The Whole World In Their Hands:

An investigation of the influence of mobile technologies on learner engagement of primary school children in outdoor settings

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Thesis submitted for the degree of

Doctor of Philosophy

Department of Educational Research

Lancaster University

June 2018

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This thesis results entirely from my own work and has not been offered previously for any other degree or diploma.

Signature ....

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Abstract

This thesis discusses a qualitative investigation into the impact of mobile learning interventions designed to promote learner engagement in primary-aged children working on science topics in outdoor settings, for three cohorts of pupils at a north-of-England primary school.

Adopting a design-based methodological approach and underpinned by a pragmatist epistemological position, the research responds to calls to address *nature deficit disorder* (Louv, 2009), drawing on a theoretical framework which combines contemporary learning theories including place-based learning (Zimmerman & Land, 2014), contextualised learning (Rikala & Kankaanranta , 2014), kinaesthetic learning (Pruet et al., 2016), constructionist learning (Papert, 1980; Zimmerman & Land, 2014), experiential learning (Lai, Yang, Chen, Ho & Chan, 2007), child-centred learning (Dewey, 1938) and cross-contextual learning (Nouri, Cerratto-Pargman, Rossitto & Ramberg, 2014), with theorisations around learner engagement (Fredricks, Blumenfeld & Paris, 2004), flow theory (Csikszentmihalyi, 1997), and Digital Capital (Park, 2017).

Drawing together two research activity streams, a series of mobile learning interventions designed for use in outdoor settings were developed, evaluated and refined over the course of eight research cycles. The *discovery-based learning* activity stream aimed to encourage learners to explore particular themes within an outdoor setting, while the *production-focused learning* stream saw learners generate video-clips and eBooks in response to a directed activity.

Employing qualitative methods, data were collected from a variety of sources, including video-recorded observations, semi-structured interviews with teachers, focus groups with children and learner-generated digital artefacts, while analysis was conducted using thematic analysis and direct interpretation within a grounded theory approach (Glaser & Strauss, 1967).

The thesis concludes that appropriately-designed mobile learning interventions in outdoor settings can promote emotional, behavioural and cognitive engagement, leading to an immersive state of flow, and can act as a bridge between technology and the natural environment, while simultaneously addressing the digital disconnect between teachers and technology.

Contents

Acknowledgements

I would like to thank my supervisor Professor Don Passey for his words of wisdom, his unerring eye for accuracy, and his invaluable feedback, often provided out-of-hours, at weekends and while on overseas trips.

I would also like to express my deep appreciation to the participant-teachers at ‘Uplands School’ for taking the time to work with me despite all their other commitments, and to the children, whose infectious enthusiasm made this research so rewarding.

To my father and stepmother, Geoffrey and Susanne Bowder, I would like to thank you for your support and unwavering faith in me, and for encouraging me to see the beauty in nature from a very young age. Dad, I know the opportunity to complete your own doctoral work was snatched away due to family pressures - I dedicate this thesis to you.

To my husband James - having written so many words, finding the few that truly crystallise all you have done to help me reach this stage is not easy. Your constant support, your encouragement, your patience and your staunch belief in me all played a part, and I do not underestimate the pressures you lifted from me by taking on the family responsibilities. Thank you for keeping me focused and sane – I greatly look forward to spending some quality time together again.

Last and most definitely not least, I would like to express my heartfelt gratitude to my children, Jonathan and Madeleine, for the patience you have both shown when I have been distracted, for your understanding when I missed family holidays, and for being the inspiration behind this study.

Topkapi Palace, Istanbul 2011

List of Abbreviations

app	mobile device application
BBC	British Broadcasting Corporation
BE	Behavioural Engagement
BESA	British Educational Suppliers Association
CE	Cognitive Engagement
CRQ	Cycle-specific Research Question
EE	Emotional Engagement
DBR	Design-based research
DBRC	Design-based research cycle
DBRC_D	Design-based research cycle (Discovery-based)
DBRC_P	Design-based research cycle (Production-focused)
eBook	Electronic Book
E-Cap	Educational Capital
HE	Higher Education
ICT	Information and Communications Technology
IT	Information Technology
LT	Learning Theory
M-Cap	Mobile Capital
MLA	Mobile Learning Activity
MKO	More Knowledgeable Other
NFER	National Foundation for Educational Research
Ofcom	The Office of Communications
OFSTED	Office for Standards in Education
PIE	Possible Impact on Engagement
PRQ	Primary Research Question
QR-Code	Quick Response Code
RSPB	Royal Society for the Protection of Birds
SATs	Standard Assessment Tests
S-Cap	Social Capital
SRQ	Secondary Research Question
ST	Student Teacher

TA	Teaching Assistant
T-Cap	Technological Capital
TPACK	Technological Pedagogical and Content Knowledge
TRQ	Tertiary Research Question
UK	United Kingdom
Y2	Year 2
Y3	Year 3
Y5	Year 5
ZPD	Zone of Proximal Development

List of Tables

List of Figures

Chapter 1 Introduction and Background

1.1 Wider Context for the Research

> *One hundred years ago children travelled to schools to sit in rows and be instructed by a teacher. Today they still do the same.* (Sharples, 2006, p.2).

The last decade has seen considerable expenditure in educational technology to support teaching and learning in the United Kingdom's (UK) primary and secondary schools, however research suggests that significant educational gains have yet to be realised through this investment (Cuban, 2009; Selwyn, Potter & Cranmer, 2010; Higgins, Xiao & Katsipataki, 2012; Luckin, Bligh, Manches, Ainsworth, Crook & Noss, 2012; Gray, Dunn, Moffett, & Mitchell, 2017). A number of key contributory factors have been identified:

- Measuring the impact of technological interventions is known to be troublesome (Underwood, 2009), and with the rapid pace of change in technology making longitudinal studies difficult, it can be argued that only inferences on the relationship between technology and attainment can be made (Higgins et al., 2012);
- Evaluations of technological interventions in schools have primarily been conducted using a lens which has emphasised technological capabilities over pedagogic value (Luckin et al., 2012);
- Teachers are often not given enough time to explore how they might exploit technology within their teaching, and tend to see it as an add-on rather than something to be embedded into teaching practice (Harris, Mishra & Koehler, 2009);
- Educational technology is often seen as being in opposition to traditional teaching methods (Gray et al., 2017).

When Prensky first introduced the notion of the 'digital native' (2001), the internet was predominantly accessed through wired, desktop-based computers; however, evolutionary change within the ecology of technology through which the internet is accessed means this is now increasingly characterised as wireless and hand-held, while the emergence of cloud computing has facilitated opportunities to shift effortlessly between working on a personal computer to tablet to laptop to smartphone. Prensky's (2001) *digital native* has therefore already been superseded by the emergence of what might be termed the 'mobile native', i.e. those growing up in a world in which the internet is 'always on', and access is personalised and tailored to the individual through rapidly customisable hand-held devices.

The general use of mobile devices in informal settings is becoming ubiquitous (Gray et al., 2017), with over 58% of households in the UK reportedly owning one or more tablet devices, and tablet computers now the most used device among 6-11-year-old children after television sets (Ofcom, 2017). However, the use of mobile devices to support learning in schools, and particularly to support learning in those authentic outdoor settings which are the primary focus of this study, remains under-researched, suggesting a growing need for an underlying, well-tested theory of mobile learning to guide practice:

> *Most theories of pedagogy fail to capture the distinctiveness of mobile learning. This is because they are theories of teaching, predicated on the assumption that learning occurs in a classroom environment, mediated by a trained teacher.*
>
> (Taylor & Sharples, 2006, p.1)

Reflecting this move away from highly localised towards broadly distributed internet access, there has been recognition that in order to harness the unique educational affordances of mobile learning (cf. Klopfer & Squire, 2008), such as portability and immediacy, teachers need support to develop the underlying pedagogy associated with traditional classroom-based teaching and learning (Beastall, 2006). Research has suggested that in order to enable children to benefit from these powerful learning opportunities most effectively (Naismith, Lonsdale, Vavoula, & Sharples, 2004), teachers must embrace a shift away from being the central focal point in a classroom as a "*sage on the stage*", to become a "*guide on the side*" (King, 1993, p.30).

In a politically-charged climate where UK government departments and teaching unions clash frequently over the administrative demands placed on teachers and the long hours put in (e.g. Exley, 2014; BBC, 2016; BBC, 2017a; The Telegraph, 2018; BBC, 2018), it may, however, be unrealistic to expect teachers to re-think their teaching practices, and to explore and embrace new interventions such as mobile learning without a shift in government policy.

Alongside growing concerns about childhood obesity and stress as possible side-effects of *nature deficit disorder* (Louv, 2009), the UK government's education policy, with its increasingly tight focus on attainment targets for mathematics and English, is also squeezing opportunities for informal outdoor learning that many agree are invaluable for healthy childhood development.

This research therefore sought to establish whether leveraging the affordances of mobile devices could balance teachers' increasing needs for measurement of target attainment with those of children to 'have fun' while learning in a natural environment.

1.2 Significance and Aims of the Research

This study investigates the influence of mobile technologies on the engagement of primary school children collaborating in groups in outdoor settings on science topic work, aiming to present findings that will: (i) help inform school policy; (ii) provide guidance to practitioners; and (iii) contribute to theory in the field of mobile learning and outdoor learning.

It is anticipated that this research will be of direct relevance to those responsible for the design and development of mobile learning policy and the implementation of strategies for mobile and outdoor learning in schools, while the findings and other outputs emerging from the research may also inform both practitioners and other stakeholders in local and national organisations with a remit to advance outdoor education. While this study will explore the influence of mobile learning on engagement in natural outdoor settings, it is anticipated that the focus on learner engagement will mean the findings will be relevant in other areas of out-of-school learning opportunities, such as museum visits and field trips.

Within the educational research community, this research can also be expected to contribute to the refinement of theory in the field of mobile learning, and to inform academic debate around authentic, situated, place-based, contextualised, constructionist, cross-contextual and collaborative forms of learning, as discussed further in Chapter 2.

1.3 Motivations for the Research

For many years, my three core passions have related to *education*, *technology* and *the environment*, and I feel fortunate to have had the opportunity to undertake research into an area that combined all three. While my professional practice in the field of educational development involved working with academics to create technology-enhanced interventions for higher education students, observing how my own children interacted with technology as they grew up focused my interest on the learning opportunities that ICT might bring to primary-aged children.

The first time it became fully apparent to me that mobile devices held the potential to support rich learning experiences for children was on a family visit to Topkapi Palace in Istanbul. Looking for ways to encourage my two children (a girl then aged 6 years, and a boy then aged 9 years) to appreciate the intricacies of what they were seeing, I suggested they create a 'film' about it using two iPods we had with us, so that they could share their experiences with friends and family once we returned home. While I had expected them to show eagerness in using what they regarded as high value objects, I had not anticipated that their engagement with this activity would continue for more than a few minutes. I was therefore pleasantly surprised when my eldest child continued creating separate video clips for the entirety of the visit to the palace, filming intently while describing what he was seeing whenever we moved to a new area. Reviewing the footage with the children on our return home, it was fascinating to see the palace from a child's viewpoint and to observe which particular aspects had captured his attention, but I was especially struck by the level of detail delivered through his narrative. This experience led me to consider more deeply the affordances that mobile devices might bring to children's learning, particularly in outdoor settings, both technologically in terms of their portability and high-quality recording ability, and also their capacity to motivate and to facilitate focused engagement.

The natural environment is something to which I have always held a deep emotional commitment. I have travelled widely, particularly in South-East Asia, where I have previously visited a range of nature reserves and wildlife sanctuaries, so am aware of the fragility of the planet, the threats to our ecosystems, and the importance of engendering respect for nature in children. In recent years, concerns have been raised regarding the physical and mental wellbeing of young people believed to result from a growing reliance on technology for social and entertainment purposes, with a particular focus on mobile devices (e.g. BBC, 2015), with some warning of the consequences of diminishing contact of children with the 'great outdoors' (e.g. RSPB, 2010; Richardson, Sheffield, Harvey & Petronzi, 2016; The Guardian, 2016) and the dangers associated with nature deficit disorder (Louv, 2009).

With reference to the emergence of the mobile native highlighted in section 1.1, an exploration of the feasibility of harnessing the motivational aspects of mobile devices to re-connect young people with learning in natural outdoor settings appears particularly timely, potentially leveraging benefits both to individuals and to the wider natural environment.

1.4 Participants and Research Domain

Following a feasibility study conducted with a group of 17 Beaver Scouts and their Leader in 2013, contact was established with the head teacher of a large, multi-cultural primary school in the north of England who had recently invested in a set of Apple iPads and who wished to explore how these might be used for teaching. On completion of a successful pilot mobile learning activity with a Year 3 class from that school, collaboration with five teachers over three years resulted in the design, implementation and evaluation of a series of mobile learning activities with about 480 children from Year 2 (6-7 years old), Year 3 (7-8 years old), and Year 5 (9-10 years old) year groups, primarily conducted within a local nature reserve.

1.4.1 Description of the School

Uplands Primary School (pseudonym) is a large, multi-cultural school for around 400 children aged from 4 to 11 years, set in a small city in the north of England. Around 30% of pupils are from minority ethnic groups, and most of these speak English as an additional language. Each year group within the school is comprised of two classes of approximately 30 children each.

Teachers are afforded a fair degree of flexibility in how they teach, providing the core learning objectives set out in the UK National Curriculum (Department for Education, 2013) are met. Most teachers opt for the 'team-teaching' approach, working together to create lesson plans which pool their expertise and help ensure parity of experience for their learners. While the school has 21 policies relating to the curriculum and teaching, it does not currently have either an 'Outdoor Learning' or 'Mobile Learning' policy. The school has a bank of three or four networked computers in each classroom, and electronic whiteboards are used extensively throughout the school.

All UK schools are subject to quality and standards inspections conducted by the Office for Standards in Education (Ofsted), rating institutions on a scale which includes Grade 1 (outstanding), Grade 2 (good), Grade 3 (requires improvement) to Grade 4 (inadequate); Uplands school was rated as 'Grade 2 (good)' by Ofsted in its most recent inspection.

1.4.2 Description of the Outdoor Setting

Greendale (pseudonym) is a well-established nature reserve and, due to its proximity to the city centre and its variety of habitats, has been used by local schools for many years as an outdoor classroom for environmental education and other topics related to the National Curriculum.

The reserve itself encompasses over 50 hectares of land comprising pasture, marshes, woods and an orchard, the latter being the most commonly used area for primary school visits due to its enclosed nature. A map of this section has been specifically drawn up to enable schools and youth groups to use it for educational activities, and tree stumps and tree trunk slices have been placed in set locations to provide focal points for 'minibeast hunts'.

1.5 Underlying Theoretical Framework

> [The] *educational process has two sides, one psychological and one sociological ...neither can be subordinated to the other or neglected without evil results following*.
>
> (Dewey, 1929, p.291)

Embracing the pragmatist epistemological position exemplified in Dewey's assertion above, this investigation is located between cognitive and social forms of constructivism (see section 2.2), drawing on theoretical work informed by both cognitive (e.g. Bruner, 1979) and social (e.g. Vygotsky, 1980) schools of thought around learning.

Adopting Crompton's definition of mobile learning as *"learning across multiple contexts, through social and content interactions, using personal electronic devices"* (2013, p.4), and drawing on the pedagogy underpinning mobile learning (e.g. Rikala & Kankaanranta, 2012; Zimmerman & Land, 2014; Nouri, Cerratto-Pargman, Rossitto & Ramberg, 2014), the intervention-focused element of this study is underpinned by a range of learning theories from the field of educational research, including work in the area of collaborative learning (e.g. Taylor et al., 2006; Zurita & Nussbaum, 2007), situated and authentic learning (e.g. Naismith et al., 2004; Herrington, Mantei, Herrington, Olney & Ferry, 2008), experiential learning (e.g. Sharples, Taylor & Vavoula, 2005; Lai, Yang, Chen, Ho, & Chan, 2007), and cross-contextual learning (e.g. Vavoula & Sharples, 2008).

1.6 Research Questions

The primary research question (PRQ) and three secondary research questions (SRQs) guiding this investigation were:

PRQ: *How might mobile learning influence learner engagement of primary school children working in groups on science topic work in outdoor settings?*

SRQ1: *How might the affordances of mobile technologies be leveraged to develop effective pedagogic interventions to engage primary-aged learners in outdoor settings?*
SRQ2: *How might engagement of primary school children be assessed in outdoor settings?*
SRQ3: *What barriers and challenges are associated with the integration of mobile learning within teachers' professional practice, and how might this be modelled?*

In addition to consideration of the central research questions immediately above, and consistent with the adoption of the design-based approach outlined in section 1.7 below, both cycle- and intervention-specific questions arose during the process of addressing the overarching research questions, and as a result of the emergent research design; these are introduced in the relevant cycles.

1.7 Research Approach

Employing design-based research as the overarching methodological approach enabled this study to remain broadly consistent with the central tenets of action-focused educational research (Brown, 1992; Collins, 1992), while taking an iterative approach to the design, development, evaluation and refinement of a range of educational interventions (e.g. Barab & Squire, 2004; Wang & Hannafin, 2005; Looi, Zhang, Chen, Seow, Chia, Norris & Soloway, 2011), and utilising multiple methods during the data collection and analysis process (Design-Based Research Collective, 2003).

Following a feasibility study, the research spanned three school years and incorporated eight design-based research cycles, conducted with about 480 primary-aged participants drawn from Years 2, 3 and 5 of a north-of-England school. The mobile learning interventions developed in collaboration with five class teachers were designed to facilitate delivery of science topic work related to the National Curriculum, with a local nature reserve providing a contextualised outdoor setting for educational activities.

During the investigation, I acted both as an adult helper in the context of delivering sessions in the nature reserve, and as a researcher with previous professional experience as a developer of technology-enhanced learning materials. I also led the design, development, implementation and evaluation of a series of mobile learning activities used during the investigation, and collected data subsequently analysed to evaluate the effectiveness of those interventions.

The five class teachers with whom I collaborated to develop the mobile learning interventions also acted as expert witnesses (Yin, 2003), examining the findings of each research cycle, and offering comment, observations and alternative interpretations. The Deputy Head teacher of the school provided a perspective into the impact of the mobile learning activities on children's engagement at a group level, while individual class teachers offered commentary on the impact on engagement for individual children within their classes.

As a result of adopting a design-based approach to the study, outputs from the investigation included deliverables associated with both theory and practice. In the domain of practice, design principles were developed to guide the design of mobile learning activities for primary-aged children in outdoor settings, while more abstract developments emerging from the research centred around models of flow and of mobile capital which drew on the psychological and sociological elements of the theoretical framework outlined above.

1.8 Overview of Chapters

Chapter 2 reviews the literature on which the investigation draws and against which it is situated. Relevant theories of learning are explored, before the investigation is contextualised against the backdrop of contemporary research in the area of learner engagement and mobile learning.

Chapter 3 discusses two pilot studies conducted in outdoor settings with (i) a local Beaver Scout pack of 17 children aged 6-8 years working towards their *Information Technology* (IT) and *Environment* badges; and (ii) a Year 3 class from a local primary school, involving about 30 children aged 8-9 years. Trialling the use of portable wifi hotspot devices to provide internet connectivity, the pilots saw children work in small groups using iPods to follow *Quick*

Response (QR) *code* nature trails and to access online sources to help them complete ‘minibeast hunts’ and quizzes. Field notes, video-recorded observations, and learner-generated photographs and video clips were subjected to thematic analysis to identify key themes, with the findings used to inform both the choice of methodological approach for the main study, and the design of mobile learning activities developed thereafter.

