. Innovation Fund Project blogs: Digital Leaders Apps for Innovation Northampton Inspire Book chapter: Blogging supporting digital literacy in schools and universities.	Digital leaders project blog https://mypad.northampton.ac.uk/digitalleaders/ Apps for Innovation project blog https://mypad.northampton.ac.uk/appsforinnovation Northampton Inspire project blog https://mypad.northampton.ac.uk/inspire/ Caldwell, H and Honeyford, G. (2012). Blogging supporting digital literacy in schools and universities. In: Burden, K., Leask, M., Younie, S. *Teaching and Learning with ICT in the Primary School*. London: Routledge.	Three one-year projects on digital themes funded by the University of Northampton Innovation Fund, each with a public project blog. This book chapter looks at using blogs to document learning from two perspectives, the personal and the collaborative, drawing examples from student teachers at Northampton University and from primary pupils in Northamptonshire schools. In both settings, the role of blogs in supporting the cycle of sharing, implementing and evaluating practice is explored and discussed so that teachers can replicate and build on the emerging themes.

Figure 5.1: Public Works referenced in Chapter 5

5.1 Introducing MOOCs

Moving on from the previous chapters that looked at how the works support conditions for enhancing teachers' pedagogical approaches to teaching computing and digital literacy, this chapter considers how TELCs can be designed and managed so that they have a positive impact on practice.

To provide some context for how these social online learning works came about, I have written open learning materials since 1990, however my journey in blended learning began in earnest when I worked as a regional manager on the Open University Vital project in 2010. More recently, I was the lead author of an online Computing and ICT Open University module, and at the University of Northampton I am the author and programme lead of the Postgraduate Certificates in Primary Computing and in Digital Leadership, which have fully online versions. I am currently the elected communications secretary post holder on the national executive committees of the subject association for Information Technology in Teacher Education (ITTE) and the International Mobile Learning Network for Teacher Educators (IMOLENTE). Both roles involve developing an online presence through social media, blogging and website development.

In addition, between 2015 and 2018 I led teams of between 12 and 50 people to create four funded MOOCs:

- Let's Teach Computing, 2015 (in collaboration with Oxford Brookes University, funded by the Department for Education (£30,000). (work 6)
- Teaching with Tablets, 2016 (funded by the University of Northampton Innovation Fund (£12,000). (work 4)
- Technology Outdoors, 2017 (funded by DLaB Erasmus+) (total project budget £270,000). (work 5)
- STEM to STEAM 2018 (funded by DLaB Erasmus+) (total project budget £270,000) (work 5)

I reflect upon these roles and works in the following sections, thinking about how they might inform the design of social online learning, such as how to recruit and retain participants, what combinations of tools work best, and what are the measures of success. In doing so, I

am mindful of calls in the academic literature for more detail about the uses of technologies and a need to articulate practices. This issue is highlighted in Brown's recent synthesis of the literature on the adoption and use of online tools in higher education (2016):

'Online tools are collapsed into blanket categories without unpacking what a technology does and how individuals interact with the technology to produce practice…..little research sufficiently characterises the online tools under study.' (Brown, 2016, p.5)

5.1.1 Background: relating practice within TELCs and CoPs

Since first proposed by Lave and Wenger in 1991, the construct of communities of practice (CoPs), has provided a useful lens for looking at social learning. The term has been repeatedly applied to teacher CPD, and a substantial body of research now focuses on online teacher communities as a constructivist platform for teachers to connect and share across time zones, removing geographical boundaries and allowing learners control over the pace and place of engagement (Somekh, 2008; Schlager et al. 2009; Lock, 2006; Wenger et al. 2002; Gannon-Leary and Fontainha, 2007). Many definitions of virtual communities, including my use of the term TELCs, retain Lave and Wenger's original notion that CoPs are groups of people learning together in a shared domain;

'a collective intention—however tacit and distributed—to steward a domain of knowledge and to sustain learning about it.' (Wenger et al., 2011, p11)

As discussed in the MESH guide (work 7), Smith et al. (2017) carried out a critical review of Wenger's CoP theoretical framework in online and blended learning research through a content analysis of 41 studies that shared CoP characteristics. In their conclusion, they call for a new phase of analysis with the aim of providing more complex understandings of the CoP learning process:

'We…believe that more attention is needed to highlight the specialized ways of knowing, thinking, and doing that people need to internalize in order to participate in a particular social practice' (Smith et al., 2017, p.221).

Smith and Rowe (2005) echo this by pointing out that there is no guarantee that adding interactive spaces will result in the communal meaning-making that characterises a CoP. I have contributed to this debate in works 2 and 8, which offer an analysis of the evolution of pedagogical beliefs and practices within MOOC online communities by examining the relationship between posts, media and comments.

A second CoP-related theme to emerge from this selection of works is that social online learning in TELCs often involves a process of participation and reification; in other words, 'making something real', identified by Wenger (1998). Goggins et al. (2011) describe this as:

'Participation involves acting and interacting, and reification involves producing artefacts (such as tools, words, symbols, rules, documents, concepts, theories, and so on) around which the negotiation of meaning is organized.' (Goggins et al., 2011 p.210).

An area in need of further consideration, they suggest, is 'the functions and uses of the technological tools that most effectively support and mediate a community's social and intellectual engagement' (Goggins et al., 2011 p.224). This sits well with my research on the role of posted media, images and digital artefacts in articulating pedagogy and practice, and the suggestion that they act as anchors for the further evolution of ideas within the community (work 8).

In work 8, then, I sought to look more closely at the role of the posted media in the online community in prompting discussions that led to transfer to practice, and how interaction between the MOOC content and the community posts facilitates the evolution of ideas. As Nilmanat acknowledges, the tacit knowledge that can be encoded in an image, can span several dimensions that would be difficult to explain in words, such as attitudes, motivations, experiences, and points of view. The images can mediate the sharing of experiences (Nilmanat, 2011). These findings are in line with connectivist theories of learning that emphasise the links between people and resources (Siemens, 2005), and the making of personal choices within an environment mediated by technology (Saadatmand, M., & Kumpulainen, K., 2014):

'Connectivist models explicitly rely on the ubiquity of networked connections between people, digital artifacts, and content' (Anderson and Dron, 2011, p. 87).

They recognise the fact that the virtual and physical worlds are interconnected rather than independent (Young and Tseng, 2008), and that information shared by participants may be drawn from either. As Young and Tseng point out, studying an online community requires an understanding of the physical as well as the virtual contexts, and this may be especially true for communities of teachers. In the context of teacher education, online learning communities allow a merge of real and virtual worlds as participants engage in discussions about real practice in the virtual world. The online community represents a continual crossover between these two spheres (Burnett, 2016). I find that a process of discussion punctuated by visual posts fosters the development of communal knowledge around shared understandings, and this has influenced my findings in Chapter 6. The next section explores MOOC design and development across works 4, 5 and 6.

5.2 MOOC design and development

This section documents the design and development of the four selected MOOCs and their associated learning communities to demonstrate some of the ways in which they can impact on practice (works 4, 5 and 6). To provide some background, MOOCs are a relatively new phenomenon; the term was coined by Dave Cormier in 2008 (Cormier, 2008). Since then, there have been various attempts to provide a theoretical framework for the learning that takes place within them. These include socio-constructivist perspectives (Wegerif 2013), connectivism (Kop, 2011) and complexity theory (deWaard et al 2011). One way of categorising MOOCs is to place them on a continuum from connectivist cMOOCs to instructivist xMOOCs, depending on whether learning results from information transmitted via the instructional materials or from network contributions made by the participants themselves (Downes, 2013; Siemens, 2013). Conole (2013) puts forward a MOOC classification framework with 10 dimensions to offer a more nuanced description than the x/c continuum.

Empirical studies have tended to focus on levels of learner engagement within MOOCs, making a distinction between active participants and more passive lurkers or samplers who dip in and out of the materials (Downes, 2011; Kizilcec et al., 2013). Other studies have focused on the low completion rates and what determines success (Belanger et al, 2013). Adams et al. highlight the uniqueness of MOOC learning, with its potential to offer the added motivational experience of ‘eventedness’ through shared participation in a public event

(Adams et al., 2014). This analysis resonates with a U.S. Department of Education study on Designing Online Communities of Practice for Educators (U.S Department of Education, 2014), a three-year project that found that participants valued the chance to play a role in the community, to have clearly structured activities that resulted in tangible products to use in their practice, and to have access to high quality content.

Similar considerations influenced the design of the four MOOCs I designed and led, (works 4, 5 and 6), and these are summarised in the paper 'Comparison of MOOC development and delivery' approaches' (work 1). This paper compares two ways of delivering MOOCs, a large-scale FutureLearn platform on cyber security and my smaller in-house MOOC on Teaching with Tablets (work 4). In this paper, I suggest that the choice of platform and delivery should take into account the needs of the audience and the size of the anticipated cohort. One aim in the Teaching with Tablets design was the need to retain control over the presentation of content to match the interests, commitment and level of expertise of the audience of teachers in schools, FE and HE contexts. In contrast, the FutureLearn MOOC was aimed at a more generalist audience and scalability was a feature of the design process. In designing a MOOC for a smaller niche audience, I was aware of the criticism that cMOOCs can be too open-ended (Nkuyubwatsi, 2013; Stacey, 2014), and the danger that xMOOCs that present a fixed route through pre-prepared materials can be over-didactic. Bearing these extremes in mind, I chose to develop the idea of a hybrid MOOC (Chauhan, 2014; Conole, 2013) that combined features of both, and used several digital tools and platforms in concert. This allowed for the pedagogic flexibility needed to address the needs of the audience and the mobile learning theme. At the time of development (2015/16), MOOC was the recognised term for free online courses, however some platforms, such as FutureLearn are currently phasing out the term 'massive' as internet learning evolves (McKie, 2018). Given that scalability has not been an essential feature, it may be that 'open online course' is an appropriate term for my future works.

The Teaching with Tablets MOOC used the Blackboard OpenLearn platform to host content based on the book Teaching with Tablets (work 4), and was intended to enable educators to translate emerging theory about the use of mobiles in education into their own classroom practice. I was keen to acknowledge the newness of the field and the potential for educators to explore innovative approaches, recognising that this is one of the challenges of working with new technologies (Luckin et al., 2010). My 'structured connectivist' approach therefore

sought to harness the power of learning in social settings with the power of a structured design. To this end, online synchronous interactions were combined with asynchronous interactions, and participants were encouraged to collaborate and share examples of their developing practice in an online community space (work 4).

In comparison, the unthreaded nature of the discussion forums in the FutureLearn course militated against depth and continued interaction, limiting the potential for the participants to develop new and shared understandings through peer to peer interaction. I decided that a different measure was needed to determine the success of the Teaching with Tablets MOOC, based on the idea that it was more suited to the small niche audience of educators rather than a large generalist audience. An interesting seam of evidence lay in the online community posts, which had the potential to show whether the participants did anything in response to the call to action in the content. I wanted to find out whether there was evidence of transfer to practice in the activity within the online community and to analyse the interactions around this to draw some conclusions about the learning process. I therefore used content analysis of the online community posts to seek evidence of transfer to practice, to determine whether engagement with the MOOC had an impact on teachers' behaviour (works 2 and 8).

The resulting analysis of the relationships between a set of randomly drawn samples of posts from the online community and Twitter using a set of axial codes demonstrated the strength of peer learning within the community, and showed that this developed as the MOOC progressed (work 2). I found that the participants' postings promoted the collaborative construction of knowledge through coaching and scaffolding, and included elements of authentic learning (Herrington et al., 2010). There was clear evidence of the transfer of ideas to classroom practice, and I could see that this knowledge transfer grew from participants' interactions with each other. However, the limited duration of the MOOC meant that there were many more statements of intent by participants to change their practice than there were strongly evidenced instances of change.

In many cases, the journey into practice was not as straightforward as expected. Participants did not simply respond to the suggested activities presented in the MOOC and directly transfer it to their own practice. Instead, they reflected on the provided material and discussed it in the community, where they considered the uses and possible impact of the new practices. When participants did transfer content from the MOOC to their own practice, it appeared to

be in response to this interaction and a subsequent period of self-reflection. This highlights the complexity of the process by which people learn from each other and the way in which knowledge transfer becomes closely linked to participants' roles within a developing community of practice.

A measure of the success of a MOOC, then, is not just the volume of participants and reach, but the quality of community relationships. Pallof and Pratt's research identifies social presence, interaction and communication in online communities as conditions that promote critical thinking and learning (Pallof and Pratt, 2007). My experience similarly suggests that a collaborative pedagogy built on strong relationships between moderators and participants, and between participants themselves, may better serve audiences such as practising educators. This agrees with findings from the U.S Department of Education:
'Our goal is not about getting just sheer quantities of people in there but thinking about who are the people that care about group learning and teams and schools, and therefore when they come to the site, they will be looking and talking with that lens.' (U.S. Dept of Ed, 2014, p.20)

In summary, the hybrid MOOC structures gave my learning communities a life cycle; as a cohort, they engaged with the materials and moved through the process of talking, reflecting and doing together. This shared pace and mutual engagement helped to create a responsive and fertile online space. The next section looks more closely at the nature and nurture of social relationships within the MOOCs.

5.2.1 Sustaining engagement

A lesson learned from all four MOOCs is that building reciprocal relationships through a strong social presence in the online community is a critical success factor. The 50 members of the DLaB community seeded the Technology Outdoors and STEM to STEAM MOOCs and then became moderators. As the MOOC progressed and educators from around the world joined in, the team was subsumed into the larger MOOC community.

Looking at this issue more closely, analysis of the interactions within the MOOC communities led me to appreciate that the comments often take the form of cheerful and encouraging chat rather than an overly scholarly or academic tone, and that the real reflective gems are embedded within this friendly flow (works 2 and 8). Successful moderators

maintained a positive tone and kept the comment trails flowing through prompts, questions and encouragement, signposting resources and sharing anecdotes from personal practice. This created an atmosphere where participants felt confident enough to share deeper reflective insights. This is consistent with the findings of Zhang et al., (2017) who note that online interaction may not always be deep and considered, but that low-level comments are a precursor to more active purposeful participation. Similar research finds that the 'human factor' inspires deeper student engagement (Garner and Rouse, 2016; Parker et al., 2013), and that interpersonal trust and non-competitiveness help sustain online knowledge sharing (Charband and Navimipour; 2016; Young and Tseng, 2008).

Close analysis of the interactions in the Teaching with Tablets community highlighted the role of positive encouragement by peers and moderators in encouraging reflection in online communities (work 2). For example, in the content analysis of postings in work 2 'Participant Reflection' and 'Positive Comment' were the two most common categories, closely followed by 'Peer to Peer Learning', 'Encouragement by Participant' and 'Encouragement by Moderator'. And in the Technology Outdoors content analysis (work 8), 'Peer Appreciation' was one of the eight summary categories. As Young and Tseng (2008) highlight in their study of teachers engaging in a virtual professional community, trust based on mutual appreciation has a key role to play in helping teachers overcome their natural reluctance to post publicly online. This concurs with the findings of Cheung et al.(2013) that reciprocity in online communities leads to satisfaction, which in turn enhances knowledge self-efficacy and furthers intentions to continue sharing knowledge. Such research highlights the importance of furthering our understanding of engagement and continuance behaviours in online communities so as to better sustain them.