Chapter 4 considers the methodological approaches available through which to conduct the investigation, exploring the potential for using ethnography, case study and action research before reaching the conclusion that design-based research (DBR) provided the most appropriate pathway to addressing the research questions. The chapter gives further consideration to the application of DBR within the study, before examining the role of Grounded Theory in the research, and exploring issues around validity and reliability in qualitative research undertakings. Acknowledging the requirement for flexibility and responsiveness within the study due to the need for an emergent research design, attention is given to anticipated data sources and the selection of methods appropriate for use in the data collection and analysis process, and a short discussion of the relevant ethical considerations is offered.

Discovery-based learning is the focus of Chapter 5, which delivers a thick description of four DBR cycles which aimed to encourage learners to explore particular topics or themes within an outdoor setting. Building on findings from the exploratory phase, collaboration with teachers (two Year 2, two Year 3 and two Year 5) over a period of three years resulted in the design, implementation and evaluation of mobile learning activities for over 170 children aged 6-10 years from a single school, which primarily took place within a local nature reserve. Findings were derived from analysis of field notes, video-recorded observations, QR-code scanner application (app) logs, learner-generated photographs and video clips, blog entries, and audio-recorded semi-structured interviews with teachers. These informed the development of a set of mobile learning design principles, which are detailed in Chapter 8.

Chapter 6 describes two DBR cycles focused on the design, development, implementation and evaluation of mobile learning activities relating to the *Production-focused learning* research stream, which aimed to support children in creating their own minibeast documentaries as part of the Year 2 *'Living things and their habitats'* curriculum topic. Spanning two academic years, collaboration with three Year 2 teachers from the same school resulted in the design of mobile learning activities for around 120 children, which took place in the same nature reserve. Findings derived from the analysis of field notes, video-recorded observations, learner-generated photographs and video clips, and audio-recorded semi-structured interviews with teachers, fed into the design of further activities which are described in Chapter 7, and informed the mobile learning design principles which are detailed in Chapter 8. The chapter also reports on the opportunistic evaluation of a further iMovie Trailers mobile learning activity designed solely by Year 5 teachers for their classes.

Chapter 7 builds on the findings in Chapter 6 and describes a further two design-based research cycles focused on the design of mobile learning activities (MLAs) which supported children in creating their own eBooks, primarily within the outdoor setting of the nature reserve. Collaboration with two Year 2 and two Year 3 teachers resulted in the design, implementation and evaluation of activities for around 120 children aged 6-8 years, which were related to the Year 2 *'Living things and their habitats'* and the Year 3 *'Lifecycle of Plants'* curriculum topics. Findings derived from the analysis of field notes, observations, learner-generated eBooks, teacher interviews and learner focus groups informed the mobile learning principles described in Chapter 8.

In Chapter 8, the thesis concludes by drawing together the findings from all DBR cycles relating to the *discovery-based learning* and *production-focused learning* research streams, discussing the implications for mobile learning theory, highlighting aspects relevant to practitioners in primary education, while also offering the study's overall contribution to knowledge and suggestions for further research.

Chapter 2 Literature Review

The previous chapter outlined the background, context, aims and motivations for this investigation, which is focused on the influence of mobile learning on the engagement of primary school children in outdoor settings. This chapter defines the theoretical scope and terms of the study, presenting a review of the literature encompassing learning theories, pedagogical considerations and notions relating to the digital disconnect, which both informed and situated the study.

This research is supported by a theoretical framework which is underpinned by both cognitive (e.g. Piaget, 1952) and social forms of constructivism (e.g. Vygotsky, 1980) while drawing on contemporary theorisations around collaborative (Zurita & Nussbaum, 2004), situated (e.g. Lave & Wenger, 1991), distributed (e.g. Pea, 1993), authentic (e.g. Herrington & Oliver, 2000), experiential (e.g. Kolb, 1984) and cross-contextual theories of learning (e.g. Sharples, 2006). As the central focus of the research is an investigation of the influence of mobile technologies on the engagement of primary school children in outdoor settings, the design and development of the mobile learning interventions will also be informed by work in the fields of outdoor (e.g. Dillon, Rickinson, Teamey, Morris, Choi, Sanders & Benefield, 2006) and contextualised forms of learning (e.g. Rogers, Price, Harris, Phelps, Underwood, Wilde & Michaelides, 2002; Zimmerman & Land, 2014).

2.1 Definitions

The following section clarifies how the terms ‘Learner Engagement’, ‘Mobile Learning’, ‘Affordance’ and ‘Outdoor Learning’ are viewed within the study.

2.1.1 Learner Engagement

Learner engagement has long been recognised as a key component in helping raise academic achievement (e.g. Jones, Valdez, Nowakowski & Rasmussen, 1994; Fredricks, Blumenfeld & Paris, 2004; McPhee, Marks & Marks, 2013), and, as a study which aims to investigate the potential of mobile devices to engage primary-age children in learning, it is necessary to define what the term ‘engagement’ means in this context.

Jones et al. (1994) specify a number of indicators for successful learner engagement, which include a shift in the role of teachers to facilitators, guides and co-learners, and the role of learners to explorers, cognitive apprentices and producers of knowledge; in a later paper, while emphasising the importance of engaging learners by providing them with authentic tasks, they define tasks as authentic when "*they are important to learners and learners use their knowledge of the subject matter in much the same way that real-life practitioners use that knowledge*" (Jones, Valdez, Nowakowski & Rasmussen,1995, p.15). Making reference both to the need to provide learners with authentic tasks coupled with appropriate means of assessment, they describe what engaged learning 'looks like':

> [Engaged learners] *derive excitement and pleasure from learning so that it is typically intrinsically motivating and yields a lifelong passion for solving problems; understanding; and taking the next step in their thinking, research, or creative production*. (Jones et al., 1994, p.11)

Engaged learning should also ensure that as well as being exciting and enjoyable, tasks should be challenging and interdisciplinary; assessment should be matched against clear and pre-defined criteria, based upon learners' overall performance in meeting the learning objectives, whether through observation, interviewing or review of learner-generated artefacts, and should also be "*seamlessly interwoven with curriculum and instruction so that it is ongoing*" (Jones et al., 1994, p.13) ; instructional strategies should be "*interactive and generative*", using a variety of techniques to encourage learners to construct their own understanding, and learners should be part of a supportive community focusing on knowledge-building (Jones et al., 1994, p.11).

More recent studies emphasise the multi-faceted nature of engagement, suggesting a complex interplay of behavioural, emotional, and cognitive elements; Fredricks et al. (2004) summarise early research in this area, characterising *behavioural engagement* as participation in academic and extra-curricular activities, *emotional engagement* as encompassing learners' attitudes towards their teachers, classmates and school in general, and *cognitive engagement* as the facet which "*incorporates thoughtfulness and* *willingness to exert the effort necessary to comprehend complex ideas and master difficult skills*" (p.60).

McPhee et al. (2013) build on this work in their study examining the impact of the Apple iPad on the engagement of primary school children. Drawing on Kearsley and Shneiderman's (1998) work on engagement theory, they highlight issues of relevance to this investigation, particularly in the area of measuring engagement, with the development of their *Classroom Engagement Checklist,* to establish markers for emotional, behavioural and cognitive engagement.

In their longitudinal study on motivation, academic achievement and engagement with 12-13-year-old school children, Wang and Eccles (2013) concluded that the most important facet of engagement is that it is malleable, and that it is most enhanced when schools fulfil student needs for "*competence, autonomy and relatedness*" (p.13), where *competence* is defined as students feeling they are able to interact successfully at a social level to achieve their aims, *autonomy*, as when they recognise tasks as authentic or when they feel they are able to exert choice in how they learn, and *relatedness*, when they feel they are connected to their peers and teacher, for example by being a member of a supportive learning environment.

One theory relating to learner engagement of interest to this study is Csikszentmihalyi's flow theory (1997), where flow is described as *"a state of deep absorption in an activity that is intrinsically enjoyable"* (Shernoff, Csikszentmihalyi, Shneider & Shernoff, 2003, p.160). Findings from this study highlighted that high school learners in the United States experienced increased engagement when they felt that the challenge of the task was matched to their level of skill, that the instructional methods were appropriate and that they had some measure of control over their learning (as later echoed in Wang and Eccles, 2013). To achieve this gold standard of 'flow' in their teaching, Shernoff et al. suggest that teachers should aim to balance the level of difficulty of the learning activities with the level of new skills that are required, aligning with Vygotsky's *zone of proximal development* (1980), where the required new skills are just out of reach but realistically achievable. Acknowledging that this balance can be difficult to achieve and maintain, they argue that when flow is disrupted *"apathy (i.e. low challenges, low skills), anxiety (i.e. high challenges, low skills), or relaxation (i.e. low challenges, high skills) are likely to be experienced"*, and that the instructor needs to address these by re-framing the task or providing feedback or further instruction to enable flow to be restored (Shernoff et al., 2003, p.160).

While acknowledging Jones et al.'s (1995) emphasis on authentic tasks as outlined above, this study initially adopted McPhee et al.'s definition of engagement as "*the emotional, behavioural, and cognitive evidence of students being actively involved in the academic experience*" (McPhee et al., 2013, p.444), where 'academic experience' refers to the learning undertaken by classes of primary-aged children under the supervision of their teacher. As the research evolved, this definition was refined to encompass markers for learners evidencing 'flow' in their learning.

2.1.2 Mobile Learning

Definitions of mobile learning exist across a spectrum, with different communities defining the term to variously reflect their particular stance. While some make mobile learning conditional on networked devices, requiring *"the exploitation of ubiquitous handheld technologies, together with wireless and mobile phone networks, to facilitate, support, enhance and extend the reach of teaching and learning"* (Learning and Skills Network, 2009, p.1), others define mobile learning as simply *"the provision of education and training on PDAs/palmtops/handhelds, smartphones and mobile phones"* (Keegan, 2005, p.3). Still others focus on the mobility of the learner rather than the device (e.g. Attewell & Savill-Smith, 2004), while some prefer a definition which references both learner and technology, describing mobile learning as *"any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of learning opportunities offered by mobile technologies"* (O'Malley, Vavoula, Glew, Taylor, Sharples & Lefrere, 2003, p.6).

For the purposes of this study, however, a broad definition will be adopted, whereby, in alignment with Keegan (2005), and following Crompton (2013), mobile learning is defined as *“learning across multiple contexts, through social and content interactions, using personal electronic devices”* (p.4).

2.1.2.1 Mobile Learning Activity

Throughout this thesis, the term ‘mobile learning activity’ (MLA) exists as a subset of a cross-contextual learning experience, and refers to combinations of pedagogic and technological elements in outdoor settings, together with preparatory or follow-up activities in the classroom. In keeping with the research focus on development of solutions likely to be of direct value to practitioners, this review will aim to seek out those studies that do not rely on bespoke hardware and/or software systems to support their mobile learning activities, to increase transferability of findings (Lincoln & Guba, 1985).

2.1.3 Affordance

The term *affordance*, originated by Gibson (1977) in the field of psychology, describes the relationship between the environment and an individual: *“the affordance of anything is a specific combination of the properties of its substance and its surfaces with reference to an animal”* (p. 67), with subsequent emphasis placed on the *direct perception* by an individual of the potentiality of all ‘action possibilities’ that an object might offer, whether for *“good or ill”* (Gibson, 1979, p.127).

The term later became widely appropriated in the fields of interaction design, human-computer interaction and user-centred design, where its constraints shifted from Gibson’s *direct perception* to Norman’s (1988) narrower view of affordance as *perceivable action possibilities*, wherein an object’s affordances are restricted to only those actions that are perceived by an individual as possible.

While a detailed discussion of the term is outside the scope of this thesis, with its particular focus on mobile learning in outdoor settings, this study adopts Kirschner’s (2002) definition of

‘Educational Affordances’, as “*those characteristics of an artifact ...that determine if and how a particular learning behavior could possibly be enacted within a given context”* (p.19); it also acknowledges Looi, Seow, Zhang, So, Chen and Wong’s (2009) statement that an affordance of a mobile device *“determines the type of learning activities that can be designed”* (p.9), and that mobile devices can act as a bridge between the learning taking place in formal and informal settings*.*

2.1.4 Outdoor Settings

As noted by Wong and Looi (2011), with many variations on what constitutes formal, informal, semi-formal and non-formal learning contexts in the literature, and acknowledging Colley, Hodkinson and Malcom’s (2003) position that discrete categorisations of learning as ‘formal’, ‘informal’ or ‘non-formal’ can be unhelpful: “*All learning situations contain attributes of in/formality ...Attributes of formality and informality are interrelated in different ways in different learning situations*” (p.65), the definition of ‘outdoor settings’ in this investigation identifies the context for the majority of the field work as being ‘semi-formal’, as something that takes place in natural outdoor settings, with activities that are teacher-initiated but learner-led, which are designed to feed into class topic work.

2.2 The Constructivist Learning Paradigm

Constructivism asserts that children learn when they are actively involved in constructing their own knowledge, either adapting new experiences to fit into their existing schema (referred to as ‘*assimilation’* by Piaget (1952) in his *Developmental Theory)*, or creating new schema if there is not an easy fit (referred to as ‘*accommodation’* by Piaget). It is in this state of *disequilibrium,* where learners are unable to assimilate new experiences into their existing schema, where Piaget argued most learning occurs. In contrast to the ‘transmission method’, where learners are described as passive recipients of knowledge, Piaget suggested that children do not simply accept what they are told at face-value - they interpret it, according to their particular stage of development and world view.

While Piaget's work proposed a model based on discrete stages of child development, Lev Vygotsky, acknowledging that children progress through a series of invariant stages in their development, also proposed his own theories on *'socio-cultural' constructivism* (1980). Here, Vygotsky emphasised the fundamental role of social discourse and culture in shaping how knowledge is constructed within an individual, arguing that child development and meaning-making cannot be divorced from their social context, and that social learning precedes development. Vygotsky also highlighted the importance of a 'More Knowledgeable Other' (MKO) in helping a child move through what he termed a 'zone of proximal development' to gain understanding or skills, where the right amount of guidance or support is given to enable the child to achieve the desired outcome on their own.

McCarrick and Xiaoming (2007) suggest that the more skilful MKO uses scaffolding to divide a task into *"manageable pieces"* (p.84), gradually increasing the difficulty and using techniques such as suggesting and reminding to support a child in reaching their goal. Along with others, they also argue that constructivism, in both its forms, is well-suited to learning at the computer, with computers providing a "*unique learning environment for peer scaffolding"* as children appear to be irresistibly drawn to working on them together to solve problems (p.84).

Reiser and Tabak (2014), while agreeing with the premise that computers can be used to provide effective scaffolding, suggest scaffolding should require learners to undertake tasks at a real-world or expert level, arguing that: "*Embedding guidance in context as learners perform a full contextualized expert-like task is the essence of the pedagogical logic of scaffolding*" (p.47), and that breaking tasks down may be underpinned by behaviourist approaches to learning if they are not appropriately contextualised, risking development of inert knowledge.

The collaborative facets of socio-constructivism have been adopted in some UK primary schools (e.g. Baines, Blatchford & Chowne, 2007) with teachers organising children to work in 'table groups' of 4-6; this research aimed to adopt similar approaches in the design of mobile learning activities as the study progressed.

2.3 Learning Theories Relevant to this Study

This section describes the various pedagogic approaches that may underpin mobile learning activities. Acknowledging the overlap that often exists between these approaches, only those theories considered relevant to children using mobile devices in outdoor settings are included.

2.3.1 Collaborative Learning

Defined as an approach "*in which students at various performance levels work together in small groups toward a common goal*" (Gokhale, 1995), collaborative learning has become an established approach for organising learning within the socio-constructive paradigm, with pooling of ideas leading to enhancement of critical thinking and retention of knowledge cited as key advantages (Johnson & Johnson, 1986). Working together in a process of social negotiation, whereby new ideas or concepts are actively co-constructed based on previous and current knowledge (e.g. Sutherland, Armstrong, Barnes, Brawn, Breeze, Gall, Matthewman, Olivero, Taylor, Triggs, Wishart & John, 2004; Taylor et al., 2006), a sense of ownership of the learning event is a key tenet of a socio-constructivist approach, with the eventual aim of encouraging learners to take responsibility for their learning (Squires & Preece, 1999).

Although some teachers have voiced concerns that using too much technology might result in social isolation for their learners (McCarrick & Xiaoming, 2007), research has found that far from encouraging social isolation, computers can act as catalysts for collaboration between learners (Clements & Sarama, 2003; Gray et al., 2017), with others reporting that pre-school children spent far more time interacting with their peers when playing at the computer than when they were playing with puzzles (Muller & Perlmutter, 1985). Where children work together on an activity using a single mobile device, the act of sharing the hardware can itself create a strong focal point for the group's work on a task, not only in motivational terms (Zurita & Nussbaum, 2004; Passey, 2010), but also in helping them to develop soft skills such as collaboration when working on tasks (Taylor et al, 2006). This study will aim to harness the pedagogical affordances of collaborative learning, where learners work together to accomplish shared goals, whilst also developing follow-up activities that enable individual group members to produce their own learning artefacts, where feasible.

As noted some time ago by Luckin et al. (2012), illustrative cases of a socio-constructivist approach being used in a mobile learning environment in an outdoor setting appear to be limited in the literature, although more examples are emerging. Some noteworthy examples have included: (i) *Environmental Detectives* (Klopfer & Squire, 2008), where pairs of high school students took part in an augmented-reality game simulating an investigation into a toxic spill; (ii) the *Savannah* project (Facer, Joiner, Stanton, Reid, Hull & Kirk, 2004), where ten 11-12-year-old children worked together as a pack of lions to achieve game objectives, interacting with the physical world using mobile devices to enable them to 'see', 'hear' and 'smell' as lions; (iii) the *Ambient Wood* project (Rogers et al., 2002), where sixteen 11-12-year-old children explored a digitally-augmented woodland using hand-held probes and other digital tools; and, more recently, (iv) *SamEx*, a mobile learning system for primary school children in Singapore which enables the capture of digital assets, addition of learner comments and sharing amongst peers (Boticki, Baksa, Seow & Looi, 2015).

While not lessening the impact of these studies on learning, it is noteworthy that all examples researched under this heading involved bespoke software and hardware solutions; the apparent paucity of illustrative cases of work with primary learners collaborating in outdoor settings which relied on using the inbuilt functionality of mobile devices or freely available apps appears to highlight an obvious gap in the literature.

2.3.2 Experiential Learning

Emerging from the work of Dewey, Piaget and Kolb, experiential learning has been described as the process of learning through reflecting on experience. With clear reference to Piaget's developmental theory, Kolb defined it as "*the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience*" (1984, p.41).

Preceding Piaget and Kolb, Dewey was a progressive who believed in the importance of the young being able to create understanding in ways that made sense to them, rather than merely accepting the handed-down wisdom of their elders. Dewey was a firm believer in the legitimacy and value of experiential educational approaches, suggesting that experience emerges from the synergy of two principles: *continuity* and *interaction*, where *continuity* is the principle that all experiences affect a person's future in some way, good and bad, and *interaction* that a person's present is governed by their past. Aware of the importance of context in shaping experience, and of the need to provide experiences that were more likely to lead to positive outcomes, Dewey urged educators to make use of settings outside the classroom "*so as to extract from them all they have to contribute to building up experiences that are worth while*" (Dewey, 1938, p.35).

Building on the work of Piaget and Dewey, Kolb (1984) believed that learning occurs when we are faced with the unexpected and have to adapt: "*It is in this interplay between expectation and experience that learning occurs*" (p.28). When describing his framework for being an effective learner, Kolb argues that learners need four different abilities: 'concrete experience' abilities, referring to the ability to "*involve themselves fully, openly, and without bias in new abilities"*; 'reflective observation' abilities, the ability to "*reflect on and observe their experiences from many perspectives"*; 'abstract conceptualization', the ability to "*create concepts that integrate their observations into logically sound theories*"; and 'active experimentation' abilities, the ability to "*use these theories to make decisions and solve problems*" (p.30).

Acknowledging the conflictual nature of the learning process within these opposing forces of direct experience and abstract reflection, Kolb argues that it is how the learner chooses which of these abilities to call on in dealing with new experiences that determines the level of learning, citing Piaget's example of *play* resulting when too many assimilation processes are brought to bear, or *imitation*, when accommodation processes dominate (1984).

Examples of mobile learning that embrace experiential learning at their core include the MOBIlearn project (Sharples, Taylor & Vavoula, 2005), the *Savannah* (Facer et al., 2004), *Environmental Detectives* (Klopfer et al., 2007) and *Ambient Wood* (Rogers et al. 2002) projects mentioned above, Looi et al.'s (2009) study focusing on school children collecting data about packaging in supermarkets in Singapore, and Lai, Yang, Chen, Ho and Chan's study (2007) of elementary school children (aged 10 to 11 years old) learning about plants in Taiwan.

This latter, despite framing its research question in positivist terms: *"This experimental study was conducted to justify the hypothesis …",* went on to discuss useful findings from the qualitative data collected from participant students on their experiences of the learning activity, contrasting those who used mobile devices with those that did not. The set of students with mobile devices were required to follow a 'learning flow', first taking photographs of particular plants, then using their senses to learn more, for example touch and smell, then recording comments and observations, and finally, developing questions if their observations of the plant did not match certain statements shown on their device. The control group followed the same flow, but were asked to sketch and write down with a pen and paper rather than record.

Key findings of interest to this investigation suggested that:

- using a camera led to increased observation in many students, with a greater level of detail shown in the final reports of the 'with-device' students than those without;
- being able to magnify the photograph was cited as an important observational feature by students;
- photographs aided recall when back in the classroom, facilitating report-writing;
- of the students who did not have devices, 12 out of 28 felt that the drawing of plants was the most frustrating aspect of the activity;
- some students did not enjoy the recording feature, citing background noise and having to re-record if there were errors as the main reasons;

- all students said they found it difficult to phrase suitable questions, for example: "*I cannot come up with any questions'*; and
- interestingly, none of students with devices expressed any liking or interest in the 'sensory' phase, in contrast to the control group.

Acknowledging Lai et al.'s (2007) point that experiential learning requires an appropriate setting to enable learners to ground their experiences, i.e. where they can "*encounter tangible learning contexts rather than abstracted knowledge*" (p.326), this study aims to design authentic activities that support the tenets of experiential learning, harnessing the rich and unpredictable learning opportunities provided by complex outdoor settings to promote reflection.

2.3.3 Situated and Contextualised Learning

Historically, the notion of situated learning significantly pre-dates mobile learning, emerging first through Lave (1988) and then Lave and Wenger's (1991) consideration of learning as occurring effectively in communities in authentic settings, whereby newcomers gradually become experts through a process of 'legitimate peripheral participation'. Brown, Collins and Duguid developed this idea of apprenticeship further, proposing that:

> *Cognitive apprenticeship supports learning in a domain by enabling students to acquire, develop and use cognitive tools in authentic domain activity. Learning, both outside and inside school, advances through collaborative social interaction and the social construction of knowledge.* (1989, p.39)

Combining characteristics of collaborative, experiential and social theories of learning, where *Social Learning* proposes learning is achieved through the observation and imitation of others (Bandura, 1977), the significance of context and authenticity in situated learning marks it as a promising theory to underpin a variety of mobile learning approaches. Although the portability of mobile devices and their ability to provide contextualised information makes them ideal for such learning experiences (Naismith et al., 2004), one challenge for teachers is to make the unstable conditions of outdoor learning conducive for learning (Sharples, 2005; Melhuish &

Falloon, 2010), and to use the devices in "*pedagogically innovative and appropriate ways*" (Herrington, Mantei, Herrington, Olney & Ferry, 2008, p.419) that enhance the learning experience and deepen understanding.

Examples of situated forms of learning using mobile devices in outdoor settings are growing in the literature, but the emphasis and terminology appear to be moving away from the notion of community learning in authentic settings to focusing more on the physical location of the learning activity and associated contextualised technology enhancements. Thus we now have a plethora of terms to refer to precise variations on these types of learning, ranging from *location-based* (e.g. Huizenga, Admiraal, Akkerman & Dam, 2009), *context-aware* (e.g. Lonsdale, Baber, Sharples & Arvanitis, 2004), *augmented-reality* (Klopfer et al. 2007), *contextualised* (e.g. Winters & Price, 2005), *information-aware* (Chen, Chang & Wang, 2008), *context-sensitive* (Wang, 2004) and *place-based* (Zimmerman & Land, 2014), with many such studies taking place in Taiwan.

In their discussion of employing mobile learning initiatives to support science learning in outdoor settings, Zimmerman and Land (2014) came up with three 'empirically-derived' guidelines for the design of such activities:

1) Facilitate participation in disciplinary conversations and practices within personally-relevant places;
2) Amplifying observations to see the disciplinary-relevant aspects of a place;
3) Extending experiences through exploring new perspectives, representations, conversations, or knowledge artifacts.

(Zimmerman & Land, 2014, p.77)

With reference to Guideline 1, rather than imposing a scenario on a place, as with augmented-reality projects like *Environmental Detectives* (Klopfer et al., 2007), Zimmerman and Land suggest the focus should be on designing mobile learning activities that support learners' discussions around the existing historical, physical and geographical features of places within their community. Arguing that learners are more likely to integrate and connect prior knowledge with new experiences in places they are familiar with, Zimmerman and Land highlight the importance of supporting learners in classifying and categorising aspects of a place in order to understand it better, for example by creating a photograph survey (Quintana, Reiser, Davis, Krajcik, Fretz, Duncan & Soloway, 2004), while also giving learners the opportunity to reflect on and express their thoughts on the experience, as recommended by Kolb (1984) and Lai et al., (2007).

The second guideline refers to using mobile devices to channel learners' observations to home in on particular disciplinary details of the place they are studying that they may otherwise have missed. As with the *Ambient Wood* project (Rogers et al., 2002) mentioned above, Zimmerman and Land highlight the affordances of mobile devices in providing contextualised information at the point of need, such as photographs, textual prompts or video clips to encourage "*comparison and explanation*" (p.79) and to focus learners' attention.

With Guideline 3, Zimmerman and Land, in line with Papert (1980), are suggesting critical thinking and deep learning can be enhanced where learners create their own digital learning artefacts, not only enabling them to more easily reflect on the experience once back in class, (for example by examining and annotating photographs or video clips they have taken outside), but also in promoting learner autonomy, enabling the sharing of thoughts with peers and teacher that might ordinarily be tacit.

Some valuable examples exist of innovative situated and authentic learning activities using mobile devices, such as those mentioned above, and while a review of the literature revealed a growing number of studies focusing on contextualised learning, few proved to be of direct relevance to this investigation. Two such examples: (i) Chen, Kao and Sheu's (2003) work focusing on school children using mobile devices to learn about bird-watching; and (ii) a follow-up study by Chen, Kao, Yu and Sheu (2004), where the focus was on butterflies, appeared to offer some insights, but both studies concentrated on fostering independent study through the use of tailored mobile apps, presenting purely quantitative findings of learning gains using pre- and post-test analyses.

One technology of interest to this study was the use of Quick Response Codes (QR-codes) to support contextualised learning. Initially developed for the car industry in Japan, QR-codes are a two-dimensional barcode that can be scanned to display text, link to websites, video clips or other media. While there is evidence of their successful use to support educational activities (e.g. Ceipidor et al., 2009; Law & So, 2010), this does not appear to be common in UK primary schools.

Some useful examples of QR-codes supporting learning activities in outdoor settings include: (i) the *M3 Trial* (Wyeth, Fitzpatrick, Good, Smith, Luckin, Underwood, Kher, Walker & Benford, 2008), where six 11-year-old children completed an outdoor treasure hunt using mobile phones and a video camera; (ii) Rikala and Kankaanranta's (2012) study, where primary school children followed QR-code trails focused on retrieval skills and physics topics; and (iii) Lai et al.'s (2013) study, which focused on 10-11-year-old children learning about plants.

While Rikala and Kankaanranta (2012) noted that teachers found planning QR-code activities laborious, all three studies highlighted the high levels of motivation and engagement shown by the participating children.

2.3.4 Constructionist and Authentic Learning

Originated by Papert and built on work he had carried out with Piaget in the 1960s, constructionism centres on the context and artefacts learners use to communicate their thoughts to others, and how this process of expressing in itself leads to deepened understanding within an individual. Papert's focus was more on the fluidity of thought processes and how this could be determined by the context in which learning was taking place, unlike Piaget, whose focus was more on learners finding equilibrium between the opposing forces of assimilation and accommodation. Papert was a strong advocate of the potential of technology to enhance learning, and while at the Massachusetts Institute of Technology, jointly developed the *Logo* programming language with a team from the Bolt, Beranek and Newman Laboratories, led by Wallace Feurzig (Logo Foundation, 2013), as a tool to develop children's understanding and problem-solving abilities. In his influential book, *Mindstorms* (1980), Papert outlined why he felt programming computers was an excellent way to promote active learning in children:

> *The child, even at preschool ages, is in control: The child programs the computer. And in teaching the computer how to think, children embark on an exploration about how they themselves think. The experience can be heady: Thinking about thinking turns the child into an epistemologist, an experience not even shared by most adults. (p.19)*

In terms of the agency of the child when programming with Logo, however, it is worth bearing in mind Pea's observation (1993), that although the child may have been solving problems without adult help, the programming structure that underlies the Logo language will in itself shape how that child goes about solving a particular problem, i.e. what the child can do is constrained by external forces, even though these may not be visible.

This does not diminish Papert's claim of the learning gains achieved through the process of creating artefacts, however, and there are many examples in the literature which do agree that constructionist learning activities provide deep, authentic learning experiences for learners, giving them ownership over their learning and promoting reflection on their problem-solving activities and emerging understanding (e.g. Harel & Papert, 1991; Kafai & Resnick, 1996; Kearney & Schuck, 2005).

While the emphasis in this investigation is on the *use* of mobile devices for learning, rather than *programming* the devices themselves, schools should be encouraged to take advantage of the valuable learning potentials afforded by mobile technologies, harnessing those features that will support their students' learning, such as artefact creation and video capture, that many children already use in their homes without a second thought.

In a study exploring the use of learner-generated video in Australian schools and teacher-training programmes, Kearney (2011) describes the development of a learning design to support learners in ‘digital storytelling’, that is, storytelling that “*integrates photographs, music, video (optional) and especially the voice of the narrator into a brief (two-six minute) piece*” (p.171). In an earlier study, Kearney and Schuck (2006) discuss findings relating to this work, which, while primarily focusing on learner-generated video, serve to highlight a number of issues relevant to this investigation, particularly in informing the pedagogical approach for activities involving learner-generation of digital artefacts.

In their findings, Kearney and Schuck (2006) suggest that:

- Learner-generated videos can become ‘*things to think with*’, that encourage dialogue and feedback with peers and teachers;
- Activities should be open-ended and foster learner autonomy, so that learners can begin to recognise their own mistakes and rectify them as part of the process;
- Having an audience for their videos appears to motivate and inspire learners to do their best work, particularly when the target audience is their peers;
- Opportunities for reflection should be built into learner-generated video tasks, to optimise learning gains;
- Authentic learning should be promoted in such activities, and was achieved by encouraging *“student autonomy and task ownership ...the meaningful nature of the student roles in their groups, and the targeting of peers as the audience*” (p.195);
- Making videos can give learners a voice, especially those that have difficulties with writing, and can also provide “*extrinsic motivation for many students, especially ‘reluctant learners’ ...*[where] *the novelty of using contemporary equipment and the perception of* [digital video] *DV work as ‘fun’ contributed to initial task engagement*” (p.204);
- In terms of assessment, teachers were reported to have focused on a variety of informally-assessed learning outcomes, which included: *“development of movie making skills, language and teamwork skills, conceptual understanding and affective outcomes*” (p.202), with high levels of engagement noted in both team planning discussions and in the finished product.

In summary, constructionism appears to provide an engaging, authentic learning experience for learners, which, given the right mix of pedagogic support, can enable them to take control of their learning and collaborate effectively in teams to produce a ‘thing to think with’, to share with peers, teachers and parents as a basis for discussions. The powerful in-built camera app that is included in most mobile devices enables the easy capture and sharing of photographs, video and audio clips by school-children, and this, combined with their portability, make mobile devices the ideal platform for learners to embark on creating their own digital learning artefacts, as recognised by Herrington and Herrington several years ago:

> *The multimedia capabilities of mobile phones, such as capturing digital pictures and video can enable the development of themes and issues that benefit from representations using educational media by, for example, producing videos, documentaries, animations of educational concepts and news bulletins ...The ability to communicate and share these artefacts through Web 2.0 technologies such as blogs and wikis provides authentic products that students can use for reflection and foundations for ‘remixing’ and further knowledge constructions.* (2007, p.5)

2.3.5 Distributed Intelligence, Learning across Contexts and ‘Seamless’ Learning

Defined by Fischer (2003) as “*an effective theoretical framework for understanding what humans can achieve and how artifacts, tools, and socio-technical environments can be designed and evaluated to empower human beings and to change tasks*” (p.87), distributed intelligence, referred to as ‘distributed cognition’ by some (e.g. Sutton, 2006), argues that cognitive human processes, like planning and reflecting, do not happen in isolation in one individual, but are spread amongst other people, the tools we use, the settings we are in and other resources. Examples that we might make use of in our distributed intelligence systems could include notes that we write to help us work things out or remind ourselves, maps, the conversations we have with others, apps we have downloaded onto a mobile device and so on. The underlying tenet behind this philosophy is that knowledge is not static (Brown, Ash, Rutherford, Nakagawa, Gordon & Campione,1993; Land & Zimmerman, 2015), that it is “*a process not a product*” (Bruner,1966, p.72), and that it is situated in activity that “*connects* *means and ends through achievements*” (Pea, 1993, p.50); it is the mediating of this activity through its distribution among resources like those mentioned above that comprise the framework, with our perceptions of the affordances particular resources have central to how effectively we co-ordinate them to achieve our aims.

Many authors have discussed the affordances of mobile learning in facilitating such a distribution of learning across a variety of contexts (e.g. Walker, 2006; Chen, Chang & Wang, 2008; Vavoula & Sharples, 2009; Passey, 2010; Sharples & Roschelle, 2010). Learning contexts include not only physical locations, such as the classroom, home or an outdoor space, but can also incorporate conversations between learners (Pask, 1976), the nature of the learning task, the level of knowledge of the user (Winters & Price, 2005), and the resources, digital or otherwise, that constitute the learning landscape (Passey, 2013).

The ‘learning continuum’ in mobile learning environments is sometimes predicated on the notion that each learner will have their own device, their learning ‘hub’ (Looi et al., 2009), that stays with them across all contexts to provide a ‘seamless learning’ experience (Wong & Looi, 2011, p.2). While this ideal of a 1:1 ratio is yet to be realised in the majority of UK primary schools (BESA, 2015), the term *seamless learning* originally made no reference to technology and was primarily concerned with connecting the learning that went on inside the classroom with informal learning that took place outside (Kuh, 1996); it is this form of the term that will be adopted for the purposes of this study.

Due to its dynamic nature and the fact that it is actively shaped by learners, Priestnall, Brown, Sharples and Polmear (2010), suggest context can be seen as:

> *an ever-playing movie: a continually unfolding interaction between people, settings, technologies and other artefacts. The movie is composed of a sequence of scenes, or context states, that represent a specific point in time, space, or sequence of learning goals. Each scene of current context is a progression from earlier ones and within the scene some elements are emphasised as relevant to the focus of learning and level of context awareness. The entire movie provides a resource for learning. But this is a*

> *movie that is continually being constructed by its cast, from moment to moment, as they share artefacts and create mutual understanding through dialogue and physical interaction.* (p.4)

Building on this idea, Sharples and Pea (2014) go on to argue that, with careful planning, mobile learning activities can enable learners to take advantage of the authentic, rich learning opportunities that are available in the 'unstable' conditions of naturalistic settings, and to bring this learning back into the class; acknowledging the inherent tension between giving learners enough freedom to experience an activity in such settings first-hand, alongside concerns that their attention is being channelled in the 'right' direction, Sharples and Pea suggest that this can be facilitated by designing in 'pauses for reflection' during outdoor activities, for example, or by supporting learning conversations out in the field, or providing tools for data collection and analysis for later examination back in class (2014).

The *MyArtSpace* project (Vavoula, Sharples, Rudman, Meek & Lonsdale, 2009) attempted to address some of these issues by making use of a bespoke app that supported learners in answering an open question, initially posed by their teacher, to guide their visit to a museum (the example given was: "*Were the D-day landings a success or a failure*?"); the app provided audio-enhanced presentations of exhibits and also enabled the capture of photographs, audio and notes as evidence to back-up learner responses to the question, which were automatically uploaded to the personal web-space of the learner for later retrieval in class. Once back at school, children were required to use these data to create presentations to share their responses to the question.

In a later paper discussing learning across contexts, Sharples (2015) cites an example relating to this aspect of the project, where some learners had taken such a large number of photographs while in the museum setting that they were unable to organise them successfully into a presentation once back in class, having forgotten where and why they had taken particular photographs; he noted the teacher then made use of this as a learning opportunity for the entire class, stressing the importance of being selective when gathering data. Sharples highlights the sometimes understated observation that where the artefacts learners have ‘brought back’ from an outside setting form the basis for subsequent classroom activities, teachers are often required to organise a lesson ‘on the fly’. Noting Sawyer’s use of the term “*disciplined improvisation”* (2004, p.13) to describe this, Sharples acknowledges this may be a challenge for teachers, but also identifies the value it may bring to learning: *“as the teacher explores connections between the brought data and the inquiry question, or extracts general principles from the results”* (Sharples, 2015, p.49). This issue will be further explored in sub-section 2.4.2 when discussing the role of the teacher in relation to mobile learning.