To look at some examples from the Technology Outdoors community (work 5), we can see considered pedagogical reflection sitting alongside peer appreciation:

> *"I also like the idea of 'wondering' to respond to the outdoor environment through layers of images. This is a thoughtful process that moves from representing to responding to the environment."*
> *"We can examine the suitability of the 3D designs in real settings in nature and the city. It should create an opportunity for reflection that's more valid than ways we've tried before. I love freeing up the creativity in every child."*

'It would be interesting to see if adding features to an image could be thought provoking. Either with real or imaginary elements. Hmmm now I'm thinking?'
'Wow! ☺ Great pictures+idea! ☺ I will certainly try GIMP!'
'Excellent idea, I am going to look into this one and give it a go'.
'Love the creativity of your Y6s, Ian. Will share their work with our Y4s as it may encourage them to continue exploring surrealism

The key, then, is to recognise that knowledge creation in an online community is an iterative process that involves multiple and reciprocal interactions with content and others in an atmosphere of peer support and trust. In creating conditions for online social learning, we also need to acknowledge that a certain complexity of interaction creates ripe conditions for the deeper personal reflection and insights that move the collective knowledge forwards and prompts individual action leading to transfer to practice.

5.3 Modes of interaction within TELCs associated with MOOCs

As noted in the MESH guide (work 7), from Lave & Wenger (1991) onwards socialisation among participants has been emphasised as a defining factor in the process of building a CoP. Numerous commentators have stressed the importance of a variety of interaction methods, varying on dimensions such as synchronicity, formality, and modality (Hildreth et al., 2000; Kimble et al., 2001; Johnson, 2001). Others have taken a socio-cultural perspective to document the influence of layers of overlapping cultures and communities in technology adoption (Somekh, 2008; Sutherland et al., 2004). I will consider these viewpoints in the sections below in relation to the works.

5.3.1 Synchronicity

As Wenger et al. note, learners may belong to several TELCs as their learning trajectory moves in and out of several 'digital habitats' (Wenger, White and Smith, 2009). However, studies also suggest that some face to face contact can be a strength and make a case for multimodal learning that mixes physical interaction with asynchronous learning (Hammond, 1998; Kimble et al., 2000). TELCs may combine physical and virtual spaces or make use of a range of social media and networking technologies to allow for synchronous and asynchronous communication.

To give an example of how the combination of synchronous and asynchronous interaction amplified learning in my own practice, a wiki was used to signpost an upcoming TeachMeet[1]

linked to a Digital Leaders project (work 9). During the event participants responded to live tweets displayed on a large screen, posted ideas on an online board and contributed to emerging themes through live interviews[3]. Visual minutes[2] were captured based on the presentations, and participants continued to access these media after the event after they are archived on the event wiki (see Figure 5.2). Allowing learning spaces to remain open before and after events in this way can make for more seamless learning as online conversations take place before and after face-to-face interactions, and learning is captured during the event.

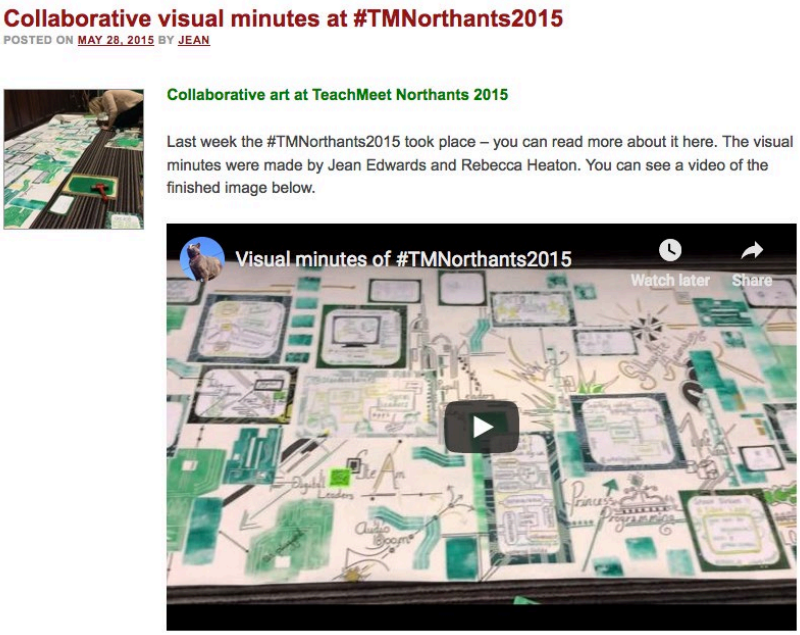


Figure 5.2: Capturing visual minutes at a TeachMeet event

[1]http://teachmeet.pbworks.com/w/page/90643295/TeachMeet%20Northampton%202015

[2]https://mypad.northampton.ac.uk/inspire/category/teachmeet/

[3]https://mypad.northampton.ac.uk/appsforinnovation/2015/02/08/95/

Similarly, the MOOCs included opportunities for synchronous interaction via Google hangouts and Twitter chats alongside the asynchronous community posting (see Table 5.1).

Tools and affordances			
Blackboard Open Education	**Google + community**	**Twitter**	**Google Hangouts**
Access to course content	Posting text, video and image-based content	Synchronous timed twitter chats	Synchronous face-to-face chats
eTivities	Asynchronous commenting on posts	Asynchronous commenting	
Announcements			

Table 5.1: Features of the hybrid MOOC design

Young and Tseng's (2008) discussion of the interplay of virtual and physical social contexts is relevant here. They point out that technology alone does not lead to successful knowledge sharing; rather it is dependent on interpersonal trust, which traditionally develops through face-to-face interactions, and they suggest that the two forms of interaction should be entwined. Some researchers propose that physical encounters can resolve online obstacles (Zheng et al., 2002). From my experience, I would suggest that even a small amount of synchronous interaction, whether face-to-face or online, facilitates the reciprocity needed to sustain successful asynchronous conversations. As one online learning student says in a community post:

> *'There is a good vibe across the group which makes me feel very much part of it from a distance.'*

In summary, this section has identified synchronicity and asynchronicity as factors to be considered when creating conditions for learning within a TELC.

5.3.2 Formality

A second dimension of interaction within online communities is the level of formality. As outlined in the MESH guide (work 7), online communities typically have different types of participation and degrees of expertise. Palloff and Pratt note that the absence of 'traditional group norms' in online communities changes the nature of the dialogue (Palloff and Pratt, 1999). This is related to the notion of technology stewardship (Wenger et al. 2005), through which an individual or a small group actively playing a facilitating role takes on the

cultivation of an online community. Wenger et al. suggest that individuals may move from the periphery to the centre as their expertise increases, bringing a new fluidity to learning. Analysis of the interactions in the Teaching with Tablets community (work 2) indicates that the stewardship role moved from instructors to learners over the course of the MOOC. Learning in the community grew through the questions, answers, and reflections, encouragement posted by both participants and moderators. Where there were clear participant and moderator roles at the beginning, these appeared to blur as the course continued. Moderators learned from participants and vice versa. Participants took on the role as the expert, sharing, answering questions of other participants, as observed by Holt and Willard-Holt (2000).

Wenger et al. (2009) also note that when a recent member brings a new element into the practice this may pull the competence of the whole community along if they accept or adopt it, resulting in the newcomer becoming the teacher. As Herrington et al., (2010 p.23) contend, often it is the person who has recently acquired the skill who is the best position to share the key elements of the constructs. This agrees with Schon's idea that knowledge generation can occur through different levels of expertise:

‘‘the movement of learning is as much from periphery to periphery, or from periphery to centre, as from centre to periphery’’ (Schon, 1973, p. 165).

Such a shift from teacher to learner within a social network is further described by Luckin et al.'s pedagogy-andragogy-heutagogy (PAH) continuum (Luckin et al. 2010). Heutagogy, Luckin suggests, is not so much about self-directed learning as learning in a socio-constructivist environment. The relationships between the teachers and learners in this environment become heterarchical, and the roles are fluid.

The PAH continuum is useful in describing the DLaB curriculum development days, webinars and online communities, in that there was no hierarchy between teachers, lecturers and students; all had an equal voice and all could take a turn at being the expert, as evidenced by the DLaB website (work 5). Amongst the project members, technology played a role in creating a flat community. Within this community, smaller groupings formed and reformed, such as when university student and school pupil digital leaders met to share ideas which were posted online. Online contributions from students sat side by side with posts and

comments by academics, cutting across formal structures and forging new understandings of the ways in which technologies can transform learning**.**

The importance of informal reciprocal learning and collegiality between beginning and experienced teachers is highlighted by many (Twining, 2013; Patrick et al., (2010); Wang and Chen, 2006; Belland, 2009) and explored in the MESH guide (work 7). Collins et al. (1989) describe a process of cognitive apprenticeship, wherein participants learn from real life examples produced by more experienced teachers. Along similar lines, Vrieling et al. (2016) applied a 'Dimensions of Social Learning (DSL) framework to optimise student teachers' roles in a group of teacher experts. An aim was to recognise the benefits of engaging in practice-driven social learning, in contrast to the traditional model of student teachers working as individuals in their own classrooms and observed by experts (Vrieling et al., 2016). This can be likened to the way in which the hierarchies of the MOOC communities altered over their lifespan as new participants were assimilated and took on different roles:

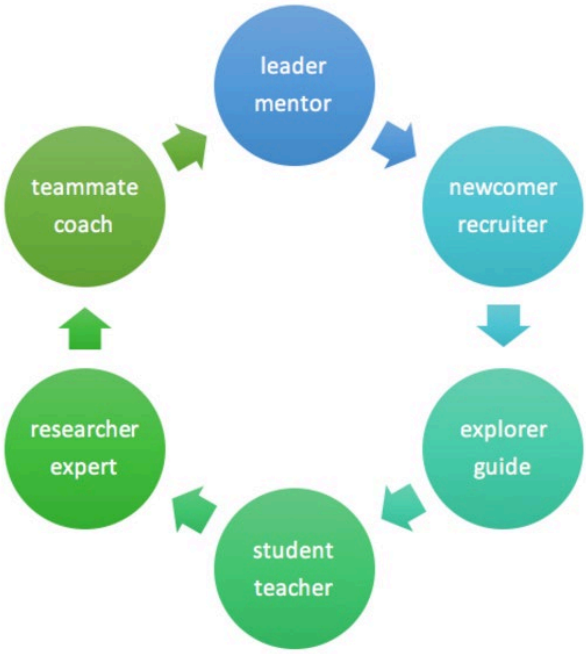


Figure 5.3: Roles adopted by TELC participants, from The MESH Guide (work 7)
Adapted from: https://www.haven2.com/index.php/archives/icann-participants

In these examples from the Teaching with Tablets community, participants reflect upon the strength of the peer-to-peer collaborations:

'It has been brilliant to connect with people who are in the same interest of doing something with apps at the same time because of the hardest things when you are isolated in your organisation and in your own job trying to find other people doing the same thing at the same time who have time to do it then. I have lots of enthusiastic colleagues but if you say, 'Can we chat about this?' or 'Would you like to share that?' it is often governed by whether they are available...we have all made ourselves available and there has been so much collaboration because of that and I've found it really powerful.'

'It's so inspiring. That's why the course has been so interesting. Because you might not have an idea. And then you might not know what to do with something so seeing someone else use it effectively just makes you go 'OK, I'm going to try that.'

Articulations such as these within a learning community can act as stepping stones to further reflection and learning. And in doing so, they help to create foundations for future practice. Within my experience, certain key postings in online communities become cornerstones that many learners travel across on their learning journeys. This provides another example of ways in which the collective learning potential of the crowd exceeds that of the individual, (Richardson, 2010; Hung, 2002; Johnson, 2001).

In summary, this discussion of formality highlights the fluidity of roles within online communities and the importance of understanding the changing nature of their structure and evolution. An idea to take forward is the importance of creating conditions for learners to have agency and voice by designing and nurturing community spaces that cut across formal hierarchies, and an impact might be that individuals subsequently gain the confidence to innovate in their own contexts. In this way, there is interaction between the individual and collective voices in the development of shared knowledge and its application to practice. This concurs with Wenger et al.'s (2011) perception that CoPs contain complex narratives:

'The narratives that frame the contributions of communities and networks to learning are complex. They involve multiple voices and perspectives. They include both personal and collective narratives. The personal narratives refer to the experience of participants. The collective narratives relate to the social networks and communities people are part of.' (Wenger et al., 2011, section 3.1)

5.3.3 Modality

The experience of leading teams to develop MOOCs led me to reflect upon the nature of multimodal literacy as a key workplace skill (also see Chapter 4.4). The production team was very often involved in multitasking and remixing content drawn from a range of sources, and moved in and out of physical and social learning spaces. For example, in Figure 5.4 lecturers, teachers and students are working across digital and physical spheres to create the MOOC content by combining ideas drawn from various digital sources to create collaborative documents.

Figure 5.4: The DLaB team collaborating to develop a MOOC

As Cope and Kolantzis suggest, learners need

> ‘a peculiar conceptualising sensibility, sophisticated forms of pattern recognition and schematisation, higher-order abstraction and metacognitive strategies…Teachers then need to become masterful users of these new meaning making tools, applying the metalanguage they and their learners need alike in order to understand their affordances.’
> (Cope and Kolantzis, 2009, p, 581)

Once the MOOC was underway, the online community then allowed for dynamic interaction between tasks, instructors and participants, as illustrated in the MESH guide (work 7). Figure 5.5 illustrates the transfer of ideas from the MOOC to classroom practice, as an idea used

with university students is adapted for use in Year 2 Primary. In this example, a lecturer uses a teacher's photo collage of pupils' work on the theme of outdoor textures as a prompt for her own drawing. There is reflection on the impact of using technology to provide a focus for children's ideas and on the cross-curricular potential of the digital artefact. This is an example of peer-to-peer knowledge transfer via an interplay of talking and making, and a crossover between the physical and digital spheres. Both images are posted on the community and a commentary builds up around them that results in a statement of intention to transfer ideas to practice.