2.3.6 Outdoor Learning

With increasing concerns about nature deficit disorder (Louv, 2009) and calls for the need to ‘re-green’ our youth (e.g. RSPB, 2010; Richardson, Sheffield, Harvey & Petronzi, 2016; The Guardian, 2016), there has been a corresponding growth of outdoor learning initiatives in the UK, such as Forest Schools, the *Council for Learning Outside the Classroom* and the *Institute for Outdoor Learning*, whose core aims are to provide young people with hands-on experiences in the natural world, as noted by the National Foundation for Educational Research in England and Wales (NFER) and Dillon (2005). In addition to the positive effects of being in the natural environment on physical and mental well-being, it has been argued that learning in outdoor settings can also lead to cognitive increases in retention and deeper learning (Wells, 2000; Littledyke, 2004). Such learning requires the design of authentic tasks (Herrington & Oliver, 2000) which incorporate appropriate follow-up classroom activities (Naismith et al., 2004; Figueiredo, Gomes & Gonçalves, 2016) to enable cross-contextual learning (Passey & Zozimo, 2014).

Natural outdoor settings provide rich and ever-changing resources for learning, be it trees, leaves, insects or ponds, to support both experiential (Sharples et al., 2005; Osawa, Noda, Tsukagoshi, Noma, Ando, Shibuya, & Kondo, 2007), kinaesthetic (Pruet, Ang, & Farzin, 2016) and contextualised (Rogers et al., 2002; Chen et al., 2008) forms of learning, which are particularly appropriate for primary-age learners aged 5-11 years. Freed from the constraints of the classroom environment, such settings can also offer an atmosphere which is conducive to collaborative learning, enabling children to share authentic experiences when working together on group tasks (Facer et al., 2004). These learning activities need not be restricted to science topics, but can include links to literacy, numeracy, Information and Communications Technology (ICT) and other core areas of the primary curriculum.

That learners can deepen their understanding of a subject when they are given the opportunity to apply their learning in different settings has been highlighted in the literature (e.g. NFER & Dillon, 2005), recognising that teachers need to blend outdoor learning with indoor activities to embed what has been learnt and to fully realise the learning gains that mobile learning can bring (Perry, 2003; Naismith et al., 2004; Passey & Zozimo, 2014).

Despite this, increasing and competing pressures on the UK primary curriculum have led many teachers to feel too stretched to explore these outdoor learning opportunities, preferring to retreat to the safety of using well-tried and tested methods of classroom instruction to achieve their teaching objectives (Waite, 2009; Young, 2016). Provision of outdoor learning varies greatly from school to school and teacher to teacher in the UK, and, due to its non-assessed nature, can mean teachers de-prioritise its use, neglecting valuable opportunities to connect experience in the field with class-based learning (e.g. Littledyke, 2004; Dillon et al., 2006; Waite, 2010).

In line with Kolb's theory that learning is a holistic, on-going process that involves transactions between the person and the environment, Wells (2000) argued that providing the opportunity for children to use all their senses when in an outdoor environment can lead to deeper learning experiences, with enhanced cognition. Using kinaesthetic learning approaches, particularly with young learners, can afford opportunities to appreciate and articulate the complexity of the real world (Thomson & Diem, 1994; Pruneau et al., 2010). Mobile technologies are valuable not only as a tool to complement kinaesthetic learning, for example as a means of engaging and focusing learners while they are in an outdoor setting (Rogers et al., 2002), but also in enabling the recording of sights and sounds while outside to enhance recall of the experience at a later date, and to feed into class and homework activities.

As previously noted, natural outdoor settings can be distracting for 'formal' learning, particularly for primary-age learners, with numerous inputs vying for attention (Sharples & Pea, 2014); in order to maximise the learning potential, activities need to be designed and structured carefully to balance the positive attributes of student-led experiential learning with instructor-led learning objectives. Within a socio-technical environment made up of learners, teachers, adult helpers and mobile devices, the distributed nature of mobile learning can not only act as a focal point to support learners engaged in collaborative activities, for example by providing contextualised information to scaffold an activity at the point learners need it, but can also connect outdoor learning with indoor learning, by facilitating recall through the capture of photographs and videos while out in the field (Vavoula et al., 2009; Zimmerman & Land, 2014).

Aside from the mobile learning examples mentioned in previous sections, such as *Savannah* and *Ambient Wood*, another study that aimed to achieve this balance was the 'Wildkey' project, funded by the Heritage National Lottery to develop an easy-to-use mobile app to aid the identification and recording of common plants and insects (Hughes, 2007). Following evaluatory workshops in school grounds or nature reserves, where learners, primarily primary-aged, used the app to support them in completing paper questionnaires identifying local wildlife, findings indicated that the majority of children were on task observing and identifying species for the entire 60 to 90 minute sessions. Subsequent follow-up questionnaires with teachers indicated that 100% of them felt it was a worthwhile learning experience that had motivated their students, and 95% that using the app had enhanced their own confidence in running wildlife identification activities with their learners. As highlighted in the literature, children appear to instinctively enjoy locating and identifying species in the natural environment (Shepardson, 2002), and the appropriate learner-centred design of the app, with learners free to choose which direction to take, fed into the success of this project.

In their evaluation of 5-6-year-old children using another bespoke mobile app to learn about and document their natural environment, Rikala and Kankaanranta (2014) also found that mobile learning aroused their learners' interest and curiosity in their surroundings: "*The* *teachers reported that the mobile device brought an inspiring and motivating element for the children. The application inspired children to look at their surroundings in novel ways …Normally, probably, no one would even notice the flowers*" (p.176). The activity fostered social interaction between peers and with adults, with children excitedly pointing out to each other the best place to take photographs, and asking for corroboration in plant identification. One unforeseen but important finding was that teachers were unclear how they would integrate this outdoor learning with their existing teaching, suggesting that they already had plenty of material and that it would likely require a lot of planning to avoid the mobile activity being 'stuck' on top of what they were already doing. Their lack of experience in manipulating the technology was cited as a contributory factor by the authors, but it was clear, as highlighted by Luckin et al. (2012), that teacher attitudes towards mobile learning are key to their integration and success.

Aside from the work of Zhang, Looi and colleagues, who explored the use of a 'mobilized' classroom using the GoKnow™ mobile learning environment with primary school children in Singapore (Zhang, Looi, Seow, Chia, Wong, Chen, So, Soloway & Norris, 2010), examples of mobile learning in outdoor settings that did not use bespoke software or hardware proved hard to locate in the literature, highlighting a gap in the literature. In their evaluation of the use of iPads in schools in Scotland, Burden, Hopkins, Male, Martin and Trala (2012) stated that: *"The full potential of this aspect of learning outdoors with a mobile device such as the iPad is yet to be understood but this report identifies it as an important and urgent recommendation for further inquiry and development*" (p.107).

2.3.7 Theoretical Framework

Following the discussion of the various learning theories outlined above, the theoretical framework informing the design of mobile learning activities for this study draws most heavily on the tenets of collaborative (e.g. Taylor et al., 2006), socio-constructivist (e.g. Vygotsky, 1980), experiential (e.g. Kolb, 1984), situated (e.g. Lai et al., 2007), contextualised (e.g. Rikala & Kankaanranta , 2014), authentic (e.g. Herrington et al., 2008), constructionist (e.g.

Zimmerman & Land, 2014) and cross-contextual (e.g. Sharples & Pea, 2014) learning approaches**.**

Figure 2.1 provides a diagrammatic representation of this framework, illustrating that the design of mobile learning activities for children in outdoor settings within a socio-technical constructivist framework can interweave elements of all these theories to optimise learning gains. The framework was developed on the following premises:

1. That appropriate scaffolding is provided to enable learners to progress their understanding and clear up misconceptions (Nouri et al., 2014);
2. That learner-generated digital artefacts developed in an outdoor setting are fed into classroom-based learning, to deepen cross-contextual learning opportunities (Zimmerman & Land, 2014);
3. That mobile learning activities encompass experiential learning at their core, providing opportunities for discussion (Bruner, 1961) and reflection (Kolb, 1984).

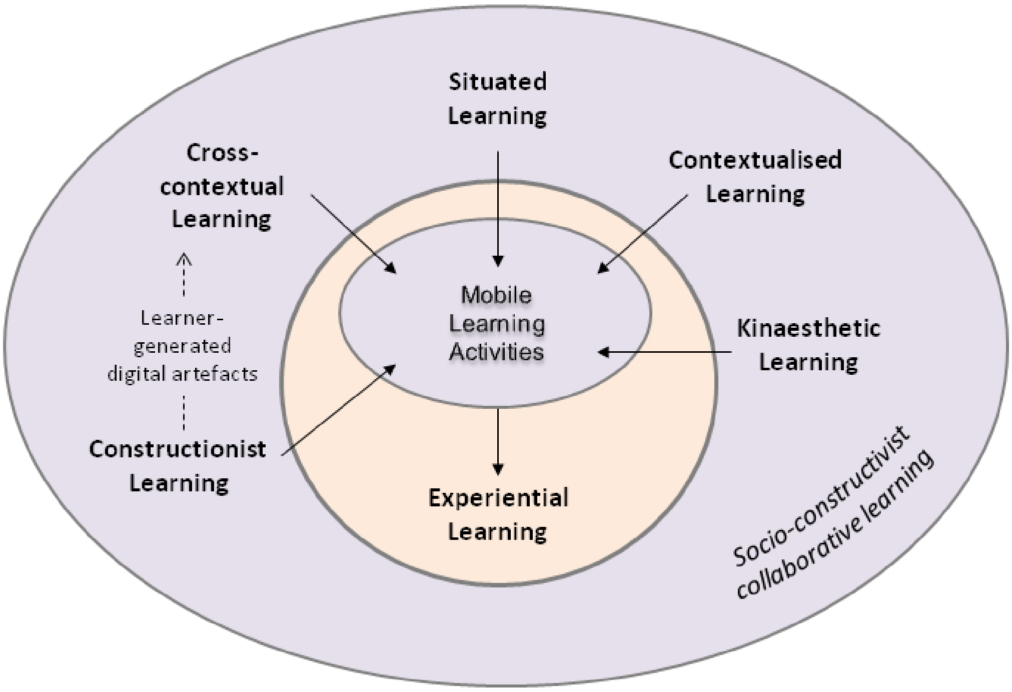


Figure 2.1: Mobile Learning socio-technical framework

The next section moves on to discuss the role of pedagogy in optimising the effectiveness of mobile learning within school settings, highlighting barriers to its uptake and going on to explore various approaches for its integration.

2.4 Pedagogy and Mobile Learning

The previous section highlighted how research into mobile learning has investigated its effectiveness where a socio-constructivist approach is adopted (e.g. Zurita & Nussbaum, 2007), where cross-contextual conversations situate learning across a variety of settings (e.g. Sharples, 2003; Wong & Looi, 2011), and where the approach is systemic (Passey, 2010). While the affordances of mobile technologies have been found to be both complementary to and disruptive for systems of formal education (Sharples, 2003), other research has sought to establish whether these tools can be leveraged to scaffold learning in 'messy' environments away from the classroom (Kurti, Spikol, & Milrad, 2008; Nouri et al., 2014).

Reiser and Tabak (2014) suggest that 'distributed scaffolding' should underpin such complex socio-technical learning environments (i.e. mobile learning in outdoor settings) to support learners: "*With distributed scaffolding, a variety of material and social tools with different affordances and constraints can be employed strategically to provide the large assortment of support learners need to develop disciplinary ways of knowing, doing, and communicating"* (p.193).

Going on to describe three forms of distributed scaffolding: (i) *differentiated,* where different forms of support (e.g. teacher, computer software) are used to scaffold different aspects of learning; (ii) *redundant,* where the same aspect is supported through different forms of scaffold (important, for example, in situations where learners may have missed one form of support); and (iii) *synergistic*, where learners are provided with different supports for the same learning activity at the same time (for example, a teacher supporting a student in making effective use of computer-driven scaffolds), Reiser and Tabak highlight that the key challenge in implementing scaffolding in such settings is in providing and withdrawing exactly the right amount of support (i.e. 'fading' the support) at the right time.

This study acknowledges the complexities of scaffolding learning in outdoor settings, and will seek to address this in the design of mobile learning activities.

2.4.1 Educational Affordances of Mobile Devices

Table 2.1 builds on the theoretical framework presented in Figure 2.1 by summarising the educational affordances of mobile devices identified in the literature reviewed above, and linking these with the learning theory or facet the affordance supports, together with the rationale for its inclusion. Only those affordances that have particular relevance for this study, i.e. the use of mobile devices by primary school children in natural outdoor settings and for follow-up class work, have been included.

Affordance	Learning Approach	Rationale
Portability & robustness	Collaborative	Enables easy sharing, can act as a focal point for organising group activities and fostering group and inter-group discussions.
	Situated/Outdoor Context-aware	Can be used in most settings without breaking or running out of battery.
Connectivity	Situated/Outdoor/ Context-aware	Can provide tailored information from web-based services, such as video or audio clips, in authentic settings at the point it is needed.
Communicative	Socio-constructivist	Can enable communication between participants and MKOs, for example, to progress understanding.
Context-aware	Situated/Outdoor Context-aware	Enables easy setting up of contextualised trails (e.g. using QR-codes) and can be tailored to work with sensors for augmented reality settings, providing relevant information to learners at the point of need.
In-built Camera app	Constructionist/ Outdoor/ Authentic	Can be used to focus in on detail, and to take/record photographs, audio or video and other data while in outdoor settings to feed into class topic work.
Scaffolding	Authentic/Situated/ Outdoor/ Context-aware	Apps (such as eBooks or insect spotter apps) can be used to scaffold learning by providing background information where learners need it, increasing learner autonomy and perception of ownership of learning.
Data-Sharing	Constructionist/ Outdoor/ Cross-contextual	Photographs, video and audio clips and data collected in one context can easily be shared for use in another to help foster reflection and class discussion, e.g. follow-up class activities.
Educational app functionality	All	There are apps to support most learning objectives, ranging from eBook or movie creators which enable learners to create and edit their own digital learning artefacts, to discipline-specific learning tools such as insect identifiers or entire learning environments.
'Prestige' item	Motivation	Still considered an object of high cultural value by children, so can act as a draw and motivating factor for learning activities.

Table 2.1: Linking affordances of mobile devices to learning theories and rationale

As is clear from section 2.3 and Table 2.1, mobile devices possess unique educational affordances that provide learners with a variety of innovative modes of interaction with learning, ranging from navigating context-aware learning environments to creation of video-enhanced eBooks; Passey (2010) identified a broad range of learning activities that can benefit from the affordances of mobile technology, while also identifying which kind of learning "*element*" a particular activity can support:

> "*Review and reflect*," where pupils capture audio, imagery, and video during lessons, used in plenary sessions to reflect on what has been covered, the key elements learned, how these fit into wider pictures, and how ideas might be taken further outside the classroom, can support higher cognitive and metacognitive levels of learning.
> "*Think forward*," where pupils access future topics via the Internet and capture relevant thoughts or ideas to contribute to these in class or through online discussions, can support aspects of the transfer of learning.
> "*Listen to my explanations*," where pupils record audio to complete homework assignments and teachers mark these verbal explanations, can support active engagement and reflection.
> "*Snap and show*," where pupils capture imagery that is downloaded, for wider pupil discussion, made accessible to parents so that they can see and discuss events that have happened in school, can support enhanced participation.
> "*This is what I've done and how I've done it*," where pupils create presentations of how they have used mobile technologies to tackle particular activities, these are recorded and made accessible on appropriate Websites for teachers and parents to see, can support enhanced social interactions.
> "*Tell me how I could improve this*," where pupils share their work in multimedia formats with peers, mentors, teachers, or trusted adults in order to seek evaluative feedback, assessments of their work, and ideas for improvement on which they can act, can support the development of supportive social networks.
>
> (Passey, 2010, p.69)

In a summary report on behalf of the BeLF charity, Pilkington (2012) discussed findings from a pilot project which studied a small number of children who had been given iPads to develop literacy skills for use in school and home settings. She noted that the iPads had enabled the children to develop ‘multi-modal literacy’ skills, where multi-modal literacy is *“the blending of sound, pictures and text in an integrated way to communicate meaning, which is an essential workplace skill for the next generation”* (p.8). While highlighting that: (i) parents reported their children had taken more responsibility for their own learning; and (ii) teachers had stated that all learners taking part had made improvements in line with progression targets to a greater degree than expected, concerns were also noted that some learners had concentrated more on the presentational aspects of their work, allowing lapses in grammar that were not as apparent in their non-iPad work. This latter was offset, however, by the greater complexity in sentence structure and vocabulary found in the iPad work.

The examples above demonstrate that teachers have at their disposal powerful learning tools that have the intrinsic ability to motivate and engage learners, particularly those not usually enthused by traditional learning methods (cf. Stead, 2005; Cooper, 2016), which can also support core learning essentials, such as reflection and discussion, and the ability for learners to easily edit and improve their work following formative feedback (Flewitt, Messer & Kucirkova, 2015).

2.4.1.1 Gender Issues

In their study of primary school children using iPads in Scotland, McPhee et al. (2013) found that there was a significant increase in the levels of emotional and cognitive engagement with boys using iPads when compared to activities without. They noted that there was no equivalent increase in girls, but suggested that this may have been related to the tendency of boys to ‘dive in’ and explore without wanting to wait for further explanation (in contrast to girls who preferred to have the learning activity explained first), and the iPad’s innate capacity to support this kind of learning. Although McPhee et al.’s study was small-scale, a related point was made by Passey, Rogers, Machell, McHugh and Allaway (2003) where they propose that ICT may enable boys to ‘shift’ in their traditional tendency to work in ‘burst’ patterns, to align with girls' more ‘consistent’ approach.

Other studies focusing on higher education students have argued that women "*quite frankly, enjoy interacting with computers less than do men*" (Cooper, 2005, p.321, citing Mitra, Lenzmeier, Steffensmeier, Avon, Qu & Hazen, 2000); this appears to be an over-simplification by Cooper, however, as it is clear from reading Mitra et al.'s paper that their position is that while in certain circumstances (for example, in the introduction of new technology), gender can play a role in initial attitudes, this is not static:

> *In conclusion it can be claimed that the process of acceptance of computer technology is related to gender where the women are far more cautious about exhibiting a positive attitude than men. However, when the functionality of a technology has been demonstrated within the context of a specific process, in this case the "learning process," women tend to embrace the technology and are often more positively pre-disposed*. (p.81)

In their recent study focusing on the use of tablet computers in primary schools in Thailand, Pruet et al. (2016) found no significant difference between the attitudes of boys and girls towards tablet computer use, although they suggested that there was evidence in the literature that girls were less likely to use computers as they grew older. Cooper raises an interesting point, where he proposes that the 'social context' of groups learning with ICT may impact on levels of anxiety or confidence when working together on tasks, thereby suggesting that girls working in girl-only groups are less likely to experience anxiety and more likely to collaborate well than those in mixed groups. It must be acknowledged that this paper was written over a decade ago, and one hopes that the proliferation of tablet computers and increased use of ICT, both in home and school settings, combined with rapid advances in how we interact with computers, will have diminished any gender differences in terms of affinity towards computers.

2.4.2 The Changing Role of the Teacher

It has been noted that the tendency when confronted with new technology is often to revert to the old safe ways of doing things, referred to as: "*one step ahead for the technology, two steps back for the pedagogy*" (Mioduser, Nachmias, Oren & Lahav, 1999, p.233), particularly when insufficient time is allocated to training and exploration (Ertmer, Addison, Lane, Ross & Woods, 2014).

Much has been written about how the use of ICT is necessitating a shift in the role of the teacher from '*sage on the stage'* to '*guide on the side'* (King, 1993, p.30), but others have highlighted concerns over this simplification: "*We view the teacher's role as involving a complex shifting of perspectives from the 'more-knowledgeable-other', to the co-constructor of knowledge, to the vicarious participant*" (Sutherland et al., 2004, p.420), arguably a more realistic perspective, particularly in the context of primary-school settings. Sharples et al., however, note that while the "*locus of control*" over learning in the classroom resides with the teacher, in mobile learning it may be "*distributed across learners, guides, teachers, technologies and resources in the world such as books, buildings, plants and animals*" (2005, p.6), which in itself can be an unnerving factor for teachers.

As can be expected with the introduction of any new educational initiative, teachers have expressed various concerns about the integration of mobile learning into their teaching, which include: their lack of experience and training (Perry, 2003) in using the technology; their perceived loss of control over their learners as referred to above (Sharples, 2003; Gray et al., 2017); whether it will actually enhance their teaching (Jones, 2004); the pressure resulting from an already over-full curriculum (Hennessy, Ruthven & Brindley, 2005); fears that the technology will 'break' (Koehler & Mishra, 2005; Gray et al., 2017); that learner-generated digital assets are not acceptable as evidence (Burden et al., 2012); and on-going issues which relate to a lack of time for exploration and curriculum development (Harris et al., 2009).

Those teachers that are confident in their ability to maintain a calm, supportive and inclusive learning environment for their learners, that are open to ceding control to learners when it is appropriate (as on field-trips or learner-led class-based activities), are more likely to embrace the potential that mobile learning affords (Sugar, Crawley & Fine, 2004). Teachers have an integral part to play in leading their learners to navigate their way through to optimising learning gains from mobile learning, but they need training and support to explore the best ways to achieve this.

McFarlane, Roche and Triggs (2007) recommend that teachers: (i) are given the chance to explore devices before being required to use them in classroom settings; (ii) have access to mentors or peers to discuss materials and approaches with; and (iii) have the opportunity to 'start small', using carefully-designed activities that "*clearly exploit the possibilities for learning inherent in mobile devices*" (p.6) to increase confidence and likely take-up.

Mishra and Koehler (2006) suggest that teachers need to develop technological pedagogical content knowledge (TPCK, later updated to TPACK) in order to integrate technology effectively in their teaching; this requires not only a deep understanding of the content they wish to teach and the most appropriate pedagogy for getting this across to their learners (i.e. their pedagogic content knowledge or PCK), which is defined as: "*the manner in which subject matter is transformed for teaching … when the teacher interprets the subject matter and finds different ways to represent it and make it accessible to learners*" (p.1021), but also an understanding of how various technologies can be used in different learning settings and how these are likely to impact on their teaching:

> *TPCK is the basis of good teaching with technology and requires an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones.* (p.1029)

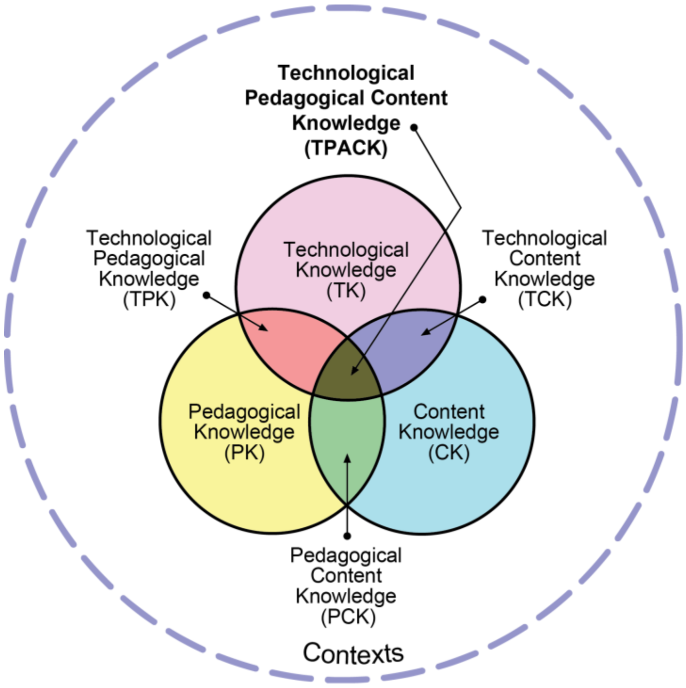


Figure 2.2: The TPACK framework (Reproduced by permission of the publisher, © 2012 by tpack.org)

This study will seek to conduct its data collection and analysis activities with an awareness of the TPACK framework, as further discussed in sub-section 4.2.5.

2.4.3 Assimilate or adapt?

While it is recognised that technology can act as a driver for pedagogic innovation (Laurillard, 2008; Law, 2008), it is also acknowledged that it requires careful planning from teachers if it is to lead to learning enhancement (Learning and Skills Network, 2009). Notwithstanding this, there is research which has posited that existing pedagogies can underpin the effective assimilation of ICT into teaching in schools, claiming that:

> *although there is an extensive research base on teaching and learning 'without ICT' which could inform teaching and learning 'with ICT'… there is a tendency to think that ICT is so 'new' that its use will be accompanied by 'new' pedagogies that will somehow transform teaching and learning.*

(Sutherland et al., 2004, p.413)

Taylor and Sharples (2006), however, have argued that such an approach risks minimising the benefits that technology can bring, and this sentiment is echoed by Luckin et al., who claim that it is:

> [necessary] *to change the mindset amongst teachers and learners: from a 'plug and play' approach where digital tools are used, often in isolation, for a single learning activity; to one of 'think and link' where those tools are used in conjunction with other resources where appropriate, for a variety of learning activities.* (2012, p.62)

A recurrent theme in the literature is that technology-based interventions in schools will fail if a teacher is not fully committed to them (e.g. Zhao & Frank, 2003; Jones, 2004; Luckin et al., 2012), and this is recognised in Naismith et al.'s statement that:

> *effective implementation of mobile learning requires a clear pedagogical approach, identification of specific learning needs/goals and teachers to be directly involved in decisions on planning and curriculum use.* (2004, p.34)

It is acknowledged that even if a teacher is keen to try out new pedagogic approaches, they do not work in a vacuum, and the learning landscape they operate in impacts heavily on how their time is allocated, with adoption of new technologies often bottom of a long list of items to be ticked off (Harris, Mishra, & Koehler, 2009). This approach, while understandable, risks short-changing both the teachers and their learners, as highlighted in sub-section 2.5 below. If mobile learning is to become embedded in the teaching of UK primary schools, teachers, and particularly head teachers, need to be further convinced of the value it brings not only to the teaching in their school, but to the working world their learners will enter.

2.5 The Digital Disconnect and Digital Capital

In their report 'Young Digital Makers', the UK-based charity Nesta warns:

> *As technology shapes our world, young people need to be able to shape it too. As skills and work become increasingly technologically mediated, the need for digital skills is paramount, with some calculating a potential £2 billion loss to the UK economy from unfilled roles requiring such skills.* (Quinlan, 2015, p.7)

While increasing numbers of young people rely upon mobile devices to consume digital content and to support daily social interactions (Ofcom, 2017), research has identified that teachers can lack the skills, knowledge and confidence in using digital tools required to innovate in their delivery of the curriculum (Perry, 2003; Harris et al., 2009; Gray et al., 2017). Characterised as a *digital disconnect* between teachers and technology (cf. Johnson, 2009; Erstad & Sefton-Green, 2013), this deficit has the potential to act as a significant barrier to the adoption of mobile learning in schools, with obvious ramifications for children's opportunities to benefit their learning through using mobile technologies in outdoor settings. Overcoming this barrier and addressing the digital disconnect is therefore essential in empowering teachers to engage confidently with digital technologies within their professional practice.

In the field of sociology, contemporary work on digital engagement (Park, 2012), which examined barriers to an individual's participation in the digital society, has recently been revisited in the context of a newly-defined model of *Digital Capital* (Park, 2017), while Hayhoe, Roger, Eldritch-Böersen and Kelland (2015) have employed the term 'technical capital' to describe "*skills in the use of and knowledge on modern technologies possessed by individuals*" (p.30), highlighting a relationship between the digital disconnect and contemporary notions of 'capital'.

Much of the literature exploring the various forms of capital has stemmed from the work of Bourdieu (1997), in which social and cultural capital were first identified, supplementing the traditional notion of economic capital. Following Bourdieu's observations that in order to "*possess the machines, he only needs economic capital;* [whereas] *to appropriate them and use them ...he must have access to embodied cultural capital*" (1997, p.50), Park emphasises that while access to digital devices facilitates the initial step towards digital engagement, this should be defined as "*the act of using digital technologies to benefit the user*" (2017, p.5). Borrowing further from Bourdieu, Park describes digital capital as "*an individual user's digital technology ecosystem* [which] *shapes and guides how the user engages with digital* *technologies*" (2017, p.1), adding that "*digital capital is not a separate entity from economic, cultural and social capital* [but] *is enmeshed with all types of capital*" (p.6).

While it can be argued that the integral nature of economic capital within Bourdieu and Park's work renders any simple appropriation of their models ineffective for the purposes of understanding how the introduction of mobile learning activities can influence the learning experience of primary-aged children, this highlights two inter-related gaps in the literature. The first of these gaps appears in connection with the specific focus on using mobile technologies rather than digital tools more generally, and it is evident that there is no discussion in the academic literature of the notion of *mobile* capital. The second gap forms around the question of how the experience of children active within an educational context can be represented, highlighting an opportunity to model *Mobile Capital* such that it incorporates both teachers and non-adult actors.

2.6 Summary of Chapter 2

In summary, this investigation adopts a broad definition of mobile learning as *"learning across multiple contexts, through social and content interactions, using personal electronic devices"* (Crompton, 2013, p.4), while the theoretical framework forming the backdrop to the study draws on assumptions of collaborative learning (e.g. Taylor et al., 2006; Zurita & Nussbaum, 2007), situated and authentic learning (e.g. Naismith et al., 2004; Herrington et al., 2008), experiential learning (e.g. Sharples et al., 2005; Lai et al., 2007), constructionist learning (e.g. Papert,1980), learning across contexts (e.g. Vavoula & Sharples, 2008) and distributed learning (e.g. Pea, 1993), and is informed by studies in the field of outdoor education (e.g. Littledyke, 2004), work exploring the pedagogy underpinning mobile learning (e.g. Luckin et al., 2012; Gray et al., 2017) as well as exploring notions of the digital disconnect (cf. Johnson, 2009; Erstad & Sefton-Green, 2013) and digital capital (Park, 2017).

While a review of the literature highlighted a number of studies exploring child mobile learning in outdoor settings (e.g. Rogers et al., 2002; Chen et al., 2004; Facer et al., 2004; Hughes, 2007; Lai et al., 2007; Klopfer & Squire, 2008; Wyeth et al., 2008; Rikala & Kankaanranta, 2014; Zimmerman & Land, 2014), all involved the use of bespoke software or hardware, suggesting a gap in the literature. Although McPhee et al.'s (2003) study of children using iPads in Scotland yielded some insights into learner engagement, no studies were identified that focused on the measurement of learner engagement in outdoor settings, highlighting a further gap in the literature.

Recognising the increasing pressures on teachers (Beastall, 2006; Harris et al., 2009), this research aims to address theoretical and practical concerns by collaborating closely with teachers to design activities that complement (rather than supplement) teaching commitments, while also seeking to engender self-confidence in teachers to harness the opportunities afforded by embedding mobile learning within their teaching practices.

In light of the above, the overarching research question guiding this study asks:

<u>*How might mobile learning influence learner engagement of primary school children working in groups on science topic work in outdoor settings?*</u> With three sub-questions emerging:

SRQ1: *How might the affordances of mobile technologies be leveraged to develop effective pedagogic interventions to engage primary-aged learners in outdoor settings?*

SRQ2: *How might engagement of primary school children be assessed in outdoor settings?*

SRQ3: *What barriers and challenges are associated with the integration of mobile learning within teachers' professional practice, and how might this be modelled?*

Having established these questions, the next chapter discusses two exploratory pilot studies used to gain experience in developing mobile learning activities for primary-aged children, which subsequently informed the selection of an appropriate methodological approach through which to conduct the investigation.

Chapter 3 Exploratory Phase

Aware from the literature that planning the whole investigation in detail at the outset was unlikely to prove valuable (Patton, 1990), and cognisant that I had not previously designed mobile learning materials for the intended audience, I undertook preliminary work to identify the specific requirements of this user group, and to assess the feasibility of employing qualitative data collection techniques in an outdoor setting. To this end, I drew on existing contacts to create an opportunity to trial a series of pilot activities, first with a group of Beaver Scouts (aged 6 to 8 years), and then with a Year 3 class (aged 8 to 9 years) at a local primary school. Working with these groups afforded opportunities to gain insights into which methodological approaches and data collection methods might be best suited to assist in addressing the study's research questions.

3.1 Pilot with Beaver Scouts

I had previously worked with a Beaver Scout Leader (pseudonomised as Mrs Cooper) to create activities to enable her scouts (aged 6 to 8 years) to gain their Information Technology badges. As Mrs Cooper had commented she would be keen to run further ICT-related activities the following year, I set up an initial meeting to describe the research and to gauge her interest in her 'pack' taking part in pilot mobile learning activities in a local nature reserve (see sub-section 1.4.2). I also explained that I would be observing and evaluating the activities, and that informed consent sheets would need to be signed by parents/carers.

Following her agreement, contact was made with the Education Co-ordinator of the reserve (pseudonomised as David Flint), with whom I had previously worked to create online learning materials, in the hope of arranging a series of meetings between him, Mrs Cooper and myself to feed into the design of the pilot activities. While David expressed interest in the research, following the second meeting it became clear that he saw the environmental activities he ran with schools as very distinct from anything that mobile devices could offer, and did not seem able to offer ideas or suggestions in terms of collaborating on the design of such activities. The decision was therefore reached that we would intersperse mobile learning activities led by myself with sensory activities run by David Flint.

3.1.2 Research and Design of Mobile Learning Activities

Initial conversations with Mrs Cooper had determined that these activities would form part of a sleepover camp, and, aside from acting as a feasibility study, were intended to be enjoyable whilst enabling the Beaver Scouts to demonstrate they had sufficient understanding and skills to earn their IT and Environment badges. Eight *iPods* provided by myself were to be distributed among seventeen Beaver Scouts (11 boys and 6 girls), working in groups of two or three; the mobile learning activities were to take place in the Greendale nature reserve (see sub-section 1.4.2) using two *mifi* devices to provide internet coverage.

In order to begin addressing the research question, these activities were designed to explore: (i) whether mobile learning activities were feasible for 6-8-year-old children working in groups in outdoor settings; (ii) the degree to which the various activities were fit for purpose; (iii) how well 6-8-year-old children were able to collaborate on tasks using *iPods* in an informal setting; and (iv) how well the technology performed.

As highlighted in sub-section 2.2.3, studies by Land & Zimmerman (2015), Rikala and Kankaanranta (2012) and Lai et al. (2013) reported on the effective use of Quick Response codes (QR-codes) in an outdoor mobile learning environment, and I was keen to assess whether this technology might be appropriate for the Beaver Scouts. I therefore created a demonstration webpage containing a short embedded video clip, and used the free website *www.qrcodegenerator.com* to create a QR-code to launch the webpage. Aware that the technical capabilities of the mifi devices would need to be tested, I ran a pre-pilot with two helpers in the nature reserve, both to gauge the extent of the network coverage provided by the devices and to assess whether scanning the QR-code would successfully launch the demonstration webpage.

Although the mifi devices had limitations in terms of the distance one could be away from them (the signal strength deteriorated beyond a distance of 50 metres), reasonable coverage could be maintained if the mifis were located at opposite ends of the designated area.

The embedded video clip was launched with no problems when within range of a mifi, and all 8 iPods were able to access it simultaneously.

Figure 3.1: Greendale Nature Reserve

Given the dual focus of the camp, collaboration with Mrs Cooper resulted in the development of three prototype activities, incorporating elements of discovery-based (e.g. Bruner, 1979), situated (Lave & Wenger, 1991), authentic (e.g. Naismith et al., 2004) and collaborative learning (e.g. Taylor et al., 2006), detailed in sub-sections 3.1.2.1 to 3.1.2.3.

3.1.2.1 Pilot Activity 1

Treasure hunts (also known as scavenger hunts) are well-known as a popular party game with primary-aged children, and an adaptation of these informed the design of the first activity, a QR-code Nature Trail, whereby the scouts would use an iPod to scan an initial QR-code to reveal a photograph clue of a location in the reserve where they would find their next code, and so on. It was felt that scanning 8 codes would suffice in terms of the trail, both to give the scouts a chance to let off steam, and to enable them to show they had mastered the IT skills.

The agreed design of the activity specified:

1) 8 locations around the orchard area of the nature reserve to be selected that were appropriate for securing the QR-codes, and photographs of these locations to be taken to act as 'photograph clues' for the trail;
2) 8 webpages to be created to incorporate these photograph clues with corresponding QR-codes to launch them, together with an activity sheet;

3) The map of the orchard area to be annotated to indicate the location of the QR-codes, to act as back-up for anyone struggling to find them;
4) A hands-on session to be held in the Scout Hut to give the scouts practice in using iPods;
5) A briefing of adult helpers to take place in the Scout Hut before walking to the reserve.

Once the QR-codes were printed, these were to be attached to trees or other suitable objects in the locations specified in 1) above, avoiding nettles and other hazards. Aside from reminding the scouts to take a photograph of the location as evidence, scanning each code also revealed a letter which the scouts were to write down on their activity sheet to form a word.

3.1.2.2 Pilot Activity 2

Aiming to harness the wifi-enabled capability of the iPods to support experiential and situated forms of learning, further collaboration with Mrs Cooper resulted in the design of a second activity; here, QR-codes would launch a series of informative video clips about insects while in the outdoor setting, to provide the scouts with contextualised information before venturing on a minibeast hunt. The activity would culminate in a short question and answer session to see if any information from the video clips had been retained.

The design of the activity therefore specified:

1) 6 short (1 to 2 minute) video clips of insects to be selected that were appropriate for this age-group, and a corresponding *Question and Answer* quiz created;
2) 6 web-pages to be created incorporating links to these videos, along with 6 corresponding QR-codes and additions to the activity sheet.

Online research into appropriate video clips determined that those on the BBC Learning Zone website fulfilled the criteria for the activity, namely that they were aimed at children aged 6-9 years, and those featuring insects most likely to be found in that area of the reserve were subsequently chosen.

3.1.2.3 Pilot Activity 3

The final activity was intended to give each group member an opportunity to share their favourite activity of the day with their group, using the simple video-capture functionality of the iPods. The aim of this was not only to contribute to the scouts demonstrating further skills for their IT badge, it was also hoped that they might be more candid without the presence of an adult. It was therefore decided that groups would be left to finish this activity on their own, with group members organising themselves to take turns to speak or film.

3.1.2.4 Follow-up Activity

It was agreed that follow-up IT activities would be held in the Scout Hut, where the scouts would be supported in incorporating the photographs and videos they took on the day into Microsoft PowerPoint presentations, which they would copy onto compact disks to take home.