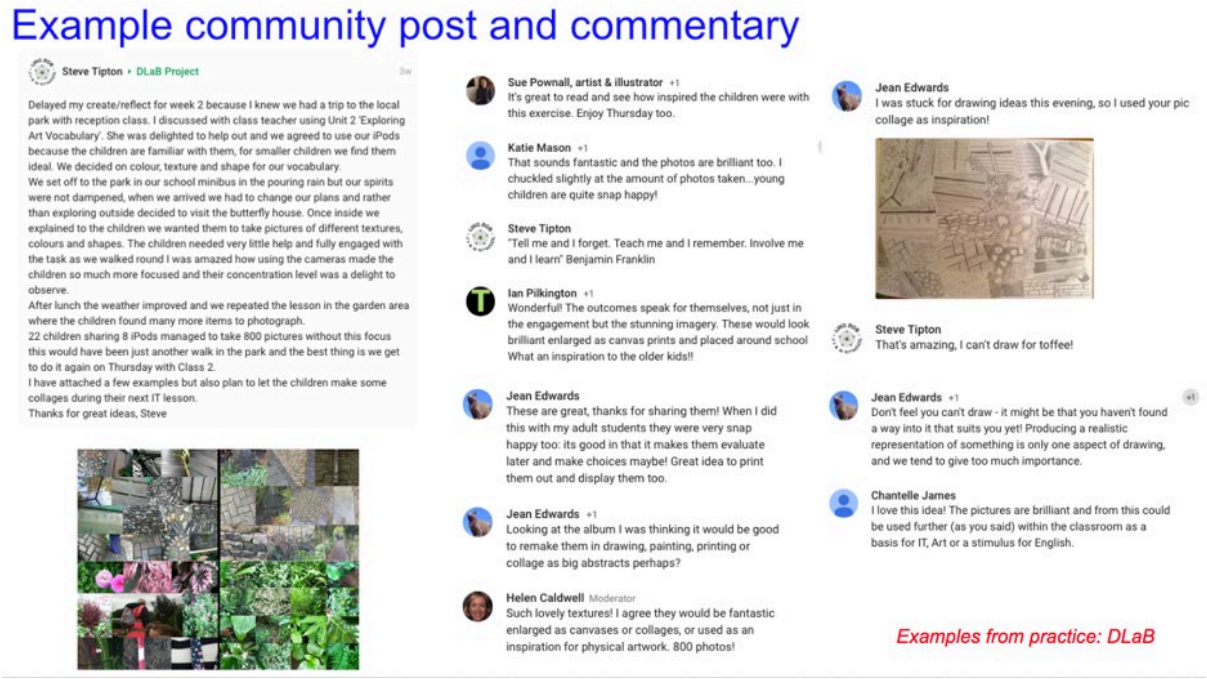


Figure 5.5: Online community facilitating the transfer of ideas to practice across educational sectors

This fits with Hoadley and Kilner's C4P framework on how knowledge is created and disseminated by participants in a CoP, based on the idea that knowledge is generated and shared when there is purposeful conversation around content within a context (Hoadley and Kilner, 2005). C4P is short for 'content, conversation, connections, context, and purpose', and comprises the non-linear system that occurs in a community of practice wherein all five elements work in partnership. One lesson learned from all four MOOCs is that there was value in aiming for an international, cross-sector audience. The rich mix of educators from early years to higher education around the world meant that ideas were adapted, remixed and

interpreted in a plethora of ways, and that knowledge and knowing were byproducts of social processes.

5.3.4 Nested communities

As the DLaB project (work 5) evolved I could see relationships developing across interdependent communities. Lecturers, students, teachers and pupils worked synchronously on designated international days, sharing simultaneously using Skype and Twitter. The eTwinning platform and website facilitated joint planning and follow-up activities connected to these events. The project community of teachers, student teachers and lecturers then came together to create the MOOCs, which were opened to a worldwide audience. An international cohort of teachers shared their own experiences around the MOOC themes. This can be seen as an example of two nested communities with overlapping connections. A third nested community was the eTwinning TwinSpace used for the pupils and teachers within the project. The coming together of these different communities around the MOOC theme reinforced the learning and supported the pupil, student teacher, teacher and lecturer involvement. This aligns with Siemens' recognition of the value of cross-pollination of learning communities (Siemens, 2005). These interlinked communities provided a chance for trainee teachers to develop 'community competence' through modelling, an opportunity that can be difficult to find in the individualistic world of teacher education (Vrieling et al., 2016; Harrison, 2009, Twining et al. 2013).

Figure 5.6: The DLaB community of teachers, student teachers and lecturers (sourced from the MESH guide, work 7)

Figure 5.7: The DLaB community of teachers, student teachers and lecturers creating the Technology Outdoors MOOC, (sourced from the MESH guide, work 7)

Likewise, Wilson (2010) recognises that members might belong to several CoPs and adopt different levels of core versus peripheral membership within them to reflect their leadership. This takes a distributed approach to practice-based learning, viewing it as a dynamic, situated process in which changes to practice result from the interactions between people, tools and routines in a context over time. It could be said that the DLaB participants experienced an interplay of the three overarching and overlapping perspectives of social learning identified by Vrieling et al (2016): social networks, communities of practice and learning teams, with technology facilitating the interplay between learners, learners and teachers, and learners and content (work 5).

Using a building firm as their example, Gheradi et al. (2002) draw on Wenger's term 'constellation of practices' (Wenger, 1998) to describe a series of interconnected communities. Pursuing a musical metaphor, they emphasise the tensions and incoherencies across linked communities, highlighting that there are opportunities for dissonance alongside order and negotiated meanings. Discourse may not be aimed at reaching understanding, but of comparing perspectives. This may result in synthesis and harmony but it can also produce a 'cacophony of tensions'. The researchers propose that learning to recognise these will help to produce form and order out of what first appears as 'noise', giving shape to the constellation of links. Similarly, Wenger et al. (2011) draw attention to the danger of expanded connectivity increasing the amount of 'noise' in a network and the need to distinguish between significance and noise to minimise diffusion.

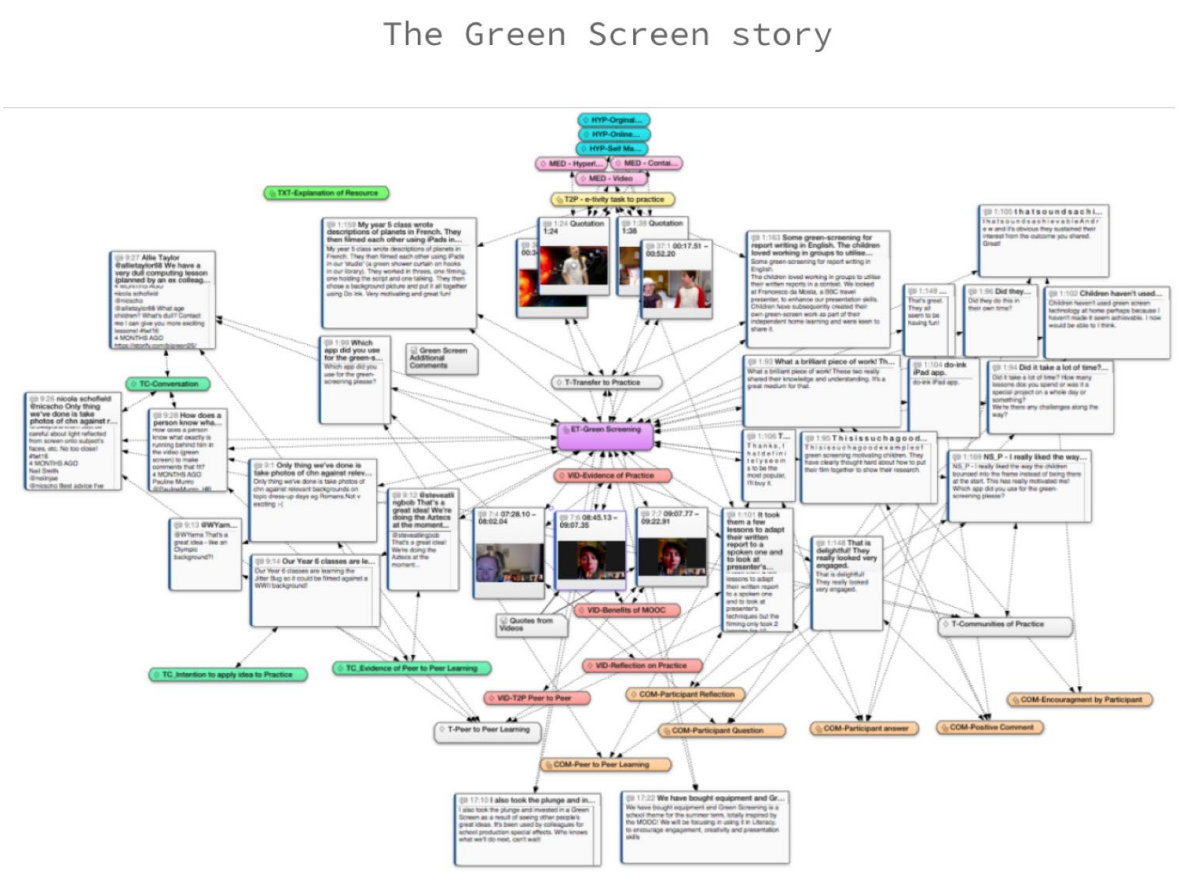


Figure 5.8: A visualisation of the network of comments that built up around the theme of green screening in the Teaching with Tablets MOOC.

To further illustrate how these ideas relate to my works, Figure 5.8 provides a visualisation of the activity that built up around the concept of green screening in the Teaching with Tablets

community (work 4). As acknowledged in section 5.2.1, we need to recognise chatter between participants as a condition for meaningful knowledge building. The presence of such noisy dissonance implies that participants feel safe in challenging each other and that a level of trust has been established that is essential to continued engagement (Hoadley and Kilner, 2005; Cheung et al., 2013).

5.4 Chapter summary

In summary, this chapter has considered the role of TELCs in supporting social learning in MOOCs. I suggest that MOOCs and online courses take many different forms, and one version that has worked in my teaching context might be described as a hybrid niche MOOC. This format provided structured learning materials alongside a lively online community with the aim of bringing together an engaged group of practitioners around a theme that enthuses them, outside of an accredited learning context.

Drawing upon Wenger's ideas about the duality of participation and reification, talking and making, I suggested that a key role of TELCs is to provide an opportunity for participants to articulate their pedagogy and practice through posted media, images and digital artefacts in response to online content. These visual posts can act as anchors for talking and making within online communities by linking people, activities and the world. In doing so they allow communal knowledge to move forwards around shared understandings that then be drawn upon to develop individuals' practice. This can result in complex and rich seams of learning that take ideas in directions across different educational contexts beyond the original course content. Such activity may cross boundaries of subject areas, age groups, countries and cultures. Sometimes it is the crossing of such boundaries that provokes fresh ideas and insights as teachers immediately grasp ideas and adapt them to their own contexts, as in this English response to a post of skiers in Norway in the Technology Outdoors MOOC:

> *'I love this idea and am wondering how it would work with a less stunning landscape. In my mind, I am thinking of a range of different windows into the play that goes on in the playground or as Liz mentioned creating the peculiar - that would maybe add a spark to a more basic background.'*

Resulting examples of practice might then be reshared within the community during its lifespan or evolve within new or nested communities via the individual's personal learning networks. These ideas contribute to the models proposed in Chapter 6.

A second theme in this chapter looked at how the social behaviour of participants can impact on practice. In my experience, reciprocity and peer appreciation are key to encouraging reflection within online communities and this in turn can lead to transfer of ideas to practice. A key finding from a focus on the relationship between community postings and transfer to practice was that this was often a complex process that was often dependent on cycles of action, reflection and peer appreciation. For example:

> *'We have bought the equipment for Green Screening and it is (now) a school theme for the summer term, totally inspired by the MOOC! We will be focussing on using it in Literacy to encourage engagement, creativity and presentation skills.'*
>
> *'I also took the plunge and invested in a Green Screen as a result of seeing other people's great ideas. It's been used by colleagues for school production special effects. Who knows what we will do next, can't wait!'*

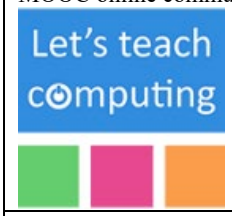
Recognition therefore needs to be given to the fluidity of roles within online communities and to the nested and evolutionary nature of many communities. In Chapter 6 I draw together examples of five evolutionary forms that TELCs might take over their active lifespan. I also examine how an interplay of five dualities that were identified in the public works TELCs might be used to create a description of the TELC learning climate. Together these models map the topology and typology of the technology enabled learning landscape, in both purely online and blended environments that include face-to-face.

Chapter 6: Towards an understanding of the epistemology of technology-enabled learning communities

Central reflective theme:

How the public works illuminate ways in which technology can facilitate high quality social learning in online and blended environments.

Summary of the works referenced in this chapter:

Work	Reference/Source	Description
1.STEM teaching community	Online community https://plus.google.com/communities/101219204832294214534/stream/46cb8a23-21f0-4a69-8a88-69448cf9d882	Online community associated with undergraduate STEM teaching sessions at the University of Northampton
2. Let's Teach Computing MOOC online community 	Online community https://plus.google.com/u/0/communities/112335386477156503633	An online community accompanying a MOOC.
3. Online community from the PG Cert Primary Computing course	Online community https://plus.google.com/u/0/communities/103318414174390823641	A comparison community of more experienced primary computing teachers.
4. ITTE subject association blog	Blog http://itte.org.uk/wp/	
5. DLaB website, Technology Outdoors and STEM to STEAM MOOCs and online community: 	Course http://dlaberasmus.eu/courses/technology-outdoors-online-course/ Course http://dlaberasmus.eu/courses/stem-steam-online-course/ Community https://plus.google.com/u/0/communities/117458443566280105364 Website http://dlaberasmus.eu/	
6. MOOC and online communities: Teaching with Tablets and Apps for Innovation	Online course https://openeducation.blackboard.com/mooc-catalog/courseDetails/view?course_id=_806_1 Teaching with Tablets community https://plus.google.com/u/0/communities/108510780639510097712 Apps for Innovation community https://plus.google.com/u/0/communities/110218249780833007111	MOOC and online community based on content from the Teaching with Tablets book. A group of lecturers in Initial Teacher Training piloting the use of iPads for teaching and learning at the University of Northampton.
7. Hong Kong Summer Camp community	Community https://mypad.northampton.ac.uk/hksc/	A group blog representing ideas and resources for student teachers on placement in Hong Kong
8. Online community of master teachers	Community https://plus.google.com/u/0/communities/116334100443162688989	Master teachers attending the training programme

9. Online community from the PG Cert Primary Computing course	Community https://plus.google.com/u/0/communities/103318414174390823641	A comparison community of more experienced primary computing teachers.
10. Let's Teach Computing MOOC and community based on the Lessons in teaching computing book.	Online course https://openeducation.blackboard.com/mooc-catalog/courseDetails/view?course_id=_400_1 Course book http://www.uk.sagepub.com/books/Book242640 Website http://letsteachcomputing.net/ Online community https://plus.googleapis.com/communities/112335386477156503633	An online course and community based on the book.
11. Digital Learning across Boundaries project (DLaB): Website, Technology Outdoors and STEM to STEAM MOOCs and online community:	Website http://dlaberasmus.eu Online community https://plus.google.com/u/0/communities/117458443566280105364 Online course http://dlaberasmus.eu/courses/technology-outdoors-online-course/	An Erasmus+ European partnership project promoting digital learning across the boundaries of physical spaces, across curriculum subjects and across languages and cultures.

Figure 6.1: Public Works referenced in Chapter 6

6.1 Aims of the conclusion

This final chapter returns to the central reflective theme to draw conclusions about ways in which technology can facilitate high quality social learning. By looking across the landscape of the public works, it pulls together some of the common threads that have emerged around knowledge-building practices within the phenomenon of TELCs.