3.1.3 Implementation, Evaluation and Initial Findings

Hands-on Session in the Scout Hut

This session was intended to give the scouts practice in using the iPods to take photographs and to scan QR-codes. The scouts appeared extremely eager to try out the technology, with the Scout Leader having difficulty in making herself heard due to their noisy enthusiasm. All scouts were able to have a turn at using the devices, and to successfully scan a test QR-code and take photographs.

Outdoor Session

The weather was extremely hot on the day, which impacted on the length of time the scouts could be out in the sun. Eleven boys and six girls took part, organised into seven groups of two or three (see Figure 3.2) and overseen by the Scout Leader, two Assistant Scout Leaders and four parent helpers.

Figure 3.2: Using iPods to follow a QR-code trail

Data collected during the day consisted of field notes (including overall impressions and details of informal discussions held with the Scout Leader, Assistant Leaders and adult helpers during the day), video-recorded observations, together with photographs and video clips taken by the scouts themselves. These were later subjected to thematic analysis to help draw out key themes and explore:

- How adept the children were in using the mobile devices;
- How the children worked together in groups, including the sharing of the mobile device;
- Whether the design of the activities was appropriate for this age-group in this setting;
- What impact the adult helpers had on how the children approached the activity;
- How engaged the children were at different points in the various activities;
- How the children dealt with the process of filming.

In a follow-up meeting to evaluate the activities, initial findings derived from this analysis were referred to the Scout Leader for her corroboration or otherwise, resulting in the following agreed set of findings being taken forward:

1. QR-code trails appear to work well with this age group, are straightforward to set up, and appear to be good at motivating and giving focus to an activity in an outdoor setting, with all Beaver Scouts observed as being on task for the duration of the trail;
2. There was a tendency for some Beaver Scouts to view following the QR-code trail as a 'race' (cf. Wyeth et al., 2008), with instructions to "*Take a photo as evidence*" sometimes ignored in order to 'beat' other groups to the next code. Where this was noted, adult helpers of these groups were asked to help reinforce the instruction during the activity, with the result that all groups built up a portfolio of photographs which they were proud to see incorporated into their digital presentations once back at the Scout Hut;
3. Despite setting the scout groups off on the trail at separate times, 'bunching' was observed at some locations, particularly at the beginning of the trail;
4. I noted two groups were left without adult supervision for extended periods during both the QR-code activities, resulting in these groups requiring on-going input from myself. It was recognised that future activities would require careful planning in terms of co-ordinating

adult-group ratios and support by adult helpers, to facilitate researcher observation rather than researcher participation;

5. ‘Hogging’ of the mobile device was observed in three groups, who all required adult input to resolve issues relating to equitable sharing;
6. In terms of the videos the children had taken of each other, three of the children (one girl, two boys) referred to the QR-code nature trail as being their favourite activity (“*finding the clue, the QR clue*”), two boys mentioned taking photographs as theirs, one other mentioned putting “*sticky-weed on my dad*”, two others mentioned playing outdoors, and three girls mentioned the sensory activities (e.g. “*feeling what things feel like*”). It was noted that two groups had taken some video clips during the day while in the reserve, but these were of each other off-task;
7. From a technological viewpoint, it was noted that video clips can be very difficult to see in certain light conditions, and difficult to hear if groups are sitting too near to each other. There were also some problems with the coverage provided by the mifi devices, as the scouts had not always followed the QR-code trail in the prescribed order and had therefore occasionally moved out of range;
8. All adults involved who gave an opinion felt the activities had been age-appropriate, enjoyable and educational, with the Scout Leaders expressing surprise as to how well the children had dealt with the technology. The following morning, three parents separately approached me to say how much their children (one girl and two boys) had enjoyed the activities, with one commenting that working with the *iPods* had appeared to motivate her son far more than other activities he had so far been involved in with the Beavers, noting that this had been the first time he had been keen to share what he had done.

3.2 Pilot with Year 3 of a local Primary School

Following evaluation of these activities, two schools were approached to gauge their interest in taking part in the research, both to deepen understanding of the feasibility of running particular mobile learning activities with particular age-groups in outdoor settings, and to help identify opportunities, barriers and challenges associated with integrating mobile learning within teachers’ professional practice. It was anticipated that initial findings from running and observing these activities would feed into the evolution of a series of research sub-questions (see sub-section 3.3).

While no response was received from one school, another, which had recently invested in a set of iPads*,* expressed a keen interest in exploring how these might be used for learning in outdoor settings (see sub-section 1.4.1). Following an initial meeting with the school's head teacher and subsequent permission granted for the school to act as participant, one Year 3 (Y3) teacher was selected to take part in a further pilot, building on the activities trialled by the Beaver Scouts.

3.2.2 Refinement of Mobile Learning Activities

An initial meeting was set up with the Year 3 teacher (pseudonomised as Mrs Baxter), to describe the research and to discuss and demonstrate the activities that had been run with the Beaver Scouts. Highlighting that she did not have much experience in using iPads or iPods, Mrs Baxter said she would be happy to follow my lead in terms of the design for these activities, mentioning that she had visited the reserve before and considered it highly-suitable for school visits; she also indicated that there would be up to 2 hours available for the outing and agreed a hands-on session should be run in school prior to the outing. In response to my raising concerns relating to the input of adult helpers, Mrs Baxter suggested that this should not be an issue, particularly given the older age of the children in her class (8 to 9 years).

3.2.2.1 Pilot Activity 1

Aware that some of the scouts had tended to treat the QR-code nature trail as a race and that there had been some issues relating to the sharing of the mobile devices, I edited the instructions on the webpages (those launched by the QR-codes) to reflect a focus on following instructions and team-working skills. As before, the web-pages included a photograph of where the next QR-code was located, but now also contained specific instructions on which group member should hold the clipboard, who should use the device to take a photograph and so on. This was achieved by providing each group member with a different-coloured sticker, and using instructions such as: "*Blue: you hold up the QR-code; Red: you take the* *photograph*". A simple activity sheet was designed to accompany this activity, requiring the groups to fill in the letter clues they found from scanning the QR-codes.

3.2.2.2 Pilot Activity 2

Following on from positive experiences in the scout pilot, the minibeast hunt informed by video-clip activity was also trialled with this age-group; refinements to the design included groups sitting further apart so that they could hear the accompanying audio, and that groups should also sit in the shade, if necessary, to improve visibility of the video. The activity sheet used in the previous pilot activity was augmented to include questions relating to the video clips about minibeasts, replacing the quiz used in the first pilot due to the practicalities of running this with the larger numbers involved.

3.2.3 Implementation, Evaluation and Initial Findings

Hands-on Session

Eight iPods were handed out to the class, seated in their 'table groups' of three or four, to give the children practice in taking photographs and scanning a demonstration QR-code. All groups in the session had at least one member with some experience in using tablet devices, and all confirmed at the end of the 30-minute session that they had had a chance to use the devices to take a reasonable photograph and scan a code.

As with the Beaver Scout session, levels of excitement were high, with all children appearing highly motivated to get a chance to use what they obviously considered a highly-valued item within the confines of their classroom. Some groups required a little help in using the QR-Code Reader app, but learnt quickly once they had been shown. Most groups spent the majority of the session taking selfies of each other and their group, with some demonstrating that they already knew how to take videos.

Outdoor Session

Eight *iPods* were distributed among twenty-nine children, working in groups of three or four, accompanied by two teachers, two teaching assistants and two parent helpers. The activity took place in the same local wifi-enabled nature reserve and the weather was very hot.

Figure 3.3: Y3 using iPods to follow a QR-code trail

Analysis of observations carried out on the day, triangulated with discussions held with Mrs Baxter and adult helpers, together with photographs and videos on the iPods, elicited the following initial findings:

1. QR-code trails appear to work well with this age group in a non-formal setting, and could be leveraged as a useful learning tool, although there were similar issues of the trail being seen as a race by the children;
2. Using an *iPod* for reading QR-codes, taking photographs and listening to video clips, in conjunction with the use of a paper worksheet to fill in, appears to work well with this age group, avoiding the difficulties associated with typing on a small screen, whilst giving a dual focus to the group;
3. Contextualised video clips can be usefully employed in outdoor settings where there is good visibility and groups are far enough apart, with analysis of the Activity Sheets showing that all groups had retained facts from the clips;
4. It is difficult to ensure that groups will share a device equitably, unless each group is allocated an adult to oversee their activity;
5. Similar issues relating to the internet coverage provided by the mifis were noted, particularly when children left the coverage provided by one device to move to the other. One device needed to be re-booted as internet access was temporarily lost. When these issues arose, it did result in confusion with children complaining that they were unable to

scan the code (cf. Rikala & Kankaanranta, 2012), although this was rectified once they were within range and the mifi was back on-line;

6. With reference to data collected on the iPods, 4 groups closely followed the instructions and took 8 or so photographs of the printed QR codes in their set locations; other groups took up to 35 photographs, including landscapes and close-ups of flowers and trees. One group took 39 photographs, but also captured over 20 minutes of video which included footage focusing on their minibeast hunt. Here, one group member was interviewing the others about ants, and it was noted that those being interviewed came up with identical facts to those covered in the relevant video clip in the Pilot 2 activity (e.g. "*Did you know that ants can carry 100 times their own weight?*"). Another member of this group later went off on his own and created an 11-minute documentary about the reserve itself, which, while not always factually correct, was carried out in a conversational and informative manner that also gave a strong sense of peace and enjoyment: "*This [nature reserve] is a really pretty one, that's why people like it ...it's the best one I've ever seen, literally. It's nice, calming and really pretty. There's a butterfly up there, but I don't think I've got time to catch it to put it on a film";*
7. Teaching staff later commented on how much the children had appeared to enjoy the activity, how it kept them focused while enabling them to 'let off steam', and that they could appreciate the educational value of using QR-code trails in a variety of settings.

3.3 Evolution of Tertiary Research Questions

Through my collaboration with the Beaver Scout Leader and Y3 teacher, and participation and observation of the mobile learning activities themselves, I was able to gain valuable insights into how children of primary school age interact with each other and mobile devices in an outdoor setting. This resulted in the formulation of a series of tertiary (TRQ) research questions:

Primary research question: ***How might mobile learning influence learner engagement of primary school children working in groups on science topic work in outdoor settings?***	
SRQ1	**How might the affordances of mobile technologies be leveraged to develop effective pedagogic interventions to engage primary-aged learners in outdoor settings?**
TRQ1.1	How does the mobile learning activity engage this age group in this setting?
TRQ1.2	How does this age group collaborate in groups using mobile devices with this activity?
TRQ1.3	How might the team leader/teacher's approach be influencing the engagement of learners with this activity?
TRQ1.4	What part do the supporting learning materials play in scaffolding the learning, and how might they be improved?
SRQ2:	**How might engagement of primary school children be assessed in outdoor settings?**
TRQ2.1	How do teachers assess learner engagement in classroom settings?
TRQ2.2	Which facets of engagement are evident in mobile learning activities?
SRQ3:	**What barriers and challenges are associated with the integration of mobile learning within teachers' professional practice, and how might this be modelled?**
TRQ3:1	How might the 'learning landscape' of the school be impacting on this activity (e.g. is ICT seen as integral or an add-on; is environmental education seen as an add-on)?
TRQ3:2	How might the provision of resources such as hardware and software be impacting on this activity?

Table 3.1: Primary, secondary and tertiary research questions

3.4 Summary of Chapter 3

Due to the complex nature of observing children in outdoor settings, it was clear from running the pilots that it would be crucial not only to clarify in advance which aspects I was intending to focus on during future activities, but also to determine which methodological lens and methods would help me collect the most valuable data to address the research questions.

In my role as observer, it was easy to position myself as one of the many adult helpers (and was accepted by the children in both pilots as such), but I was aware this was likely to have implications on my ability to freely observe if I was also being called upon to help run the activity. As a corollary, however, I was able to gather authentic and valuable insights into how the activities worked, both from the viewpoint of the children and as an adult helper.

In terms of methodology, the experience clarified that the approach chosen would need to be agile, responsive to feedback, and flexible enough to deal with unforeseen circumstances as they arose, and that close collaboration with practitioners was likely to be key in helping ensure that the mobile learning activities designed were fit for purpose and had ‘buy-in’ from the participant teachers.

With specific reference to data collection and analysis, I learnt that: (i) video recordings would provide an extremely rich data source from which to derive findings; (ii) the use of field notes was likely to prove valuable to aid recall, especially in summing up and contextualising an activity or where chance conversations were not recorded (Fitzgerald, Hackling & Dawson 2013); and (iii) given the complexity of dealing with large quantities of data source files (e.g. video files and photographs), *Computer Assisted Qualitative Data Analysis* (CAQDAS) software should be used to help organise the various data sources.

This chapter has described the design and implementation of five pilot mobile learning activities carried out as part of an exploratory phase looking into the feasibility of running mobile learning activities with primary-aged children in outdoor settings. Following the drafting of the tertiary research sub-questions outlined in section 3.3 above, the next chapter details and justifies the methodological approach, research design, methods and analytical approach chosen to address these.

Chapter 4 Methods and Methodology

The previous chapter described how initial findings that emerged from designing and running mobile learning pilot activities fed into the evolution of a series of research sub-questions; this chapter details the methodological approach and methods chosen to answer these questions, using insights gained from the exploratory phase to inform decisions relating to both the methodological lens and analytical approach used in the later phases of the study.

4.1 Research Context

Within an overarching pragmatist approach to the research (Dewey, 1938), the epistemology underpinning this investigation leans towards interpretivism (Denzin & Lincoln, 2000), and is supported by an ontological stance which can be described as subjectivist. As an investigation examining the influence of mobile technologies on engagement across contexts, this research explored the experience of both schoolchildren and teachers and their relationships to technologies and to interventions designed to promote engagement with learning in outdoor settings.

4.2 Discussion of Possible Research Methodologies

In seeking to identify the optimal vehicle through which to examine this diverse range of characteristics, several methodologies appeared to offer approaches to answering the research questions:

(i) *ethnography*, as the research explored the lived experience of teachers and pupils, and the culture within which they operate (Hammersley & Atkinson,1983);

(ii) *case study*, as the research was likely to involve a relatively small number of teachers and classes as participants (Yin, 2003);

(iii) *action research* or *design based research*, as the research was focused on the development of a series of mobile learning interventions requiring iterative cycles of design, implementation, evaluation and refinement (Kemmis & McTaggart, 2005).

4.2.1 Consideration of Ethnography

While the research focus encompassed the experience of teachers and children, the primary purpose of this aspect of the study was to inform the design of mobile learning activities; although an ethnographic lens was employed when conducting observations and interviews with practitioners, an approach based purely in ethnography would not be expected to accommodate effecting change within a situation, and this approach was therefore rejected as the over-arching methodological approach.

4.2.2 Consideration of Case Study

Similarly, in an investigation yielding multiple sources of mixed forms of evidence, aspects of case-study methodology such as Yin's 'chain of evidence' (2003) offer useful mechanisms to assist in the triangulation of findings; however, while illustrative cases were employed to highlight findings to practitioners in an easily-assimilable form, *case-study* as the over-arching approach would have been largely incompatible with an investigation seeking to effect change, and was therefore also rejected as the central methodology guiding this investigation.

4.2.3 Consideration of Action Research

In seeking to identify an over-arching methodology that was consistent with the aim of effecting change through the development of a series of iterative cycles of design, implementation, evaluation and refinement, both action research and design-based research were worthy of consideration.

Since the first introduction of the term by Lewin (1946), 'action research' has emerged as a diverse methodology which boasts a number of significant variants, popularised in different social and cultural settings as 'emancipatory' (Zuber-Skerritt, 2003), as 'participatory' (cf. Freire, 1972), and as 'critical social science' (Habermas, 1972). A full discussion of these variants is outside the scope of this chapter; however, a methodology such as action research that is broadly consistent with the aim of driving change was clearly worthy of consideration. While this focus on effecting positive change might on the surface appear to offer immediate appeal, it is particularly noteworthy that action research is frequently described as a methodology which is intended to be owned by practitioners rather than researchers, for example, Cohen, Mannion and Morrison (2007) highlight that action research:

is not research done on other people. Action research is research by particular people on their own work, to help them improve what they do, including how they work with and for others (Cohen, Mannion & Morrison, 2007, p.298).

This emphasis on the practitioner is further underlined by Carr and Kemmis (1986), for whom action research is regarded as an activity characterised by "*self-reflective enquiry*" (Carr & Hemmis, 1986, p.162) on the part of its participants, while Kemmis and McTaggart (1992) later suggest that a practitioner undertaking an action research project would simply "*plan, act, observe and reflect more carefully, more systematically, and more rigorously than one usually does in everyday life*" (Kemmis & McTaggart, 1992, p.10). The insistence on practitioners undertaking research to effect change in *their own practice* therefore rendered action research inappropriate as a framework for this study.

4.2.4 Consideration of Design-Based Research

While the generation of theory remains the key focus of many methodological approaches, such as ethnography, *design-based research* (DBR) attempts to bridge the gap between theory and practice, seeking to use theory to inform practice while also developing theory in response to evidence emerging in that practice. As such, DBR supports, and indeed advocates, working with practitioners in naturalistic settings to develop solutions to real-world practical problems (Barab & Squire, 2004), while simultaneously embracing the aim of developing evidence-based design principles from those solutions that will enable other practitioners to apply these in their own settings (Brown, 1992).

Having emerged in response to recognition in the field of educational psychology that the evaluation of interventions in laboratory conditions did not yield findings which were transferrable into the messy conditions of classroom situations (Brown, 1992), contemporary definitions of DBR describe it as "*a series of approaches, with the intent of producing new theories, artefacts, and practices that account for and potentially impact learning and teaching* *in naturalistic settings*" (Barab & Squire, 2004, p.2). The pragmatist-leaning epistemology underpinning DBR affords a degree of flexibility and responsiveness to emerging findings and unforeseen events that facilitates the introduction of different methods and techniques as the need arises. In conjunction with this, DBR's focus on working with practitioners through iterative cycles of design, implementation, evaluation and refinement of technology-enhanced learning interventions (see Figure 4.1) marked it out as the most promising methodological approach to answer the research questions, and over the last two decades DBR has become the *de facto* choice for many researchers seeking to develop and evaluate technological interventions in educational settings (e.g. Wang & Hannafin, 2005; Looi, Zhang, Chen, Seow, Chia, Norris, & Soloway, 2011; Kucirkova, 2017).

As an approach which remains flexible and responsive to findings as data are collected and analysed, the capacity of DBR to both adapt to emerging circumstances and to incorporate aspects of other methodologies, such as the development of illustrative cases outlined above, marked it out as the most suitable methodological approach for this study.

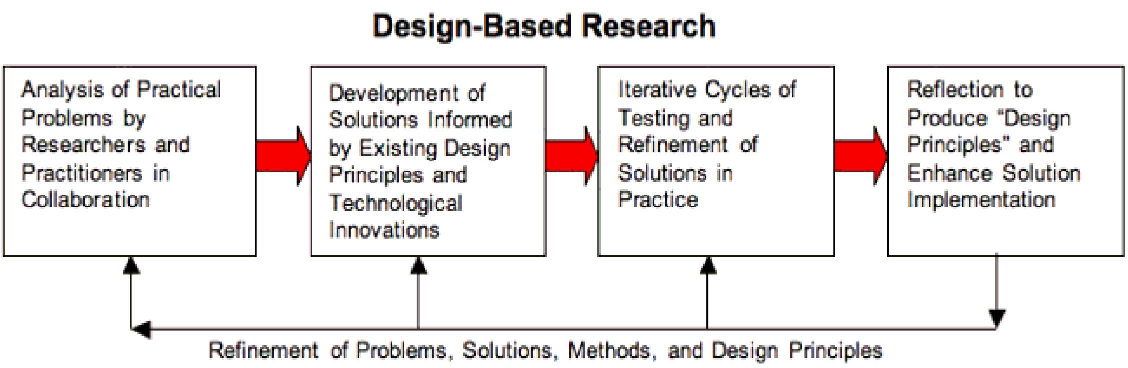


Figure 4.1: A Design-Based Research approach (Reeves, 2006, p.59)

4.2.5 Application of Design-Based Research in this Study

This study employed a qualitative, design-based research methodology, and following both Brown (1992) and Wang and Hannafin (2005), took an iterative approach to the design, development, evaluation and refinement of a range of mobile learning interventions.

Building on Passey's view of effective mobile learning as occurring both within and across contexts (2010), the study designed a series of mobile learning activities (MLAs) that sought to integrate learning carried out in the field with classroom activities, "*bringing the outside inside*" (Ekanayake, 2011). Employing a flexible, emergent and iterative research framework, the design and deployment of these interventions across formal, semi-formal and situated learning environments was responsive to evaluative feedback from learners, teachers and other stakeholders as it arose.

Collaboration with teachers was conducted with an awareness of Mishra and Koehler's (2006) TPACK framework (see sub-section 2.4.2), wherein the overlap of a teacher's *content*, *pedagogic* and *technological* knowledge impacts on their use of technology in their teaching. Aiming to engender higher levels of TPACK in teachers, particularly those with little experience or under-confident in using technology, hands-on demonstrations, technological advice, support and step-by-step guides were provided to teachers, to inspire, highlight possible solutions and increase confidence.

Throughout the study, qualitative data were collected through a combination of observations in both formal and situated contexts, informal conversations while out in the field, field notes, semi-structured interviews with teachers and focus groups with learners, alongside analysis of learner-generated digital and paper-based artefacts, to help triangulate findings and strengthen issues relating to validity.

As a dual-focused study aiming to address both practitioner interests and theoretical considerations, data collection both drove the refinement of the interventions, and responded directly to the research questions. Analysis of the data adopted an approach based in grounded theory (Glaser & Strauss, 1967; Charmaz, 2006), and informed the development of theory as the research progressed.

4.3 The Role of Grounded Theory in the Research

Grounded theory is a widely-used approach for analysing qualitative data that develops theory from the systematic coding and categorisation of data (Glaser & Strauss, 1967). Theories emerge from the data, wherein, following an inductive and iterative approach, patterns and relationships within the data reveal themselves to the researcher.

While Glaser and Strauss initially maintained that researchers using grounded theory should start their analysis purely from the data in front of them, delaying a review of the literature until after data analysis to avoid contamination from any preconceptions, they also (separately) clarified that this was unrealistic in practice (e.g. Glaser & Holton, 2004) and the aim for the researcher should therefore be to remain open to following the data, wherever it leads (Ramalho, Adams, Huggard & Hoare, 2015). Acknowledging the importance of understanding the background and context to a research area, Charmaz (2006) suggests that the literature "*set[s] the stage for what you do in subsequent sections or chapters*" (p.166), while Bryant and Charmaz (2007) later emphasise the importance of being able to "*situate your work within the body of related literature*" (p.123). This study aligns with both Charmaz (2006) and Bryant and Charmaz (2007) in recognising the value of grounding one's research within the existing academic literature, whilst also stressing the importance of using reflexivity to mitigate against researcher preconceptions and bias.

4.3.1 The 'Mechanics' of using Grounded Theory

Grounded theory makes use of the following coding methods in order to generate theory:

- *Open coding*, where the data are examined in order to identify units of analysis to which one can attach codes and categories, to help give meaning to the data;
- *Axial coding*, where relationships between codes, categories (and existing theory, if applicable) are explored to generate further theory;
- *Selective coding*, where the core category or categories (i.e. the variables around which most of data are focused) is identified.

Three processes run simultaneously when developing grounded theory. Coding is carried out within a process of *constant comparison* (Glaser & Strauss, 1967), where new data are constantly compared with existing data and categories to ensure that the coding and theoretical frameworks remain appropriate, with modifications made, where necessary, to ensure best fit and development of theory that is faithful to the data. This process should also continue to use data gathered across different settings, different times or with different methods, until no new codes, categories or insights emerge, a point known as *saturation* (Glaser & Strauss, 1967). As part of this, *progressive focusing* (Parlett & Hamilton, 1976) can also be employed to get closer to the data, where each batch of data is explored and reflected upon to provide the lens with which to focus in on the next batch.

Running alongside the coding process is *theoretical sampling*, described by Glaser and Strauss as:

> *the process of data collection for generating theory whereby the analyst jointly collects, codes, and analyses his data and decides what data to collect next and where to find them, in order to develop his theory as it emerges. This process of data collection is controlled by the emerging theory.* (1967, p.45)

This iterative process continues until *theoretical saturation* is reached, that is, sufficient data are gathered for the researcher to feel confident in drawing up a theoretical explanation of the issues under research. Glaser and Strauss (1967) highlight four key criteria for evaluating the strength of such a theory:

- The theory must closely *fit* the substantive area in which it will be used;
- It must be readily *understandable* by laymen concerned with this area;
- It must be sufficiently *general* to be applicable to a multitude of diverse daily situations within the substantive area, not just to a specific type of situation;
- It must allow partial *control* over the structure and process of daily situations as they change through time. (Glaser & Strauss, 1967, p.237)

In the same way as grounded theory was used to generate knowledge to inform *theory*, a similar process fed into the development of a set of guidelines to inform *practice*. Once saturation of codes and categories had been reached, *ATLAS.ti* query tools were used to analyse recurring patterns or themes within and across cycles, in conjunction with member-checking and referral of emerging findings to expert witnesses. Remaining patterns were then re-examined against the backdrop of the literature during the final stages of the study, and those that demonstrated a high degree of confidence between the theoretical claims made and the empirical evidence collected were used to generate guidelines for practitioners wishing to trial similar mobile learning activities within their own schools.

4.4 Validity and Reliability Considerations

It is broadly accepted that validity and reliability are essential components in ensuring the robustness of findings in any research endeavour, with qualitative research particularly prone to criticism for its perceived lack of rigour (e.g. Denzin & Lincoln, 2000). Hoepfl's (1997) summary of the characteristics of qualitative research serves to highlight areas where the practice underlying the interpretivist paradigm might be susceptible to such criticism:

1 Qualitative research uses the natural setting as the source of data. The researcher attempts to observe, describe and interpret settings as they are, maintaining what Patton calls an "empathic neutrality" (1990, p.55).

2 The researcher acts as the "human instrument" of data collection.

3 Qualitative researchers predominantly use inductive data analysis.

4 Qualitative research reports are descriptive, incorporating expressive language and the "presence of voice in the text" (Eisner, 1991, p.36).

5 Qualitative research has an interpretive character, aimed at discovering the meaning events have for the individuals who experience them, and the interpretations of those meanings by the researcher.

6 Qualitative researchers pay attention to the idiosyncratic as well as the pervasive, seeking the uniqueness of each case.

7 Qualitative research has an emergent (as opposed to predetermined) design, and researchers focus on this emerging process as well as the outcomes or product of the research.

8 Qualitative research is judged using special criteria for trustworthiness.

(Hoepfl, 1997, p.49)

Pre-emptively countering the potential paradigmatic conflict between qualitative and quantitative research approaches, Lincoln and Guba (1985) argue that the term validity as used in quantitative research is not appropriate in qualitative research, instead proposing four alternative measures to judge what they term the ‘trustworthiness’ of a study, namely:

- **Credibility** (ensuring the findings are credible from the participant’s viewpoint; replaces *internal validity*);
- **Transferability** (describing the research in enough detail to enable judgements to be made regarding its transferability to different settings; replaces *external validity*);
- **Dependability** (as above, providing enough detail of the research context to enable judgements to be made regarding the consistency of its findings; replaces *reliability*);
- **Confirmability** (ensuring that the research findings can be corroborated by others; replaces *objectivity*).

In order to maintain epistemological alignment with the qualitative paradigm, and the design-based methodological approach underpinning the research, Lincoln and Guba’s recommended terminology was adopted for the purposes of this study.

To help strengthen the credibility and dependability of the study, repetition of DBR cycles was built into the research design (see Figure 4.2) in an attempt to replicate findings and thereby promote generalisability (Design-Based Research Collective, 2003), with continuing contact with teacher participants used to encourage reflexivity and evaluation of the interventions (Brenner, 2006).

In acknowledging the infeasibility of accurately reproducing the messy conditions of the learning environment, particularly where situated in outdoor settings, thick descriptions (Collins, 1992) were included in the account of cycles to help strengthen issues relating to transferability, and to assist practitioners in determining the feasibility of undertaking similar activities within their own praxis. Any emergent findings within each cycle were also highlighted at the point they occurred within the description, to aid clarity.

4.4.1 Researcher as Research Instrument

As highlighted by the Design-Based Research Collective in 2003, there is an inherent tension in being both the facilitator and the researcher, as in trying to promote confirmability of the research findings *“while attempting to facilitate the intervention, design-based researchers* *regularly find themselves in the dual intellectual roles of advocate and critic*" (p.7). This dual role is further complicated when the researcher is called upon to act as participant (as occurred in the pilot activities in the exploratory phase), while also serving as the primary research instrument.

Whilst it is acknowledged that it is no easy task for researchers to guard against unconscious bias slipping in at all stages of data collection and analysis (Patton, 2003), there are many strategies a researcher can employ to counter this, as highlighted below. Alongside the need to remain vigilant and objective, there are other human qualities that are necessary to give credibility to findings; Strauss and Corbin, for example, highlight theoretical sensitivity as a key quality for researchers, referring to it as: "*the attribute of having insight, the ability to give meaning to data, the capacity to understand, and capability to separate the pertinent from that which isn't"* (Strauss & Corbin, 1990, p.42).

It is hoped that the systems for data analysis developed in collaboration with teachers, and subsequent regular referral of findings to them as expert witnesses (Yin, 2003) and participants using 'member checking' (Lincoln & Guba, 1985), helped mitigate against possible researcher bias, particularly when employed in conjunction with methodological triangulation (McKenney, Nieveen & van den Akker, 2006) and the repetition of cycles. In addition, it is hoped that the extensive use of learner-generated video clips as a data source both strengthened the credibility, confirmability and authenticity (Kucirkova & Falloon, 2018) of findings, positioning the learner voice as central within the research.

4.5 Research Design

Following the exploratory phase described in Chapter 3, a formative phase was undertaken during the 2013-2014 academic year (running from September to July), incorporating close collaboration with four primary school teachers from the same school. Two streams of research activity emerged from this: a form of *discovery-based learning* (cf. Bruner, 1979), wherein learners discover facts for themselves, and *production-focused learning*, where learners build and demonstrate their learning through the development of an artefact (Papert, 1980), such as video clips or blog-posts.

Building on these initial findings, a further formative phase was developed in close collaboration with teachers in 2014-2015, increasing both the opportunities for refinement of mobile learning activities associated with the two research activity streams mentioned above, and the pool of teacher experience to draw on. This phase resulted in the formulation of a set of draft mobile learning design principles (Reeves, 2006) which informed the design of the final set of summative MLAs, which took place in the academic year 2015-2016.

Responsive to feedback and changing circumstances as they emerged, iterative cycles of design, development, implementation and evaluation for the activity streams were built into the research design, with findings from each cycle feeding into the next, as illustrated in Figure 4.2.

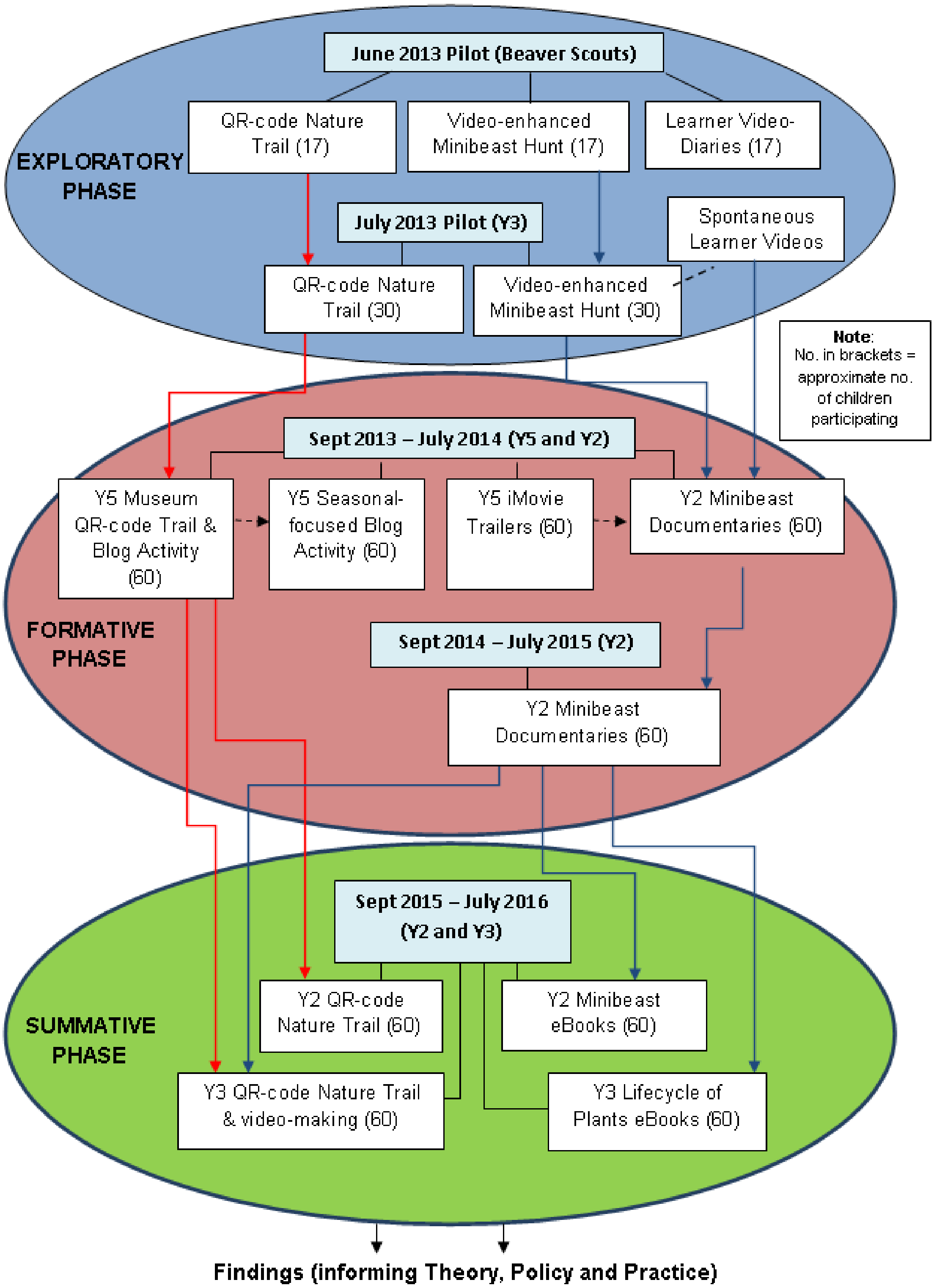


Figure 4.2: Research Design illustrating links between exploratory, formative and summative phases

4.6 Data Sources and Research Methods

A key strength of design-based research is its flexibility in enabling the researcher to select those data gathering and analysis methods that best answer the research questions, as the need arises. This advantage is amplified when grounded theory has been adopted as the underlying analytic approach, where data (likely from a variety of sources), continue to be collected until the point of saturation is reached (Glaser & Strauss, 1967).

As detailed in Chapter 3, a series of tertiary research questions was formulated during the exploratory phase of the research, which are listed in Table 4.1 for convenience.

Primary research question: ***How might mobile learning influence learner engagement of primary school children working in groups on science topic work in outdoor settings?***	
SRQ1:	**How might the affordances of mobile technologies be leveraged to develop effective pedagogic interventions to engage primary-aged learners in outdoor settings?**
TRQ1.1	How does the mobile learning activity engage this age group in this setting?
TRQ1.2	How does this age group collaborate in groups using mobile devices with this activity?
TRQ1.3	How might the team leader/teacher's approach be influencing the engagement of learners with this activity?
TRQ1.4	What part do the supporting learning materials play in scaffolding the learning, and how might they be improved?
SRQ2:	**How might engagement of primary school children be assessed in outdoor settings?**
TRQ2.1	How do teachers measure learner engagement in classroom settings?
TRQ2.2	Which facets of engagement are evident in mobile learning activities?
SRQ3:	**What barriers and challenges are associated with the integration of mobile learning within teachers' professional practice, and how might this be modelled?**
TRQ3:1	How might the 'learning landscape' of the school be impacting on this activity (e.g. is ICT seen as integral or an add-on; is environmental education taught?
TRQ3:2	How might the provision of resources such as hardware and software be impacting on this activity?

Table 4.1: Primary, secondary and tertiary research questions

Reflecting on the experience gained from designing, collaborating on and observing the pilot activities, consideration was given to which data sources and research methods might be most appropriate to answer these questions, the results of which are summarised in Table 4.2; this is followed by a description of how the particular methods selected were addressed within the study.

Data Source/ Research Method	Research Purpose	TRQ Addressed
Observation:		
Research journal/ Field notes	To be written up shortly after an event (e.g. mobile learning activities, meetings, class observations) to provide an in-depth record of impressions on the day and a reminder of any informal conversations.	TRQ1.1 TRQ1.2 TRQ1.3 TRQ1.4 TRQ2.2 TRQ3.1 TRQ3.2
Photographs	A record to complement field notes.	TRQ1.1 TRQ1.2 TRQ1.4 TRQ2.2
Video recordings	A record of how an activity was run, how the children collaborated, how they used the device, what they said, how engaged they were, how the teacher interacted with them, how many adults were present, etc.	TRQ1.1 TRQ1.2 TRQ1.3 TRQ1.4 TRQ2.2 TRQ3.1 TRQ3.2
Interviews *(audio recordings)*	To help explore teachers' and group leaders' views on teaching/learner engagement/mobile learning/how the activities ran, etc.	TRQ1.1 TRQ1.2 TRQ1.3 TRQ1.4 TRQ2.1 TRQ3.1 TRQ3.2
Focus groups *(audio recordings)*	To help explore children's views on mobile learning and the activities they took part in.	TRQ1.1 TRQ1.2 TRQ1.3 TRQ1.4 TRQ3.2
Artefacts:		
Teacher-produced	To give context to and support learning activities (e.g. blog entries, worksheets).	TRQ1.3 TRQ1.4 TRQ3.1
Researcher-produced	To support mobile learning activities, e.g. development of eBooks and worksheets to give context/focus to activities in outdoor settings.	TRQ1.3 TRQ1.4 TRQ3.1
Learner-produced	To help understand how the devices were used, how learners interacted in their groups while using them, and to evaluate possible cognitive gains.	TRQ1.1 TRQ1.2 TRQ1.3 TRQ1.4 TRQ2.2 TRQ3.1 TRQ3.2

Table 4.2: Data source/method, research purpose and TRQ addressed

4.6.1 Observations

From the experience of running the pilots, I recognised that video-recorded observations were likely to be a key data source from which to derive findings for the study, due to: (i) the inherent richness of the medium in capturing images and sound over time; and (ii) the ability to record from multiple viewpoints while moving around with groups as they took part in the activities.