Firstly, in this chapter the commonalities across the TELCs are examined with a broad lens to suggest a set of five forms for analysing the topology of TELCs from a distance. Secondly, using a closer lens, this chapter identifies consistencies among the multiple TELCs regarding the nature of knowing and knowledge within them through five dualities which provide a descriptive typology. By presenting these two ways of analysing social learning within TELCs, this chapter offers an analytical framework that suggests some conditions for success. This framework might inform the design and evaluation of online learning communities by delineating the process of knowledge-building within them. It might also be used as a diagnostic tool to identify ways of improving a TELC.

Other researchers have identified a need for more specificity in this field. For example, Brown (2016) observes that, 'Technology is frequently described in broad strokes' (Brown, 2016, p.5). Similarly, Fenwick et al. (2011) state that one of the challenges of theorising

about technology involves connecting the thinking processes of individuals and the material influence of objects. Future research, they suggest, should seek to conceptualise the socio-technical system.

6.1.1 Developing a framework for the role of technology in social learning

There have been numerous attempts to map the learning landscape when working with technology, many of which have been helpful in discussing the public works, e.g. TPACK (Schmidt et al., 2009), SAMR (Puentedura, 2010), Mobile Pedagogical Framework (Burden, 2018), PAH Continuum (Luckin, 2010), Characteristics of Ubiquitous Learning (Cope and Kalantzis, 2009), C4P Framework (Hoadley and Kilner, 2005). Some of these analyses focus on the relationship between the users and the technology, others on what technology adds to the individual learning process or on the affordances of the technology.

A central theme across my works is the nature of the knowledge-building that takes place in social learning communities facilitated by technology. This conclusion draws examples from the works to illustrate how this process can take various forms. It presents a model of technology-enabled social learning that emerges inductively from a critical reading of the layers of public works alongside the accounts from literature associated with them. The process is interpretative, in that the concepts and relationships that emerged through a reflexive analysis of the works are organised into an explanatory scheme (Strauss and Corbin, 1998). It is also autoethnographic in that it is grounded in my own personal experience of educators' beliefs, values and practices in their situated educational contexts.

A consistent feature of the works is the instances of TELCs across a range of contexts: undergraduate and postgraduate teaching in the UK, international project work, teacher CPD and a range of international MOOCs. These varied perspectives have been significant in giving me opportunities firstly to firstly draw some general conclusions about distinct types of TELCs by looking how TELCs can function differently across a range of contexts, and secondly, to draw conclusions about the conditions for success in TELCs by looking at factors that remain constant across contexts. As such, they provide some generalisable guidelines for building and sustaining TELCs.

Some of the commonalities to transpire from this analysis of the works reflect the affordances of the technologies. These include the ability to:

- cross boundaries and barriers of time, place, cultures, language, media and diversity
- move in and out of digital and physical spaces with agility
- occupy more than one space simultaneously
- use technology to transition between cognition, reflexivity and practice

These technology affordances fundamentally change the nature of interaction and communication in TELCs by:

- mediating the process of connecting people and resources
- altering the context and nature of participants' interactions
- changing the social relationships and roles of teachers and participants
- increasing the potential for shared purpose across diverse groups
- allowing for variety in the pace of interaction

These commonalities within the works have helped me to make the relationships between interrelated variables more explicit. As a result, I present a descriptive tool that might be useful at the design stage when planning online learning and appraising the functionality of combinations of technology tools, and at the evaluation stage, when assessing the quality of participant engagement with learning within TELCs after it has taken place. Within my description, the term 'teacher' embraces any activity undertaken by a facilitator or coordinator of a TELC.

First, looking at the TELCs within the works from a distance, I suggest five distinct forms of learning communities, each of which has implications for the roles of the teachers and learners and the nature of the knowledge building within them. Second, with a closer lens, I offer an analysis of the knowledge-building process itself based on my observations of behaviours within the TELCs. This ties in with the autoethnographic aim of displaying multiple layers of a phenomenon;

> 'Back and forth autoethnographers gaze, first through an ethnographic wide-angle lens, focusing outward on social and cultural aspects of the personal experience; then they look inward' (Ellis and Bochner, 2000, p.739)

Together these two perspectives provide a framework for describing the nature of learning, knowing and knowledge within the TELCs associated with the public works.

6.2 Five distinct forms of TELCs: Contained, Expansive, Nested, Heritage and Satellite

6.2.1 The Contained Community

The contained community is an enclosed, standalone community that pursues common goals for a specified period. Interaction might be private within a single online space. Activity within the group is seeded by the teacher and they retain a strong presence, initiating and guiding the online activities and direction of growth. The growth of knowledge within the community may be staggered over time with bursts of activity following an impetus. The result can be likened to a cross section of a tree trunk with bands indicating periods of growth prompted by teacher interaction or the release of new content.

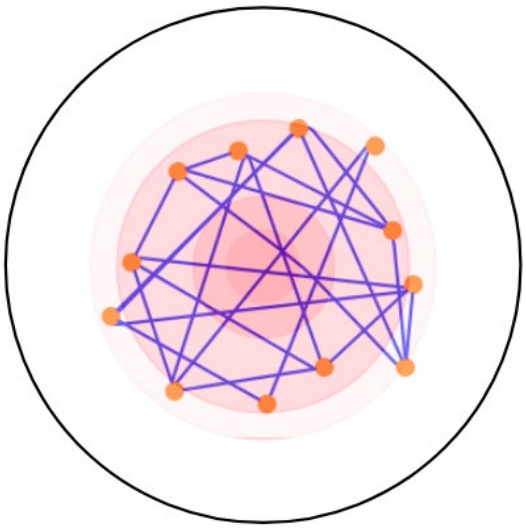


Figure 6.2: A contained community

In Figure 6.2 the orange dots represent community members and the blue network represents a growing set of community members and interactions. The black boundary indicates that the community is contained. This may be by privacy controls and/or by time limits controlled by the teacher. Points of input by teacher interaction or the release of content are indicated in red. The bands show that these may vary in duration and intensity.

Examples of contained communities from my published works include taught modules at the University of Northampton, which make use of an online community alongside a series of face to face sessions. Students post in the community before, during and after the taught sessions. An example is a community based around my STEM teaching (work 1). In this example, forty-eight students participated in STEAM sessions testing robots and drones in simulated disaster environments. Facilitated by myself as the teacher, designated 'makers' customised and tested the robots and drones, 'reporters' devised news reports using iMovie, and 'researchers' recorded visual minutes to document the STEAM learning process as it unfolded. Groups reflected before and after their sessions using Lego Serious Play. IPads were used to post evolving ideas on an online community to prompt group reflection. In this instance, the technology became a learning lens and the posted visual media represented new viewpoints that invited feedback. Other examples from my own practice are online communities associated with groups of teachers engaging in CPD, the PG Certificate in Primary Computing group (work 3) and the Let's Teach Computing MOOC community (work 2). Within these communities, the direction of growth is determined by the learning objectives and timescales set by the teacher. It may be nurtured by a set of moderators, as in the case of the MOOC. As a contained community is likely to have a limited lifespan, key considerations in choosing technology tools may be privacy, ease of use and teacher presence.

6.2.2 The Expansive Community

An expansive community is public and is characterised by growth. From the outset, it seeks to gather momentum. Although it needs one or more teacher-moderators to initiate and nurture growth at the beginning, it becomes increasingly heterarchical and connectivist as the learners become interdependent. Unlike the contained community, the growth is unpredictable and may take different tangential directions, resulting in a shape that is more amoeba-like and has no definite boundaries. Learning within this community tends to be rhizomatic in nature (Siemens, 2011).

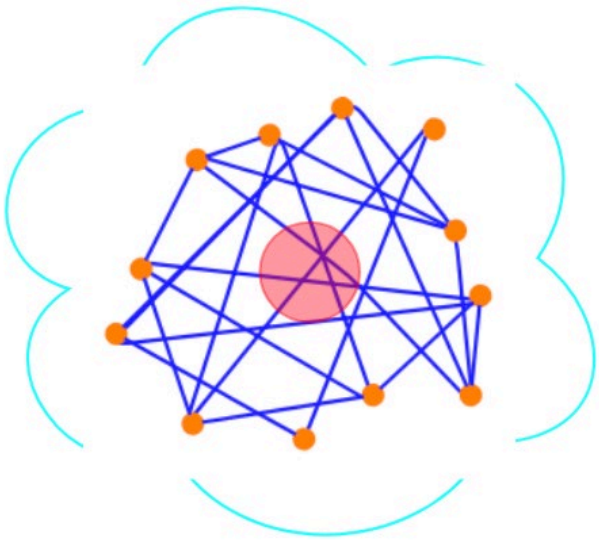


Figure 6.3: An expansive community

In Figure 6.3 the orange dots represent community members and the blue network represents an expanding set of community connections. The light blue boundary indicates that growth can occur in any direction. Points of teacher input are indicated in red and, in this case, are essential at the outset. Teacher presence may continue in varied amounts throughout the life of the community.

Examples from my own practice include my involvement as a national executive committee member of the TPEA, ITTE and IMOLENTE subject associations, which aim to gather like-minded people around the broad themes of educational technology and mobile learning. In the case of ITTE, community engagement has evolved over many years through a combination of face to face and online activities; a newsletter, website, blog, conferences, social media, seminars and committee meetings. The committee is key in creating opportunities for these events and interactions to take place, however, to a large extent, it allows the themes to evolve from within the community. A key idea is that the community has a life and direction of its own and that the committee takes the role of facilitating and sharing. My involvement in the national executive committees of these associations has been as a social media officer and an output I have co-facilitated is the ITTE subject association blog (work 4). A second example of an expansive community within the works is the international DLaB project community (work 5) which has slowly grown during the 3-year lifetime of the project.

As a goal of the expansive community is to continue to grow over time, the online space needs to be structured so that it does not become unwieldy. Technology tools that allow for categories and tags associated with posts are likely to be useful. There may be less need for structured learning materials in an expansive community as the growth is in response to the community interests.

6.2.3 The Nested Community

A nested community is characterised by osmosis. A core community establishes group norms and interests. Once these are in place, it may evolve into a second larger community. This may be a natural process or controlled by a teacher. A teacher presence is needed to initiate the core community, which at the outset is similar in shape to the contained community. Teachers, moderators or participants from the core community are then needed to enable the merger into a second larger community, which develops and expands upon ideas seeded by the first. Over time, the boundaries between the two communities become increasingly blurred. There is potential for several overlapping groups to be nested, and for them to be expansive or contained. They may eventually be subsumed or continue to overlap.

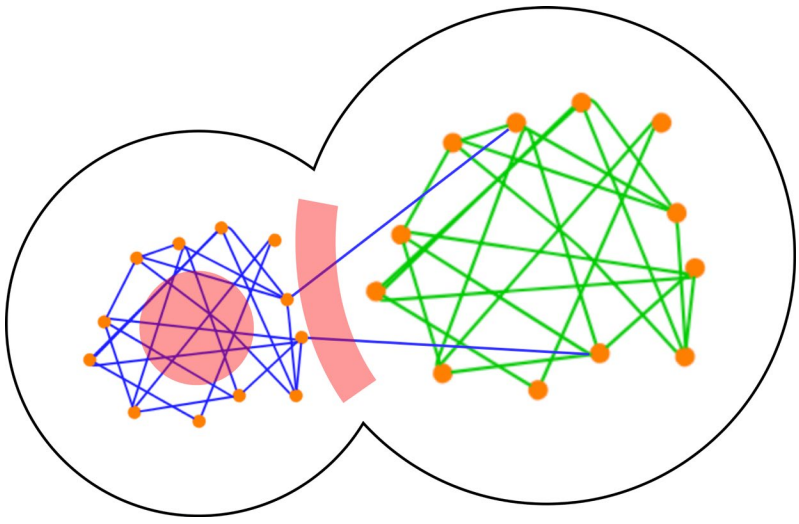


Figure 6.4: A nested community

In Figure 6.4 the orange dots represent community members, the blue network represents an original set of community connections and the green network represents a second set of community connections. Points of teacher presence and input are indicated in red.

An example from my own practice is the DLaB project community nested within the MOOC community (work 5). The DLaB project community began with a core of around 50 students, teachers and lecturers from four European countries exploring a digital theme for each of the three years of the project. They began by interacting in private online spaces, FaceBook, eTwinning, Google Docs, Skype and a members' area on the project website. The collective knowledge resulting from these activities was used to seed the public MOOCs. This was complemented by the public website and online community space, which was used to host a MOOC at the end of each of the three academic years. The public community now has 299 members and the associated website over 700 members. Social media such as Twitter and the social networks of the original 50 members have been key to recruiting for the public community. The core group acted as moderators at the beginning of the 3-4 weeks when each MOOC became active. Roles become more blurred as there is a cross-pollination of ideas across the two communities.

A second example is the Apps for Innovation Pilot (work 6). Here a core community of 15 lecturers from the Faculty of Education and Humanities explored the use of iPads in their teaching over the course of a year, sharing ideas through face to face meetings supported by an online community. At the end of this time they shared their ideas via a faculty forum and invited the rest of the faculty to join in with the iPads project. At this time, every member of the faculty was issued with an iPad on condition that the ideas sharing continued.

A third example is the transition in progress from the existing ITTE and Mirandanet subject associations (work 4) to a new Technology, Pedagogy and Education Association (TPEA), merging two distinct groups of members from itte.org.uk and mirandanet.ac.uk.

A nested community is likely to begin with one or more groups that have some collective knowledge to pass on. Thought needs to be given to structuring this content in a logical way so that it can become an impetus for the larger community to grow, and as to how the larger community will be encouraged to respond to the content. For example, in the MOOCs

etivities were designed to function as ‘calls to action’ for the larger group to carry out activities and share the results.

6.2.4 The Heritage Community

A heritage community is characterised by curation. An initial group develops and documents their collective expertise around a theme. The teacher facilitates this curation and then acts as a gatekeeper for the subsequent handing over to a second community that is distinct from the first. This may take place several times, with each group adding to the collective knowledge. This process is reliant on a structured and accessible digital space that represents the group’s collective experiences and expertise.

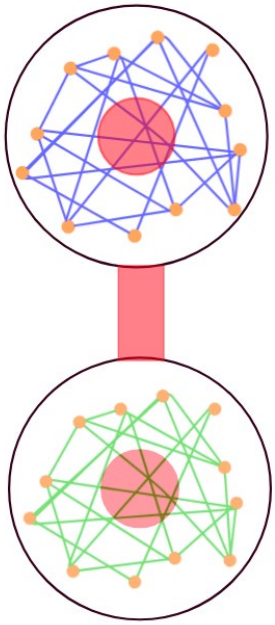


Figure 6.5: A heritage community

In Figure 6.5 the orange dots represent community members, the blue network represents an original set of community connections and the green network represents a second set of community connections. The black boundaries indicate that the communities are contained by time or privacy. Points of teacher presence and input are indicated in red. In this case, they indicate the seeding of each distinct community and the facilitation of knowledge curation and transfer between the two.

To draw from my experience, the Hong Kong Summer Camp (HKSC) community represents a heritage community (work 7). Each year a new group of students builds shared expertise through face to face meetings, webinars, shared lesson planning and shared experiences at the HKSC. These are documented and curated on a blog and passed on by the teachers to the next group, who then add to them. This process might be repeated many times as long as there is a new group to inherit and add to the shared resources.

A heritage community will need to make use of technology for curation so that each group leaves an orderly set of resources for another group to pick up. In the HKSC example this was achieved through a combination of 'magazine-style' blog posts and pages of reflections, tips and videos, including shared lesson planning, to which all the members contributed.

6.2.5 The Satellite Community

A satellite community takes the form of a parent community and several self-sufficient offspring communities, each of which is generated and maintained by a member of the parent community.

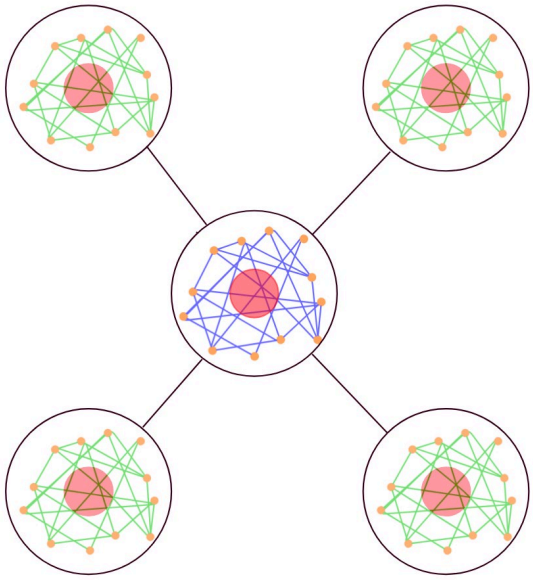


Figure 6.6: A satellite community

In Figure 6.6 the orange dots represent community members, the blue network represents an original set of community connections and the green networks represent additional sets of

community connections. The black boundaries indicate that the communities are contained by time or privacy. Points of teacher presence and input are indicated in red. In this case, they indicate the seeding of each distinct community and the facilitation of knowledge curation and transfer between the two.

Examples from the works include the Master Teachers group (work 8), which explored the theme of the new computing curriculum over the course of a year via face to face sessions accompanied by an online community. These teachers then used their shared knowledge from the group as a springboard for developing their own communities of practice. My presence as the teacher of the core group gradually diminished as the satellite groups became established. A similar pattern emerged during the Postgraduate Certificate in Computing group (work 9), as members gained the confidence and expertise to run their own network groups in individual schools or clusters of schools. This is an example of a contained community evolving into a satellite community. The technology needs are likely to be similar to the contained community in that there will be smaller network groups, each with a strong teacher presence.

6.2.6 Summary of the form characteristics

Form	**Key feature**	**Key characteristic**
Contained	standalone	A community constrained by time and/or membership
Expansive	tangential growth	Unstructured learning in response to community dynamics
Nested	osmosis	One or more communities evolving into larger overlapping communities
Heritage	curation	The handing over of community expertise to a new contained community
Satellite	offspring	A period of incubation which results in a parent community generating new communities

Table 6.1: Summary of the form characteristics

This section has presented five distinct forms for knowledge building TELCs, based upon examples drawn from my public works, with the aim of describing the structures of their learning landscapes. It should be noted that the nature of learning within all forms of TELCs is evolutionary, and so their forms may alter over time.

The next section takes a closer look at the process of knowledge building within TELCs, as suggested by the works.

6.3 Conditions for success: Five dualities for knowledge building within TELCs

Based upon a closer analysis that examines activities and behaviours within the TELCs, this section identifies an interplay of five dualities promoting knowledge building in a typical TELC. These are Connectivist and Content, Making and Talking, Physical and Digital, Synchronous and Asynchronous, and Personal and Collective.

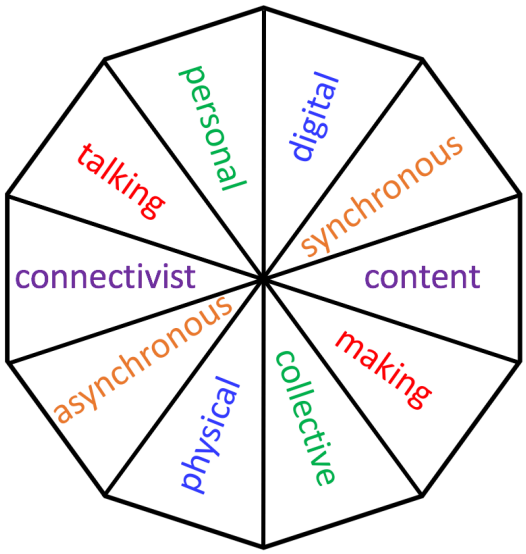


Figure 6.7: An interplay of five dualities within a TELC

This model suggests that the dualities are interdependent and balanced, although within each pair, one may be more dominant at any given time. It recognises that the learning climate is in flux as participants interact with it, and that knowledge within a TELC is an evolutionary flow, rather than fixed. The dualities provide a set of definitions for describing the nature of the interactions and knowledge building within a TELC. They could be used to plot the journeys of travel for individual participants or to document the co-creation of knowledge

within the group. An analysis of the relative presence of the dualities and dominances might offer a diagnosis of how well a TELC is functioning.

Furthermore, each duality takes a spiral or cyclical path within the life of the community that recognises their mutual dependence in the iterative process of building collective expertise. This process will be continuous during the active life cycle of the community.

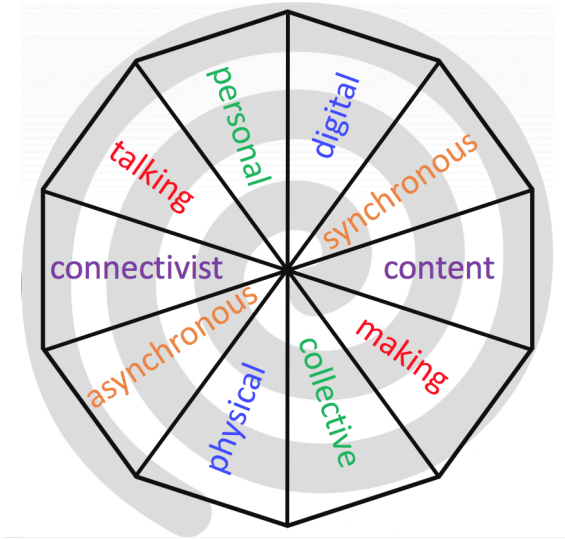


Figure 6.8: The iterative nature of knowledge building in the TELCs.

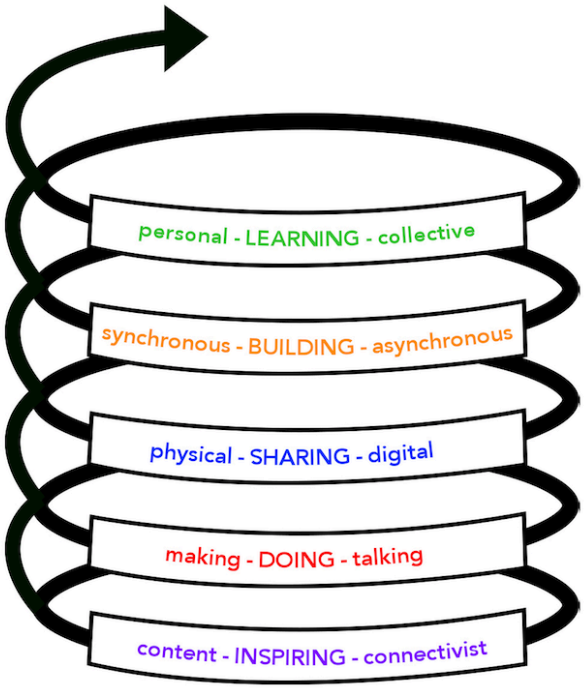


Figure 6.9: The dualities supporting a cycle from inspiration to learning within a TELC

Viewed from a progressive perspective, the spiral in Figure 6.9 indicates how ideas are defined and refined within a community through a route that travels from inspiration to learning through a process of doing, sharing and building along the way.

A key idea, then, is that there is a dynamic flow and interaction across the dualities and that they work in tandem. The five dualities can be viewed as a process that combines **inspiring** through content/connectivism, **doing** through making/talking, **sharing** through physical/digital, **building** collective learning through the synchronous/asynchronous activity and **learning** through the personal/collective duality. This route may be travelled many times, individually or collectively. The personal-collective duality ensures the continued existence of the community as personal reflections are shared and built upon by the community.

The next section considers each duality in turn.

6.3.1 Connectivist and Content

Within the connectivist-content duality participants may be initially inspired either by teacher created content or by connectivist activity, as in the X-C MOOC continuum. From a social

online learning perspective, the teacher-created content may be intended to seed connectivist activity. These two sources of inspiration can coexist and may be balanced differently at times for individuals as well as for the collective group. This duality acknowledges the blending of the acts of reading and writing as participants interact with knowledge and each other in a decentralised and distributed way. It recognises learner agency and heutagogy.

An example from my public works is the hybrid MOOC Let's Teach Computing (work 10). The content posted by the teacher acts as a springboard for individual posts extending the themes in different directions, and the evolution of ideas may take place through a content or connectivist-driven route.

6.3.2 Talking and Making

This duality acknowledges that the bridge between talking and making is crucial to community knowledge-building. Learning within a TELC means that situated devices are embedded in our physical lives. Making refers to the articulation of ideas, and might take a physical or digital form. This could be as simple as a written or spoken description or it could take forms such as an image, video, or piece of code. It is essentially the externalisation of an idea or an example from practice in a form that someone can respond to. Within the community, the to and fro between articulations and responses is essential to the knowledge building process. The idea of bricolage is part of this duality as knowledge or artefacts may be picked up and recombined in new ways.

6.3.3 Physical and Digital

This duality acknowledges that learners move in and out of digital and physical spaces as they learn and share in a TELC. They may create or engage with both digital and physical artefacts as part of their learning. This process adds authenticity to the learning as it crosses the physical boundaries of time and space. New knowledge is applied to real situations and these are articulated, often through multimodal posts, which in turn stimulate more dialogue. Learning takes place in both digital and physical habitats.

An example from the works that illustrates these first three dualities is a visual post on the theme of virtual sculptures in the Technology Outdoors MOOC (work 11). A participant responds to the original MOOC content by applying the idea of virtual sculptures to her own

context. Rather than using green screening to post a physical object in a digital image as in the original, she experiments with layering acetate images between glass.

Figure 6.10: A post illustrating an interplay of digital and physical activity

This is an example of the interplay of digital and physical as a printed digital image is sandwiched between glass in the outdoor environment and then used to make further layered digital images to post in the community. The community discussion around the image focuses initially on photo layering tools and techniques, extending participants' understanding beyond the original MOOC content in a connectivist way:

> *'We tend to use paint.net but I prefer Pixelmator on the Mac or even Sketchbook on iPads'*
> *'Gimp is a great open source alternative to Photoshop'.*

Inspired by the posted images, the participants consider how the technique might be applied to different contexts to inspire children's creativity. One idea is to add an unexpected element to the image:

> *'I'm curious whether it would be a good contrast to use appropriate combinations vs peculiar ones. So, this amazing skier vs a very different addition e.g. a skiing ballerina. Something graceful but in another context.'*

This idea is developed further by another participant wondering about the impact of adding unusual images into a familiar environment such as the school playground,

> *'I...am wondering how it would work with a less stunning landscape... different windows into the play that goes on in the playground...creating the peculiar...add a spark to a more basic background'.*

The discussion touches upon an intercultural aspect by considering how the idea might translate to a more mundane environment in a different country. Subsequent posts take forwards the theme of layered images initiated by this post through further talking and making. Peer-to-peer learning thus occurs naturally, arising out of social behaviour as the participants are inspired by the idea of creating different views of the world by creatively manipulating images.

This is in line with the work of Moore et al. (2018), who suggest that multimodal learning, 'allows increased scrutiny and retrospective analysis, as learners can represent, record and reflect on their own learning through visuals, dialogues and written texts' (Moore et al., 2018, p. 45).

6.3.4 Synchronous and Asynchronous

This duality recognises that there is likely to be a mix of types of social interaction within a community, and that a balance of both can help to build group knowledge as well as individual learning. Either type may be mediated by online tools. There may be various combinations of physical or virtual face-to-face interactions, or asynchronous exchanges may take place over varying periods of time. In terms of the knowledge building process, the synchronous interactions often play a more prominent role in moving the community forwards, however there may be fewer of them. Equally there may be key asynchronous posts that carry greater weight and thus assume a similar knowledge building role. An example from the works is the discussion of the combination of synchronous and asynchronous TeachMeet activities in section 5.3.1.

6.3.5 Personal and Collective

This duality recognises that ideas posted in the public sphere influence personal practice, and that this is an iterative and reciprocal process. Without this duality, most TELCs would wither and die. At its best, it comprises reflection and interaction, and enables learners to gain agency and voice as they share the results of their own learning and see others build upon it. It can prompt a process of rhizomatic learning as learners develop their own directions, taking other community members along the way, with increasing independence and collective understanding. The Teaching with Tablets MOOC community is discussed in relation to this duality in section 5.3.2. We can also see it at play in the practitioner research cycle discussed in 2.2.1.

6.3.6 Summary of the dualities

When these dualities are present, albeit in varying amounts, learners in the TELCs examined in the works typically access resources, reflect, comment, make and do, reflect, share and remake during the lifespan of the community. The collective multimodal interactions lead to the posting of an artefact, which is evaluated with criticality within a context and becomes the impetus for another cycle of making and doing. The technology is ubiquitous, enabling various levels of making, talking and doing within the community. The interactions may be synchronous or asynchronous. The process of interplay between the dualities is illustrated by sample commentary from the Technology Outdoors MOOC (work 5) below:

> *'We need to acknowledge different ways of making meaning through multi-modal artefacts.'*
> *'We used Sculpt+ on the iPads to create virtual sculptures. These are fully rotatable and are manipulated like digital clay. We then placed these in our 'real' environments within the app itself.'*
> *'The photographs they create can then be used to inspire their writing.'*
> *'Following my last reflection, where I raised a concern that the technology could stop children interacting meaningfully with their environments, I believe this addresses it very well indeed'*
> *'That is spectacular. I think we may well work in something similar with forest school next term. Great snow too.'*
> *'I love this idea and will definitely be using it in the future, your example is an inspiration.'*

Ultimately, it is the personal journeys fuelled by the collective expertise within an online community that result in transfer to practice, a measure of success in the TELCs associated with the works.

To conclude, the combination of the TELC forms and dualities outlined above offers two lenses, distant and close, that contribute towards an understanding of the epistemology of social online learning communities within the context of my public works. Together they offer descriptive and diagnostic tools for analysing the nature of learning, knowing and knowledge-building within TELCs, demonstrating how some key variables are interrelated.

These tools may be useful in the design or evaluation of social online learning. They may help to describe conditions for successful learning by illuminating ways in which collective and individual understandings emerge from a variety of stimuli. They could be used to chart the journeys within TELCs that lead to impact on beliefs and practice. By developing a better understanding of the conditions for successful knowledge-building in TELCs, we can choose technology tools and design courses that suit our learners' needs. And by building metacognitive awareness of the role of social online learning processes, we can increase participants' reflexivity and give them greater control over their own learning. After a learning event has taken place, we can analyse the impact of the structure of the learning community and the types of the types of activities it supported, and consider ways they might be improved.

6.4 Recommendations

6.4.1 Recommendations for practice

Taking the forms and dualities into account, I recommend that learning designers:

- evaluate the affordances of the tools they use for social online spaces, considering the degree of multimodality and the option for threaded discussions.

- tune in to the nature of the interactions of the learners in online communities and encourage their learners to recognise the interrelationship between behaviours within

them, such as responding to others in ways that encourage them to become reflexive and confident within the learning environment.

- recognise the differences in the nature of social online interaction and face-to-face social interaction, including factors such as synchronicity and asynchronicity, digital and physical making, and personal and collective learning.

- develop an understanding of the relationship between digital and physical habitats within a learning event, so that technology is embedded in an authentic and purposeful way and learners can move between the two with ease.

- encourage learners to value peer interaction and appreciation in an online environment and recognise that online collaboration enriches learning.

- work with moderators to use online spaces to help people to move forwards by using posted digital artefacts as a basis for rethinking, redefining and recalibrating their ideas.

- recognise that knowledge-building can take different forms and use an understanding of these to select effective combinations of tools and design spaces with learning needs in mind.

- evaluate online learning communities by considering factors such as longevity, size, teacher presence, content, tone of commentary, role of moderators and the nature of the interactions.

6.4.2 Recommendations for research

It is anticipated that the community forms and dualities described above can act as a springboard for further research towards developing a framework of knowledge-building within technology-enabled learning communities. For example, an even closer lens might be achieved using a social network map analysis of the interactions within a community. Smith et al. from the Pew Research Centre (2014) found six distinct types of conversation on

Twitter based on the structure of people's networks, the content and the nature of the interaction by matching network maps with topics discussed.

Lave and Wenger (1991) proposed that observation from the boundary, 'lurking' or more formally, legitimate peripheral participation is a valid form of participation in the online learning community. The impact of this form of participation merits further exploration.

The hybrid MOOCs described in the public works do not provide for authentic assessment of learning within the tasks apart from self and peer assessment and encouragement by moderators. This would also be a research avenue worth investigating.

Related social learning themes that might be explored include peer support and encouragement within TELCs; the impact of different levels of involvement; reflection on transfer to practice; documenting the process of building, growing and developing communities of practice over their lifetimes; further analysis of how online conversations develop understanding; and further elucidation of the process of collective knowledge-building in online environments.

6.5 Personal reflection on the DProf process

The DProf by Public Works will go down as one of my life's great expeditions. My challenge was to retrace trodden paths, unravel the many strands of my professional experience, and then to rethink and realign. I dissected the assemblages of artefacts, people, dialogues and technologies that make up my working life, tested the connections between them, and sought pattern and coherence. In doing so, I was mindful of my position as a reflective practitioner, somewhere between inside and outside, oscillating between theory and practice, and beginning to think about ways in which practice might lead to theory (Kahuna, 2002).

The threads are various: computing, digital literacy, online learning, international projects, assistive technology; as are the works themselves: articles, books, websites, communities and MOOCs. Although technology is present across these, I am aware that, at its best, it is an invisible conduit that enables us to make, store, and access meanings in new ways, to reconceive the content and the relationships that bring teaching and learning alive. Most of the works have in fact been springboards for the pervasive theme of learning communities.

My real inspiration is the groups of people I have been privileged to join, their enthusiasm for learning with technology and their creativity that so often takes us somewhere new. I marvel at the way communities take on a life of their own as participants become prosumers, creating and sharing knowledge, and I am proud to set their pendulums in motion.

Over the course of this year, I gained insight into the rich multi-layered forms and functionings of these communities, and into the complexity of relationships between people and technologies within them. I am excited to investigate ways social learning informs the evolution of innovative pedagogies. I have also acquired a better understanding of what it means to be embedded within the research process, and of the power of intimacy and subjectivity in enabling me to tune into participant voices and the counterpoint of their stories.

For me, the DProf journey has been a creative experience, which resulted in outcomes to build upon in the field of social constructivist learning. It redefined my relationship to the field and led to reflexivity within the culture of TELCs. In many ways, I have been a virtual ethnographer working at a distance from my participants. This positioned me at an intersection of person, practice, research and theory. From this nexus I have analysed my own experience in relation to theory, methods and literature and this shed light on the intertextuality of my works. Through an iterative process of selection, observation, vignettes, reflection and analysis of notes and artefacts, I identified emergent themes, discerned patterns and arrived at some tentative conclusions about the topology and typology of TELCs that merit further testing. This fulfilled the overarching reflective theme of how the public works illuminate ways in which technology can facilitate high quality social learning in online and blended environments. The reflection also addressed reflective themes relating to computing, digital literacy, and pedagogy and practice in social learning supported by technology.

The process of writing the context statement gave me time and space to create rich descriptions and through them to tease out conclusions about how they worked as vehicles for collective knowledge building. I was keen to develop ways of understanding the process by which practitioners engaged with the communities and under what conditions they were prompted to change their beliefs and/or practices, taking this as a measure of impact.

There was a sense of the unknown in that I needed to develop the confidence to trust my own convictions within what was for me a new field of research. Tensions arose in sampling the works to tell a coherent story and yet demonstrate impact; in creating a simple tool to describe a complex phenomenon; and in not knowing what the end result might be within a field of fast paced change. The methodology was untidy in that it shifted during the process of analysis and writing, and researcher bias was both a strength and a weakness. In the event, it was within an unfamiliar environment across the other side of the world that the forms and dualities in Chapter 6 took shape through multiple instances of drawing and thinking whilst supporting students on a summer school placement. This experience suggests that there is value in stepping outside of the box and combining familiar and unfamiliar physical and digital habitats. Overall, the experience of reviewing the works and writing the context statement has been a transformational process which has resulted in new understandings.

I take away a desire to put my new knowledge directly to use. My next steps will be to refine the analytical tools and test their applications to ensure that they have a positive impact on my own practice and relevance to others. I aim to continue to harness the social and connective affordances of technologies, and use them to enhance the way we teach and learn.

My contribution is a characterisation of the landscape of technology enhanced learning, involving the typology and topology of TELCS, towards an epistemic understanding of what knowledge and knowing look like within them from personal and collective viewpoints, and how this leads to transfer to practice. The outcomes include the mapping of TELC topologies and typologies outlining key forms and features of the technology enabled learning landscape in online and blended environments. In this way, the context statement makes a contribution to the debate around contemporary theories of learning in our digital age.

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Zheng, J., Veinott, E., Bos, N., Olson, J.S. and Olson, G.M., 2002, April. Trust without touch: jumpstarting long-distance trust with initial social activities. In *Proceedings of the SIGCHI conference on human factors in computing systems*, Minneapolis, USA, 20-25 April 2002, pp. 141-146. ACM. Available at: < https://dl.acm.org/citation.cfm?id=503402&dl=ACM&coll=DL > [Accessed December 2018].

Appendices

Appendix A

The selected works by chapters

Online link to this appendix: http://bit.ly/HCAppendix1

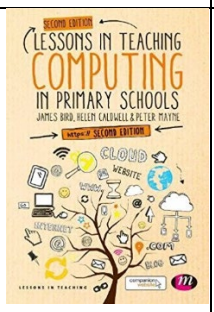
Chapter 2: Defining the reflective themes explored in the Context Statement

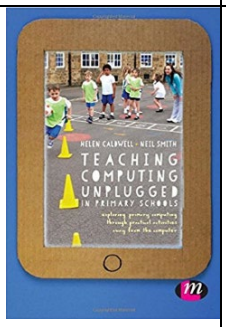
Work	Reference/Source	Description
1. DLaB website, Technology Outdoors and STEM to STEAM MOOCs and online community.	http://dlaberasmus.eu/ http://dlaberasmus.eu/courses/technology-outdoors-online-course/ http://dlaberasmus.eu/courses/stem-steam-online-course/ https://plus.google.com/u/0/communities/117458443566280105364	Digital Learning across Boundaries Erasmus+ project, comprising a website, two MOOCs and an online community. The MOOCs provide subject knowledge guidance and facilitate teachers taking ownership of what recent changes in the field mean in their own work through creating conditions for social learning and collective knowledge building.
2. Peer reviewed journal article: The interdisciplinary use of blogs and online communities in higher education	Caldwell, H. and Heaton, R. (2016). The interdisciplinary use of blogs and online communities in higher education. In: *The International Journal of Information and Learning Technology (IJILT)* 33(3) p2056-4880. https://www.emeraldinsight.com/doi/abs/10.1108/IJILT-01-2016-0006	A peer reviewed journal article on the strengths and limitations of using blogs and communities in teacher education.
3. MESH guide: Technology Enhanced Learning Communities	http://www.meshguides.org/guides/node/880	A peer-reviewed research digest published by the Education Futures Collaboration on the topic of Technology Enhanced Learning Communities. MESH stands for Mapping Educational Specialist KnowHow and the guides are designed to support teaching as an evidence-informed profession by providing research summaries to underpin educators' professional judgement. The MESH initiative comprises a community of educators from 178 countries.

Chapter 3: Developing a pedagogy of computing through technology and social learning

Reflective theme 1:

How the public works have enhanced social learning approaches in computing via technology-enabled learning communities (TELCs).

Work	Reference/Source	Description
1. Conference paper: Master Teachers in Computing: What have we achieved?	Smith, N., Allsop, Y., Caldwell, H., Hill, D., Dimitriadi, Y. and Csizmadia, A.P., 2015, November. Master Teachers in Computing: What have we achieved? In *Proceedings of the Workshop in Primary and Secondary Computing Education* (pp. 21-24). ACM. https://dl.acm.org/citation.cfm?id=2818332	A review of the master teacher training programme undertaken in 2015 run by the association Computing at School (CAS), in which I was a lead facilitator.
2. Online community of master teachers	https://plus.google.com/communities/116334100443162688989	A community of Master teachers attending the training programme.
3. Conference paper: Ubiquitous computing devices in the training of teacher-trainers	Smith, N. and Caldwell, H. (2015) Ubiquitous computing devices in the training of teacher-trainers. In: Morris, L., and Tsolakidis, C (eds), *The International Conference on Information Communication Technologies in Education (ICICTE 2015) Proceedings,* Southampton Solent University, pp. 42-51. http://oro.open.ac.uk/43810/	A peer-reviewed outline of techniques used in the master teacher teaching training programme, describing physical computing projects that were used in preparing teachers to deliver improved classroom lessons and tailored CPD for their peers.
4. Book: Lessons in teaching computing in primary schools	Bird, J., Caldwell, H. and Mayne, P. (1st ed. 2014, revised 2nd ed. 2017). *Lessons in Teaching Computing in Primary Schools*. London: Sage. https://uk.sagepub.com/en-gb/eur/author/helen-caldwell 	One of the first books on primary computing at the time of curriculum change. The second edition of the edited book provides an opportunity to reflect upon national and international initiatives and technological developments, to develop computing in a creative way within the primary curriculum.
5. Let's Teach Computing MOOC and community based on the Lessons in teaching computing book.	MOOC: https://openeducation.blackboard.com/mooc-catalog/courseDetails/view?course_id=_400_1 Course book: https://uk.sagepub.com/en-gb/eur/author/helen-caldwell Google+ Community: https://plus.google.com/communities/112335386477156503633	An international MOOC funded by the Department of Education and based on the book, 'Lessons in Teaching Computing in Primary Schools' and designed to develop a community of practice around the teaching of computing in primary schools.
6. Online community from the PG Cert	https://plus.google.com/u/0/communities/103318414174390823641	A comparison community of more experienced primary computing teachers.

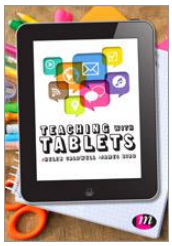
Primary Computing course		
7. Book: Teaching Computing Unplugged: Exploring primary computing through practical activities away from the computer	Caldwell, H. and Smith, N (2016). *Teaching Computing Unplugged: Exploring primary computing through practical activities away from the computer.* London: Sage. https://uk.sagepub.com/en-gb/eur/author/helen-caldwell 	This edited book looks at how the fundamental principles and concepts of computer science can be taught without any hardware as children analyse problems and computational terms and apply computational thinking to solve problems without turning on a computer.
8. Book chapter: Planning computing in the national curriculum	Caldwell, H. and Grantham, S. (2015). Planning Computing in the National Curriculum. In: Sewell, K and Fairley, H. *Planning the Primary National Curriculum*. London: Sage. https://uk.sagepub.com/en-gb/eur/planning-the-primary-national-curriculum/book244230	This book chapter considers factors that are specific to planning effective computing lessons. It looks at how teachers can provide the conditions to enable children to take on personally relevant and real world computing challenges, which then allow them to apply computational thinking concepts and become productive makers using technology.
9. Digital Leaders across Boundaries blog	Blog https://mypad.northampton.ac.uk/digitalleaders/ Digital Playdate https://mypad.northampton.ac.uk/digitalleaders/2016/06/11/digital-playdate-for-the-symposion-network-of-european-schools-of-education/	Pilot for the Digital Learning across Boundaries project outlined in Chapter 5.
10. MESH guide: Technology Enhanced Learning Communities	http://www.meshguides.org/guides/node/880	A peer-reviewed MESH Guide published by the Education Futures Collaboration on the topic of Technology Enhanced Learning Communities. MESH stands for Mapping Educational Specialist KnowHow and the guides are designed to support teaching as an evidence-informed profession by providing research summaries to underpin educators' professional judgement.

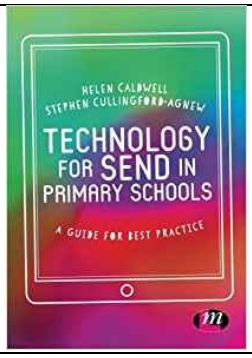
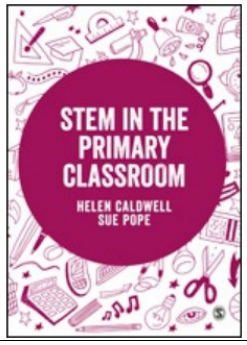
Chapter 4: TELCs enhancing pedagogy in digital literacy

Reflective theme 2:

How the public works have enhanced social learning approaches in digital literacy via technology-enabled learning communities (TELCs).

Work	**Reference/Source**	**Description**
1. Book chapter: Computing and Digital Literacy	Caldwell, H and Honeyford, G. (2013). Computing and Digital Literacy. In: Dawes, L and Smith,	This book chapter works towards a definition of digital literacy that involves rethinking what teaching and learning looks like in contemporary classrooms.

	P., *Subject Teaching in Primary Education*. London: Sage. https://www.amazon.co.uk/Subject-Teaching-Primary-Education-Patrick/dp/144626789X	
2. Digital Learning across Boundaries project (DLaB): Website, Technology Outdoors and STEM to STEAM MOOCs and online community:	Website http://dlaberasmus.eu Community https://plus.google.com/u/0/communities/117458443566280105364 Online course http://dlaberasmus.eu/courses/technology-outdoors-online-course/	An Erasmus+ European partnership project promoting digital learning across the boundaries of physical spaces, across curriculum subjects and across languages and cultures. Three of the project intellectual outputs of the 3 year Erasmus+ DLaB project are yearly MOOCs and online communities on the themes of Technology Outdoors, STEM to STEAM and CLiL (Content and Language Integrated Learning).
3. Book: Teaching with Tablets  	Caldwell, H. and Bird, J. (2015). *Teaching with Tablets*. London: Sage. https://uk.sagepub.com/en-gb/eur/author/helen-caldwell	This edited book looks at the teaching and learning benefits offered by mobile devices such as their portability, connectivity, accessibility and range of media, and how these present new challenges and opportunities for teaching and learning.
4. MOOC and online communities: Teaching with Tablets and Apps for Innovation	Online course https://openeducation.blackboard.com/mooc-catalog/courseDetails/view?course_id=_806_1 Teaching with Tablets Community https://plus.google.com/u/0/communities/108510780639510097712 Apps for Innovation community: https://plus.google.com/u/0/communities/110218249780833007111	The teaching with Tablets MOOC is an interactive and participatory online course on how to make effective use of iPads and tablets for teaching and learning based on the book. It offers participants the chance to share and reflect upon co-created resources with the online community of fellow practitioners. The Apps for Innovation community is a group of lecturers in Initial Teacher Training piloting the use of iPads for teaching and learning at the University of Northampton.
5. Journal article: Mobile technologies as a catalyst for pedagogic innovation within teacher education	Caldwell, H. (2017). Mobile technologies as a catalyst for pedagogic innovation within teacher education. *The International Journal of Mobile and Blended Learning* (IJMBL), 10(2). https://www.igi-global.com/article/mobile-technologies-as-a-catalyst-for-pedagogic-innovation-within-teacher-education/201894	This peer-reviewed paper explores the use of mobile technologies within teacher education at the University of Northampton. Experiences from mobile technology projects involving ITT students, primary teachers and academics are shared to illustrate how mobile technologies have been a catalyst for new approaches to teaching and learning based on a social constructivist model of learning in our teacher education programmes.
6. Book: Technology for SEND in Primary Schools and associated student communities studying an assistive technology module.	Caldwell H. and Cullingford-Agnew, S. (2017). *Technology for SEND in Primary Schools: A good practice guide.* London: Sage. https://uk.sagepub.com/en-gb/eur/author/helen-caldwell https://plus.google.com/u/0/communities/106740593214746976225 https://plus.google.com/u/0/communities/108570514394376300693	An edited book exploring the theme of assistive technology in primary schools.

	https://plus.google.com/u/0/communities/111901416660428070164	
7. MESH guide: Technology Enhanced Learning Communities	http://www.meshguides.org/guides/node/880	A peer-reviewed MESH Guide published by the Education Futures Collaboration on the topic of Technology Enhanced Learning Communities. MESH stands for Mapping Educational Specialist KnowHow and the guides are designed to support teaching as an evidence-informed profession by providing research summaries to underpin educators' professional judgement.
8. Peer reviewed journal article: The interdisciplinary use of blogs and online communities in higher education	Caldwell, H. and Heaton, R. (2016). The interdisciplinary use of blogs and online communities in higher education. In: *The International Journal of Information and Learning Technology (IJILT)* 33(3) p2056-4880. https://www.emeraldinsight.com/doi/abs/10.1108/IJILT-01-2016-0006	A journal article on the strengths and limitations of using blogs and communities in teacher education. It provides a critical overview of the use of blogs and online communities to enhance interdisciplinary subject teaching, staff development and student engagement. Through a series of case studies, it puts forward the strengths and limitations of the practices adopted and demonstrates how learning can occur through the promotion of participant voice, the creation of communities of practice and reflexivity.
9. Book: STEM in the Primary Classroom	Caldwell, H and Pope, S. (2019). *STEM in the Primary Classroom.* London: Sage. https://uk.sagepub.com/en-gb/eur/stem-in-the-primary-curriculum/book265180	An edited book on the theme of STEM education. 

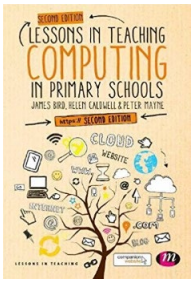
Chapter 5: TELCs influencing practice: the design and delivery of MOOCs

Reflective theme 3:

How an analysis of pedagogy and practice within TELCs can shed light on the processes of social learning.

Work	Reference/Source	Description
1.Peer-reviewed journal article:	Smith, N., Caldwell, H., Richards, M., and Bandara, A., 2017. A comparison of MOOC development	This work compares two ways of designing and delivering MOOCs.

A comparison of MOOC development and delivery approaches	and delivery approaches. *The International Journal of Information and Learning Technology*, *34*(2), pp.152-164. http://oro.open.ac.uk/49137/	
2. Peer-reviewed conference paper: The online learning hive: transfer to practice within a MOOC community of educators	Caldwell, H. and Smith, N. (2017). The online learning hive: transfer to practice within a MOOC community of educators. In: *The International Conference on Information Communication Technologies in Education (ICICTE 2017) Proceedings, Southampton Solent University.* http://nectar.northampton.ac.uk/10175/	This paper examines the nature of the interactions within a community of practice associated with the online hybrid MOOC, 'Teaching with Tablets' to see whether the learning environment facilitates a more effective transfer of skills to practice. The analysis indicates that MOOC participants moved towards peer-to-peer interactions, wherein they shared expertise and suggestions, showing clear indications of socially constructed knowledge processes.
3. Book chapter and online community: The use of technology to build digital communities	Bugby, M. and Caldwell, H. (2018) The use of technology to build digital communities. In: Sykes, G and Teszenyi E. *Young Children and their Communities: Understanding Collective Social Responsibility.* Routledge. https://www.routledge.com/Young-Children-and-Their-Communities-Understanding-Collective-Social-Responsibility/Sykes-Teszenyi-Eunice/p/book/9781138558526 Associated community: https://plus.google.com/u/0/communities/111686472878126744345	This book chapter explores the potential for digital communities to support learning in the Early Years.
4. Book, MOOC and online community: Teaching with Tablets 	Caldwell, H. and Bird, J. (2015). *Teaching with Tablets*. London: Sage. https://us.sagepub.com/en-us/nam/author/helen-caldwell Online course https://openeducation.blackboard.com/mooc-catalog/courseDetails/view?course_id=_806_1 Online community https://plus.google.com/u/0/communities/108510780639510097712	MOOC and online community based on content from the Teaching with Tablets book.
5. DLaB website, Technology Outdoors and STEM to STEAM MOOCs and online community.	Website http://dlaberasmus.eu/ Online course http://dlaberasmus.eu/courses/technology-outdoors-online-course/ Online course http://dlaberasmus.eu/courses/stem-steam-online-course/ Online community https://plus.google.com/u/0/communities/117458443566280105364	Digital Learning across Boundaries project, comprising a website, two MOOCs and an online community.

6. Book, MOOC and online community: Let's Teach Computing 	Bird, J., Caldwell, H. and Mayne, P. (1st ed. 2014, revised 2nd ed. 2017). *Lessons in Teaching Computing in Primary Schools*. London: Sage. https://openeducation.blackboard.com/mooc-catalog/courseDetails/view?course_id=_400_1 Online community https://plus.google.com/u/0/communities/112335386477156503633	A MOOC and online community inspired by a book: Lessons in Teaching Computing 
7. MESH guide: Technology Enhanced Learning Communities	http://www.meshguides.org/guides/node/880	A peer-reviewed MESH Guide published by the Education Futures Collaboration on the topic of Technology Enhanced Learning Communities. MESH stands for Mapping Educational Specialist KnowHow and the guides are designed to support teaching as an evidence-informed profession by providing research summaries to underpin educators' professional judgement.
8. How do visual postings impact the evolution of pedagogical beliefs and practice in a MOOC online community?	Paper presented at the MiTE International conference on mobile technology in teacher education. http://www.gratek.ie/mite2018/	Co-authored research paper.
9. Innovation Fund Project blogs: Digital Leaders Apps for Innovation Northampton Inspire Book chapter: Blogging supporting digital literacy in schools and universities.	Digital leaders project blog https://mypad.northampton.ac.uk/digitalleaders/ Apps for Innovation project blog https://mypad.northampton.ac.uk/appsforinnovation Northampton Inspire project blog https://mypad.northampton.ac.uk/inspire/ Caldwell, H and Honeyford, G. (2012). Blogging supporting digital literacy in schools and universities. In: Burden, K., Leask, M., Younie, S. *Teaching and Learning with ICT in the Primary School*. London: Routledge.	Three one-year projects on digital themes funded by the University of Northampton Innovation Fund, each with a public project blog. This book chapter looks at using blogs to document learning from two perspectives, the personal and the collaborative, drawing examples from student teachers at Northampton University and from primary pupils in Northamptonshire schools. In both settings, the role of blogs in supporting the cycle of sharing, implementing and evaluating practice is explored and discussed so that teachers can replicate and build on the emerging themes.

Chapter 6: Towards an understanding of the epistemology of technology-enabled learning communities

Central reflective theme:

How the public works illuminate ways in which technology can facilitate high quality social learning in online and blended environments.

Work	Reference/Source	Description
1.STEM teaching community	Online community https://plus.google.com/communities/101219204832294214534/stream/46cb8a23-21f0-4a69-8a88-69448cf9d882	Online community associated with undergraduate STEM teaching sessions at the University of Northampton
2. Let's Teach Computing MOOC online community 	Online community https://plus.google.com/u/0/communities/112335386477156503633	An online community accompanying a MOOC.
3. Online community from the PG Cert Primary Computing course	Online community https://plus.google.com/u/0/communities/103318414174390823641	A comparison community of more experienced primary computing teachers.
4. ITTE subject association blog	Blog http://itte.org.uk/wp/	
5. DLaB website, Technology Outdoors and STEM to STEAM MOOCs and online community: 	Course http://dlaberasmus.eu/courses/technology-outdoors-online-course/ Course http://dlaberasmus.eu/courses/stem-steam-online-course/ Community https://plus.google.com/u/0/communities/117458443566280105364 Website http://dlaberasmus.eu/	
6. MOOC and online communities: Teaching with Tablets and Apps for Innovation	Online course https://openeducation.blackboard.com/mooc-catalog/courseDetails/view?course_id=_806_1 Teaching with Tablets community https://plus.google.com/u/0/communities/108510780639510097712 Apps for Innovation community https://plus.google.com/u/0/communities/110218249780833007111	MOOC and online community based on content from the Teaching with Tablets book. A group of lecturers in Initial Teacher Training piloting the use of iPads for teaching and learning at the University of Northampton.
7. Hong Kong Summer Camp community	Community https://mypad.northampton.ac.uk/hksc/	A group blog representing ideas and resources for student teachers on placement in Hong Kong
8. Online community of master teachers	Community https://plus.google.com/u/0/communities/116334100443162688989	Master teachers attending the training programme
9. Online community from the PG Cert Primary Computing course	Community https://plus.google.com/u/0/communities/103318414174390823641	A comparison community of more experienced primary computing teachers.
10. Let's Teach Computing MOOC and community based on the Lessons in teaching computing book.	Online course https://openeducation.blackboard.com/mooc-catalog/courseDetails/view?course_id=_400_1	An online course and community based on the book.

	Course book http://www.uk.sagepub.com/books/Book242640 Website http://letsteachcomputing.net/ Online community https://plus.googleapis.com/communities/112335386477156503633	
11. Digital Learning across Boundaries project (DLaB): Website, Technology Outdoors and STEM to STEAM MOOCs and online community:	Website http://dlaberasmus.eu Online community https://plus.google.com/u/0/communities/117458443566280105364 Online course http://dlaberasmus.eu/courses/technology-outdoors-online-course/	An Erasmus+ European partnership project promoting digital learning across the boundaries of physical spaces, across curriculum subjects and across languages and cultures.

Appendix B

Summary of the impact of key works on my professional life

A selection of key works	Associated works	Description of the works and their public impact	My role	Evidence of impact through dissemination	Influence on my professional life and development
Theme 1: Uniting theory and practice related to technology-enabled learning communities within teacher education.					
MESH guide: Technology Enhanced Learning Communities Caldwell, H and Cox, A. (2018). http://www.meshguides.org/guides/node/880		A peer-reviewed MESH Guide published by the Education Futures Collaboration on the topic of Technology Enhanced Learning Communities. MESH stands for Mapping Educational Specialist KnowHow and the guides are designed to support teaching as an evidence-informed profession by providing research summaries to underpin educators' professional judgement. The associated outputs are an international project website, MOOC and online community on the theme of technology outdoors. The design of these outputs is based on the evidence base from the MESH guide. They are chosen to illustrate the journey from theory to evidence-based practice.	Lead author and project lead	471 MOOC registrations from over 28 countries, 216 active members of the online community. Papers presented at *The ITTE Preparing 21st Century Educators Conference*, University of Hull, 21 June 2017 and London, 2016. Association for Information Technology in Teacher Education (ITTE) research fellow award.	The guide looks at how technology can facilitate high quality social learning in online and blended environments within teacher education. Drawing from relevant learning theory and research evidence, it suggests pedagogic strategies and frameworks for designing online learning spaces. Case study examples are presented to illustrate how the ideas can translate into practice. This work has deepened my understanding of blended and online learning as a social process involving digital making, reflection, and interaction. It has helped me to recognise the value of student-generated content within online communities of practice. It has led me to consider the interplay of participation and reification, as two complementary processes for learning in an online community of practice.
	Digital Learning across Boundaries (DLaB) project website: http://dlaberasmus.eu	A European partnership promoting digital learning across the boundaries of physical spaces, across curriculum subjects and across languages and cultures.			
	Digital Learning across Boundaries (DLaB) Massive Open Online Course (MOOC): http://dlaberasmus.eu/courses/technology-outdoors-online-course/ and online community: https://plus.google.com/u/0/communities/117458443566280105364	One of the project intellectual outputs of the 3 year Erasmus+ DLaB project is a yearly MOOC and online community on the themes of Technology Outdoors, STEM to STEAM and CLiL (Content and Language Integrated Learning).			
Theme 2: Developing online learning design principles within the field of mobile learning.					
Smith, N., Caldwell, H., Richards, M., and		The key work is a peer reviewed paper comparing two ways of designing and	Lead author	570 MOOC registrations and	This work led to the development of a hybrid

Bandara, A., 2017. A comparison of MOOC development and delivery approaches. *The International Journal of Information and Learning Technology*, *34*(2), pp.152-164. http://oro.open.ac.uk/49137/		delivering MOOCs. The approaches had very different profiles of pedagogic flexibility, cost, development processes, institutional support and participant numbers. This comparison shows that there are many viable designs for MOOCs. The associated outputs are a peer reviewed paper on mobile technologies, a peer reviewed paper on transfer to practice within a MOOC, a Teaching with Tablets book, a MOOC based on the book, and an online community aimed at developing practitioners' understanding of mobile learning.	and project lead	294 engaged in the online community. Papers and workshops presented at *The International Conference on Information Communication Technologies in Education, Greece, 2015, 2016 and 2017.* Papers presented at BETT *British Educational Technology and Teaching Conference Higher Education Forum*, London, 25 January 2017 and 2015. Paper presented at *The International Conference on Mobile Technology in Education (MiTE),* conference, Galway, Ireland 15-16 January. Poster presentations at the *Mobilising and Transforming Teacher Education Pedagogies (MTTEP)* conference. Karlsruhe, Germany, 1-2 October 2015. Apple Distinguished Educator award.	MOOC design based on a collaborative pedagogy. It resulted in a methodology for analysing the nature of roles and interactions within a MOOC to identify evidence of transfer to practice and demonstrate the effectiveness of the approach. This deepened my knowledge of how roles played out by participants and their nested connections impacts the nature of the learning and how is this linked with knowledge transfer within communities of practice. The MOOC led to the development and sharing of approaches to teaching with mobile technologies and an understanding of how knowledge acquired in the virtual world can be applied in the real world.
	Caldwell, H. (2017). Mobile technologies as a catalyst for pedagogic innovation within teacher education. *The International Journal of Mobile and Blended Learning* (IJMBL), 10(2). https://eric.ed.gov/?id=EJ1172409	This peer reviewed paper reviews the use of mobile technologies within teacher education at the University of Northampton. Experiences from mobile technology projects involving ITT students, primary teachers and academics are shared to illustrate how mobile technologies have been a catalyst for new approaches to teaching and learning based on a social constructivist model of learning in our teacher education programmes.			
	Caldwell, H. and Smith, N. (2017). The online learning hive: transfer to practice within a MOOC community of educators. *The International Conference on Information Communication Technologies in Education (ICICTE 2017) Proceedings,*	This peer reviewed paper examines the nature of the interactions within a community of practice associated with an online hybrid MOOC, 'Teaching with Tablets', to see whether the learning environment facilitates a more effective transfer of skills to practice. A social network analysis clearly indicates that MOOC participants quickly moved from interactions between instructor and participant to peer-to-peer interactions, where participants shared expertise and suggestions, showing clear indications of socially creating and sharing knowledge.			

	Southampton Solent, University. http://nectar.northampton.ac.uk/10175/	This finding is corroborated by the coding of the interactions and texts, which show clear examples of reflection on the MOOC content in discussions.			
	Caldwell, H. and Bird, J. (2015). *Teaching with Tablets*. London: Sage. https://uk.sagepub.com/en-gb/eur/teaching-with-tablets/book243836	This edited book looks at the benefits offered by mobile devices such as their portability, connectivity, accessibility and range of media, and how these present new challenges and opportunities for teaching and learning.			
	Teaching with Tablets MOOC https://openeducation.blackboard.com/mooc-catalog/courseDetails/view?course_id=_806_1 and online community: https://plus.google.com/u/0/communities/108510780639510097712	This is an interactive and participatory online course on how to make effective use of iPads and tablets for teaching and learning based on the above book, 'Teaching with Tablets'. It offers participants the chance to share and reflect upon co-created resources with the online community of fellow practitioners.			
Theme 3: Applying social learning theories to the teaching of the computing curriculum.					
Smith, N. and Caldwell, H. (2015) Ubiquitous computing devices in the training of teacher-trainers. In: Morris, L., and Tsolakidis, C (eds), *The International Conference on Information Communication Technologies in Education (ICICTE 2015) Proceedings,* Southampton Solent University, pp. 42-51. http://oro.open.ac.uk/43810/		The key work is a peer reviewed paper considering ways of introducing teachers to the field of computer science based on the Master Teacher programme run by the association Computing at School (CAS). This paper describes physical computing projects that were used in training a cohort of Master Teachers, preparing them to deliver both improved lessons in classrooms and to deliver CPD tailored for the requirements of their peers. The associated outputs are two edited books aimed at teachers of computing, a book chapter, a MOOC and an online community associated with the book, 'Lessons in Teaching Computing', as an example of MOOC design and resources. They provide an opportunity to analyse ways in which a social learning environment has given teachers the opportunity to develop common understandings of the national curriculum computing programmes of study. The MOOC provided subject knowledge guidance and facilitated teachers taking ownership of what recent changes in the field mean in their own work through creating conditions for social learning and collective knowledge building.	Lead author and project lead	Release of a second edition of the book 'Lessons in Teaching Computing'. 406 registrations for the MOOC. Computing Unplugged work presented at *The Guardian Teacher Network*, [online] Available at: http://bit.ly/2m0lP3e Workshop presented at *The Roehampton University Festival of Computing,* London, 17th June, 2016. Raspberry Pi Certified Educator award.	This work enabled me to develop strategies for teaching computing to trainee and in-service teachers based on social constructivist learning theories. I considered ways in which technology can be used to make a seamless connection between online and offline learning so that there is a strong connection with face to face learning. This increases student control over time, pace, place and learning path, blurring the boundaries between formal and informal learning. I thought about how to repurpose time and restructure delivery methods using technology in favour of collaborative, problem-based learning. This enhances student collaboration so that students look to each other for feedback rather than just their tutors and understand the value of belonging to a community of practice.
	Bird, J., Caldwell, H. and Mayne, P. (1st ed. 2014, revised 2nd ed. 2017). *Lessons in Teaching Computing in Primary Schools*. London: Sage.	The second edition of the edited book, 'Lessons in Teaching Computing in Primary Schools' provides an opportunity to reflect upon national and international initiatives and technological developments, to develop computing in a creative way within the primary curriculum.			

	https://uk.sagepub.com/en-gb/eur/lessons-in-teaching-computing-in-primary-schools/book250681				
	Caldwell, H. and Smith, N (2016). Teaching *Computing Unplugged: Exploring primary computing through practical activities away from the computer.* London: Sage. https://uk.sagepub.com/en-gb/eur/teaching-computing-unplugged-in-primary-schools/book250148	This edited book looks at how the fundamental principles and concepts of computer science can be taught without any hardware as children analyse problems and computational terms and apply computational thinking to solve problems without turning on a computer.			
	Let's Teach Computing MOOC https://openeducation.blackboard.com/mooc-catalog/courseDetails/view?course_id=_400_1 and online community: https://plus.google.com/u/0/communities/112335386477156503633	An international MOOC funded by the Department of Education and based on the book, 'Lessons in Teaching Computing in Primary Schools' and designed to develop a community of practice around the teaching of computing in primary schools.			
	Caldwell, H. and Grantham, S. (2015). Planning Computing in the National Curriculum. In: Sewell, K and Fairley, H. *Planning the Primary National Curriculum*. London: Sage. https://uk.sagepub.com/en-gb/eur/planning-the-primary-national-curriculum/book244230	This book chapter is a consideration of the key factors which are specific to planning effective computing lessons. It looks at how teachers can provide the conditions to enable children to take on personally relevant and real world computing challenges, which then allow them to apply computational thinking concepts and become productive makers using technology.			
Theme 4: Developing social learning within teacher education.					
Caldwell, H. and Heaton, R. (2016). The interdisciplinary use of blogs and online communities in higher education. *The International Journal of Information and Learning Technology (IJILT)* 33(3) p2056-4880. http://www.emeraldinsight.com/doi/abs/10.1108/IJILT-01-2016-0006		The key work is a peer reviewed article on the strengths and limitations of using blogs and communities in teacher education. It provides a critical overview of the approaches taken in the education division at the University of Northampton using blogs and online communities to enhance interdisciplinary subject teaching, staff development and student engagement. Through a series of case studies, it puts forward the strengths and limitations of the practices adopted and demonstrates how learning can occur through the promotion of participant voice, the creation of communities of practice and reflexivity. The associated outputs are two book chapters and a short article on the theme of developing digital literacy in the context of teacher education.	Lead author and project lead	Keynote presentations at *The ICT for Education Conference*, Newbury, November 2016. http://www.ictforeducation.co.uk/conference/45/?mode=schedule and at *The Annual Special Educational Needs and Disability conference.* University of Chichester, May 2017. Paper presented at *The Athens Institute for Education and*	This work helped to develop a methodology for analysing media-rich multimodal content to determine how social learning tools such as blogs and communities can enhance interdisciplinary subject teaching in teacher education. It gave me an understanding the contribution of visual media to online communities and of the balance between artefact creation as a catalyst for individual understanding and artefact sharing as a springboard for more learning.

				Research 18th Annual International Conference on Education. Athens, Greece, 16-19 May.	I thought about how to use online tools such as communities, blogs, forums and collaborative documents to create an online classroom where interactions occur, facilitating self-directed learning.
	Caldwell, H and Honeyford, G. (2012). Blogging supporting digital literacy in schools and universities. In: Burden, K., Leask, M., Younie, S. *Teaching and Learning with ICT in the Primary School*. London: Routledge. https://www.amazon.co.uk/Teaching-Learning-ICT-Primary-School/dp/1138783153	This book chapter looks at using blogs to document learning from two perspectives, the personal and the collaborative, drawing examples from student teachers at Northampton University and from primary pupils in Northamptonshire schools. In both settings, the role of blogs in supporting the cycle of sharing, implementing and evaluating practice is explored and discussed so that teachers can replicate and build on the emerging themes.			
	Caldwell, H and Honeyford, G. (2013). Computing and Digital Literacy. In: Dawes, L and Smith, P., *Teaching Primary Subjects*. London: Sage. https://www.amazon.co.uk/d/Books/Subject-Teaching-Primary-Education-Patrick-Smith/144626789X	This book chapter works towards a definition of digital literacy that involves rethinking what teaching and learning look like in contemporary classrooms.			

Appendix C

Conference presentations based on the selected works

Chapter 2. Defining the reflective themes explored in the Context Statement

Caldwell, H. and Cox, A. (2017) *Technology-enabled learning communities: How technology can facilitate high quality social learning in online and blended environments within teacher education.* Paper presented to the Preparing 21st Century Educators Conference, University of Hull, 21 June.

Chapter 3. Developing a pedagogy of computing through technology and social learning

Caldwell, H. and Smith, N. (2016). KS1/KS2 *Computing Unplugged!* Workshop presented to the Roehampton University Festival of Computing. London, 17 June.

Caldwell, H. (2016). *Teaching maths and computing through hands-on practical activities.* Workshop presented to the MaST Conference. Peterborough, 9 June.

Caldwell, H. and Smith, N. (2016). *Teaching Computing Unplugged: Examples and Practice.* Workshop presented to the International Conference on Information Communication Technologies in Education. Rhodes, Greece, 7-9 July.

Chapter 4. Developing a pedagogy of digital literacy through technology and social learning

Caldwell, H; Heaton, R. and Whewell, E. (2018) *How does mobile technology facilitate teachers to learn outdoors?* Paper presented to the International Conference on Mobile Technology in Teacher Education (MiTE). Galway, 19 January.

Caldwell, H. (2018) *Technology transforming learning.* Presentation to Versailles Institute of Education delegates at BETT. London, 25 January.

Caldwell, H. (2017) *Technologies to support inclusion.* Keynote presentation at the Annual Special Educational Needs and Disability conference. University of Chichester, May 2017.

Caldwell, H. (2017) *Technology to understand and change the world.* Presentation to the Reading Primary Headteachers Association Conference. Dorset, 13 October.

Caldwell, H. (2016). *Perspectives on ICT for Education.* Keynote presentation at the ICT for Education Conference, Newbury, November 2016. http://www.ictforeducation.co.uk/conference/45/?mode=schedule

Caldwell, H. and Green, B. (2016). *Technology as a catalyst for pedagogic innovation at the University of Northampton*. Workshop presented to the Symposion Network of European Schools of Education Annual Conference. University of Northampton, 7 June.

Caldwell, H., Hartley, E. and Whewell, E. (2016). *Digital Leaders across Boundaries*. Paper presented to the Northampton Learning and Teaching Conference, University of Northampton 17 May.

Caldwell, H. (2016). *Supporting students with literacy difficulties using digital technology*. Presentation to the PATOSS Northampton Branch. University of Northampton, 18 April.

Caldwell, H. (2015). *Stem to SteAm* and *Technology Outdoors*. Poster presentations at the Mobilising and Transforming Teacher Education Pedagogies (MTTEP) conference. Karlsruhe, Germany, 1-2 October.

Caldwell, H., Edwards, J, Cox, A, Cousens, D, Scott, H. (2015) *Apps for Innovation*. Paper presented to the Learning and Teaching conference, University of Northampton and at the Opps for Apps Symposium, University of Northampton 17 June.

Caldwell, H., Bracey, P, Whewell, E and Heaton, R. (2015) *Enhancing cross-curricular Primary ITT teaching in an outdoor context though the use of group blogs*. Paper presented to 6th TEAN Conference Presentation Aston, Birmingham 13 May.

Caldwell, H. and Cullingford-Agnew, S. (2016). *Immersive multisensory environments supporting innovative pedagogies for SENDs in primary education.* Paper presented to the Athens Institute for Education and Research 18th Annual International Conference on Education. Athens, Greece, 16-19 May.

Caldwell, H. (2017) *Technology for inclusive creative arts.* Workshop at the Annual Special Educational Needs and Disability conference. University of Chichester, May 2017.

Caldwell, H. Smith, N., and Whewell, E. (2016). *Digital Leaders across Boundaries.* Workshop presented to the International Conference on Information Communication Technologies in Education. Rhodes, Greece, 7-9 July.

Chapter 5. TELCs enhancing practice: the design and delivery of MOOCs

Caldwell, H. and Edwards, J. (2018) *Digital Learning across Boundaries*. Workshop presented to the Council for Learning Outside the Classroom (CLOtC) Annual Conference. Black Country Living Museum, 22 November.

Caldwell, H. and Cox, A. (2017) *Technology-enabled learning communities: How technology can facilitate high quality social learning in online and blended environments within teacher education.* Paper presented to the Preparing 21st Century Educators Conference, University of Hull, 21 June.

Caldwell, H. and Smith, N. (2017). *The Online Learning Hive: Transfer to practice within a MOOC community of educators.* Paper presented to the International Conference on Information Communication Technologies in Education. Rhodes, Greece, 6-9 July.

Caldwell, H. and Frydenberg, M. E. (2017). *BYOD: Bring your own device and the seamless transition from informal to formal learning using mobile technology.* Presented at BETT *British Educational Technology and Teaching Conference Higher Education Forum*, London, 25 January.

Edwards, J., and Caldwell, H. (2016) *Exploring the use of digital technology in assessment with students in higher education: assignment design and assignment guidance*. Paper presented to the ITTE 30th International Annual Conference. London, 2 July.

Caldwell, H. and Edwards, J. (2016). *Teaching and learning beyond the institution: building an international community of practice on the theme of teaching with tablets*. Paper presented to the ITTE 30th International Annual Conference. London, 2 July.

Caldwell, H. (2016). *Mobile technologies as a catalyst for pedagogic innovation within learning communities in teacher education*. Paper presented to The International Conference on Mobile Technology in Education (MiTE), conference, Galway, Ireland 15-16 January.

Smith, N., Caldwell, H. and Richards, M. (2016). *A comparison of MOOC Development and Delivery Approaches.* Paper presented to the International Conference on Information Communication Technologies in Education. Rhodes, Greece, 7-9 July.

Caldwell, H., Green, B., Edwards, J., and Atkinson, J. (2016). *Running a-MOC*. Paper presented to the Northampton Learning and Teaching Conference, University of Northampton 17 May.

Caldwell, H., and Heaton. R. (2014) *Stem to SteAm*: workshop presentation at the International Conference on Information Communication Technologies in Education (ICICTE) Kos, Greece, 3-5 July.