I had also learnt that I might be called upon to participate in the running of activities at short notice and that this, while affording alternative perspectives on the activity, would impact on my ability to freely observe. As primary-aged children in the participant school were accustomed to the presence of ‘adult helpers’ during outings, I decided that the best strategy for collecting the most authentic data would be to not over-emphasise my role as researcher i.e. to act as “*observer-as-participant*” (Cohen, Mannion & Morrison, 2007, p.404). I therefore limited my use of video-recording to : (i) ‘over-view’ clips, where I was seeking to record a holistic view of an activity from a distance, for example; and (ii) where I was following or supervising a group, the use of ‘close-up clips’, to focus in on what it was the children were looking at rather than the children themselves. Whilst being the least-obtrusive method from the children’s perspective, and thus diminishing any Hawthorne effect (Roethlisberger & Dickson, 2003), this also enabled me to record their voices along with enough visual information to give context.

Remaining cognisant of my primary role as an observer, I decided not to discourage conversations with children should they initiate them with me, as I felt that not communicating if they spoke to me might come across as unfriendly or odd (Cohen et al., 2013), and that gaining insights from them as they were engaged in the activity was likely to prove valuable in data collection terms.

Finally, I also determined that, following on from my experience in running the pilots, I would take stills to remind myself of particular scenarios as they occurred, and that any chance conversations would be written up in my research journal following the session (if they had not been video-recorded), as well as general impressions of how the activity had gone.

During the pilots, it became obvious that it would be easy to get ‘swamped’ by attempting to follow too many leads when observing in the outdoor setting, risking collection of superficial data that were unlikely to address the research questions. This echoes Wilkinson’s warning (2000), who suggests that it is important for the researcher to distinguish between observing *molecular* and *molar* units of behaviour, where molecular refers to short units such as gestures or snatches of a conversation, and molar, larger units as determined by the researcher.

In light of this, and following Goldman, Erickson, Lemke and Derry (2007), the methodological lens was established before observations took place, in order, for example, to help determine: (i) the focus of the analysis (the teachers, the pupil groups, the individuals within groups, the whole class); (ii) my role (e.g. as research instrument, as designer, as adult helper); and (iii) which elements to focus on (e.g. group interactions, time on task, adult input).

In collaboration with teachers, this led to the development of a set of markers to help establish emotional, behavioural and cognitive measures of engagement, drawing on Fredricks et al. (2004) and McPhee et al.'s (2013) work in this area, to guide my approach while out in the field. Purposive sampling (Cohen et al., 2007) was employed as a strategy to identify cases likely to yield rich data and details of how this worked in practice are presented in Chapters 5, 6 and 7.

4.6.2 Meetings and Interviews with Teachers

Regular, informal meetings and email exchanges took place with teacher-participants to: (i) collaborate on the design of mobile learning activities; (ii) develop the markers for engagement mentioned above; and (iii) discuss findings from the activities as they emerged. While I felt it was unnecessary to digitally-record the informal meetings, I did create agenda and follow-up notes to maintain a record of what issues were covered and what was agreed.

A series of semi-structured summative interviews were conducted with participant teachers at the end of each DBR cycle, to evaluate the mobile learning activities and to gain insights into their teaching approach. These interviews were audio-recorded.

Following Kvale (2008), the drafting of questions and conduct of the interview aimed to ensure that:

- the purpose of the interview was explained;

- questions asked were clear, to-the-point and unbiased (both in content and delivery);
- questions were sufficiently open to ascertain aspects of key importance to the interviewee, while ensuring interviews remained relevant;
- responses were listened to carefully, and reference back to these was made where appropriate;
- the interviewee's responses were fully understood through requests for clarification.

A guide was created for each round of interviews to ensure that teachers were asked a similar set of questions (Hoepfl, 1997), while the semi-structured nature of the interviews also enabled me to go into greater depth where an issue looked worth pursuing.

4.6.3 Child Focus Groups

Focus groups were intended to explore: (i) how the activities were perceived by the children; (ii) whether any resultant learning could have been identified from their having taken part; and (iii) whether the children had any ideas for other activities that might be appropriate for a mobile learning approach.

Following Morgan, Gibbs, Maxwell and Britten's (2002) recommendations, I determined that questions would be asked in an open and non-judgemental manner, to increase the likelihood of eliciting genuine responses from the children. A guide was created prior to the focus groups, to be shared in advance with teachers to ensure that questions were phrased in an appropriate format for each age-group.

It was intended that focus groups would comprise the same children who worked as a group in the outdoor activity (generally 3 or 4 children) and that these would take place a few days after the activity, while it was fresh in their minds. It was expected that 4 to 5 groups would be selected at random by the teacher, and that 10-15 minute sessions would take place in the 'quiet corner' of the classroom, with relaxed seating and familiar surroundings.

Focus groups were observed and audio-recorded where possible, with teachers asked to forward comments from the children, where not. While intending to locate the recording device unobtrusively during the focus group, I also determined that children would be told in advance that they would be recorded, and that they were free to leave when they wished.

4.6.4 Learning Artefacts

Working in collaboration with teachers, assets such as eBooks, worksheets and edited video clips were produced to help scaffold the learning in class prior to an outdoor activity, to support activities while in the outdoor setting or to enable pupils to show-case their learning. The impact on engagement of these was analysed after activities had taken place. Learner-generated digital assets, such as photographs, videos, blog posts or eBooks, together with stills taken of other non-digital learner artefacts, such as posters, workbooks or artwork, were used to help triangulate findings in the analysis phase, using markers for cognitive engagement developed in collaboration with teachers.

4.7 Data Analysis

Ensuring the trustworthiness of qualitative research is inherently challenging, so repetition of DBR cycles, methodological triangulation (Denzin, 1989), member checking (Lincoln & Guba, 1985), referral to expert witnesses (Yin, 2003) and thick description (Collins, 1992) were some of the techniques used to help strengthen the quality of the findings.

4.7.1 Using *ATLAS.ti* to aid the Analysis Process

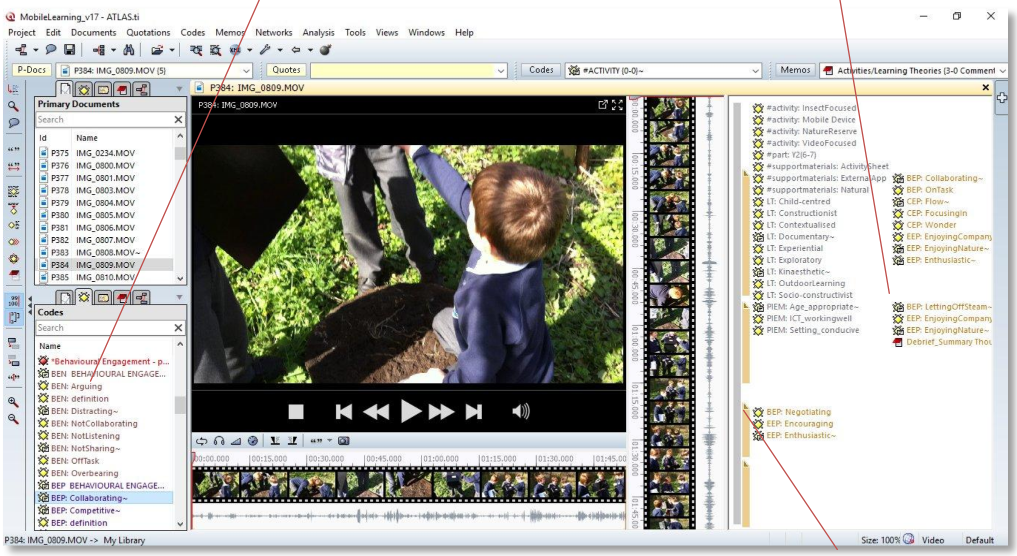
Given the likelihood of large quantities of data source files, a decision was made to use *ATLAS.ti* software early on in the research, both as a repository for the various data source files, and to aid linking, coding and querying:

> *ATLAS.ti is a powerful workbench for the qualitative analysis of large bodies of textual, graphical, audio and video data. Sophisticated tools help you to arrange, reassemble, and manage your material in creative, yet systematic ways*."
> (atlasti.com, 2017)

This software is widely-used and well-respected in qualitative research circles, and is provided as part of a suite of programs by Lancaster University to support research students. It enables the creation of codes, categories, memos and network diagrams which can be linked to extracts of a variety of data source files within a grounded theory process.

Codes are ‘dragged and dropped’ from the *Codes* panel onto data source files, such as video or audio clip extracts.

Codes can be linked to each other (using the *Relationship Editor*), other quotations or memos to aid generation of theory.



Extract of video clip (known as a *Quotation*) with attached codes.

Figure 4.3: Annotated screenshot of *ATLAS.ti* being used during analysis

Following a data collection exercise, data source files were imported into *ATLAS.ti* and elements of Ash’s (2007) analytical approach were adopted to aid data reduction, whereby video clips were initially viewed to gain a ‘large-grained’ overview of their content, and subsequently organised and categorised within *ATLAS.ti*, depending on whether any significant events, described by Ash as “meaning-making” events (p.217), were uncovered within them.

Where there were, a more detailed analysis was undertaken, using *ATLAS.ti* to attach categories, codes and/or memos to particular extracts of the video clip (see Figure 4.3). This iterative process was followed with all data source files, to begin the process of building relationships between codes and categories in order to elicit findings and aid generation of theory. A listing of all categories and codes using during the study can be found in Appendix One.

A suite of tools such as the *Co-Occurrency Table* and *Query Tool* (Figure 4.4), enabled the generation of a range of queries to test out correlations between the various entities.

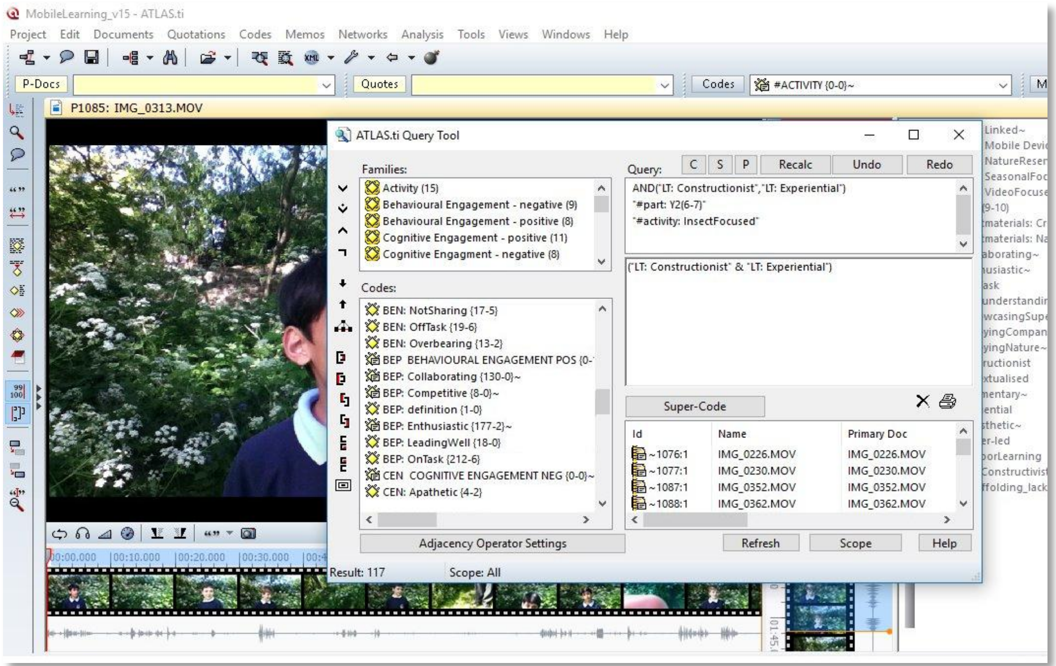


Figure 4.4: Using the *ATLAS.ti* Query Tool

The memo function of *ATLAS.ti* was also widely used throughout analysis, with a variety of memos created to note coding issues, theoretical musings, interview transcriptions and to house field notes, all of which could be attached to particular video segments as appropriate.

4.7.2 Video Recordings

Video footage was the primary data source used to record observations, due not only to the richness of the data collected: "*Video as a research tool opens up a multitude of possibilities in terms of attending to the layers of complexity that are inherent in the acts of teaching and learning*" (Fitzgerald, 2013, p.58), but also to its inherent qualities of retrievability (Kearney & Schuck, 2005), whereby clips can easily be re-visited or presented to expert witnesses for corroboration or revisions to interpretation.

The data collection approach referred to in sub-section 4.6.1, where my primary focus was on what a group were looking at, enabled me to see where the children were in the reserve and what they were doing; alongside hearing what was being discussed and how they were communicating with each other, this provided a useful resource to help gauge levels of enthusiasm, boredom, confusion, understanding and group dynamics, for example, from which to derive findings. Table 4.3 details the duration of video-recorded observations for each outdoor session.

Date	**Activity**	**Duration (Activity)**	**Duration (Recordings)**
02/2014	Y5 Museum QR-code trail	60	20:13
03/2014	Y2 Minibeast hunt (Class 1)	60	32:50
03/2014	Y2 Minibeast hunt (Class 2)	60	17:35
03/2014	Y5 Staged Activity	60	33:06
05/2014	Y5 Staged Activity	60	35:17
06/2014	Y5 iMovie Trailers	60	39:23
07/2015	Y2 Minibeast hunt	45	23:23
02/2016	Y2 Explorers Map Reading (split into 3 sessions)	60	35:45
04/2016	Y2 Explorers QR-code trail (split into 3 sessions)	60	41:28
02/2016	Y3 Plants QR-code trail (split into 2 sessions)	90	56:28
05/2016	Y2 Bughunt & iPad Familiarisation (split into 3 sessions)	60	32.46
06/2016	Y2 Insects eBooks (split into 3 sessions)	60	36:00
07/2016	Y3 Plants eBooks (split into 2 sessions)	90	53:32

Table 4.3: Number of minutes of recorded observation by activity

Video clips, varying in length from less than a minute to over 20 minutes, were imported into *ATLAS.ti* software to help organise, code and categorise clips of particular interest; these included those which appeared to address the research questions by highlighting learner engagement or disengagement with an activity, for example, or that illustrated the practical application of a particular learning theory in the field. In some cases, the *Comment* or *Memo* functionality was used to enable notes, such as transcriptions and concepts related to theory, to be attached to particular clips where appropriate. These notes were cross-referenced with other clips and data sources (e.g. photographs, field notes, learner-generated artefacts, interviews with teachers), to help elicit and triangulate emergent findings.

As mentioned above, emotional, behavioural and cognitive markers of engagement were developed in collaboration with teachers, and these acted as *a priori* categories for the purposes of the data analysis. Adopting a grounded theory approach (Glaser & Strauss, 1967) and following an iterative process (Barron & Engle, 2007), close examination of the video clips led to identification of further categories and codes, with progressive focusing and constant comparison employed to get closer to the data, continuously refining the coding and theoretical frameworks to ensure best fit. I found playing the video clips at full-screen on a large monitor was key in enabling me to spot certain details, such as facial expressions, that might otherwise have been missed.

The persistence of recordings enabled clips to be re-played numerous times, with the functionality of *ATLAS.ti* making navigation between clips much more efficient where codes or categories needed to be refined or re-defined.

4.7.3 Field Notes and Photographs

Field notes written up on the day proved to be an unexpectedly rich resource, both as a reminder of issues that had not been captured by other data sources (such as informal conversations with parent helpers), and of my overall impressions of how activities had gone on the day. Photographs were also valuable in quickly capturing the essence/context of an activity, as well as providing an efficient means of recording non-digital learner artefacts, such as hand-written activity sheets.

4.7.4 Interviews

A series of semi-structured interviews were conducted with teachers at the end of each cycle, with questions focusing on: (i) their day-to-day teaching commitments; (ii) their views on teaching, their views on using ICT in their teaching, both in general terms and with particular reference to mobile learning; and (iii) their views on the mobile learning activities they took part in. Details are shown in Table 4.4.

Date	Participant-Teacher	Duration (in minutes)
07/2014	Y2 teacher	53:11
07/2014	Y5 teacher	44:34
07/2014	Y5 teacher	26:37
07/2015	Y2 teacher	25:51
07/2015	Y2 teacher	35:47
07/2016	Y2 teacher	33:03
07/2016	Y2 teacher	25:24
07/2016	Y3 teacher	30:45
07/2016	Y3 teacher	33:43

Table 4.4: Number of minutes of recorded interviews with teacher-participants

Recordings of these interviews were transcribed, and grounded theory analysis carried out to help draw out emerging themes and elements of commonality. The audio files and associated transcriptions of those interviews were imported into *ATLAS.ti*, enabling links to be made between the various data sources to aid triangulation. Findings were referred back to the participants for member-checking, following Lincoln and Guba (1985).

4.7.5 Child Focus Groups

While learner focus groups had been scheduled to take place at the end of the year to get the children's perspectives on the MLAs and mobile learning in general, various practical issues (such as teachers being absent or issues relating to end-of-year commitments) impacted on the scheduling of these, resulting in only five taking place. Where the groups did not go ahead, teachers agreed to ask the children questions on my behalf and fed back their responses. Those focus groups that did take place were audio-recorded in the 'quiet corner' of the classroom, and the resulting audio files and transcriptions imported into *ATLAS.ti* for analysis.

As highlighted in sub-section 4.6.1, in my role as 'adult helper' I was also able to communicate with the children about their experiences during the outdoor sessions, which provided useful insights while they were participating in an activity.

4.7.6 Learner Artefacts

Where applicable, learner artefacts, such as video clips or textual content from blog posts, were also imported into *ATLAS.ti* and analysed using grounded theory to help draw out key themes, employing elements of conversational analysis to aid identification of any emerging patterns in collaborative work, where available.

Initial categories that emerged from learner-generated video clips included markers for cognitive engagement developed in collaboration with teachers, such as identification of a particular learning objective having been met, alongside concepts such as whether children were on task, how they were collaborating in their groups and other issues relating to the specific outdoor activity.

4.8 Evaluation

Evaluating the impact of technological interventions on learning is challenging, but is even more exacting in a mobile learning environment where learning is likely to occur across a variety of contexts (McAndrew, Taylor, & Clow, 2010), and with a resultant variety of data sources to interrogate (Vavoula & Sharples, 2009).

Passey (2013) highlights the importance of considering contextual factors, differentiating between *outcomes* and *impacts* associated with an intervention, wherein measurability is emphasised as an essential property of impact. For a measure of impact to hold legitimacy, the instrument used must demonstrate an unambiguous relationship between the affordances, the uses, the outcomes and the impact of an intervention (see Figure 4.5), where the instrument identifies "*outcomes arising from uses that are related to affordances*" (Passey, 2013, p.5).

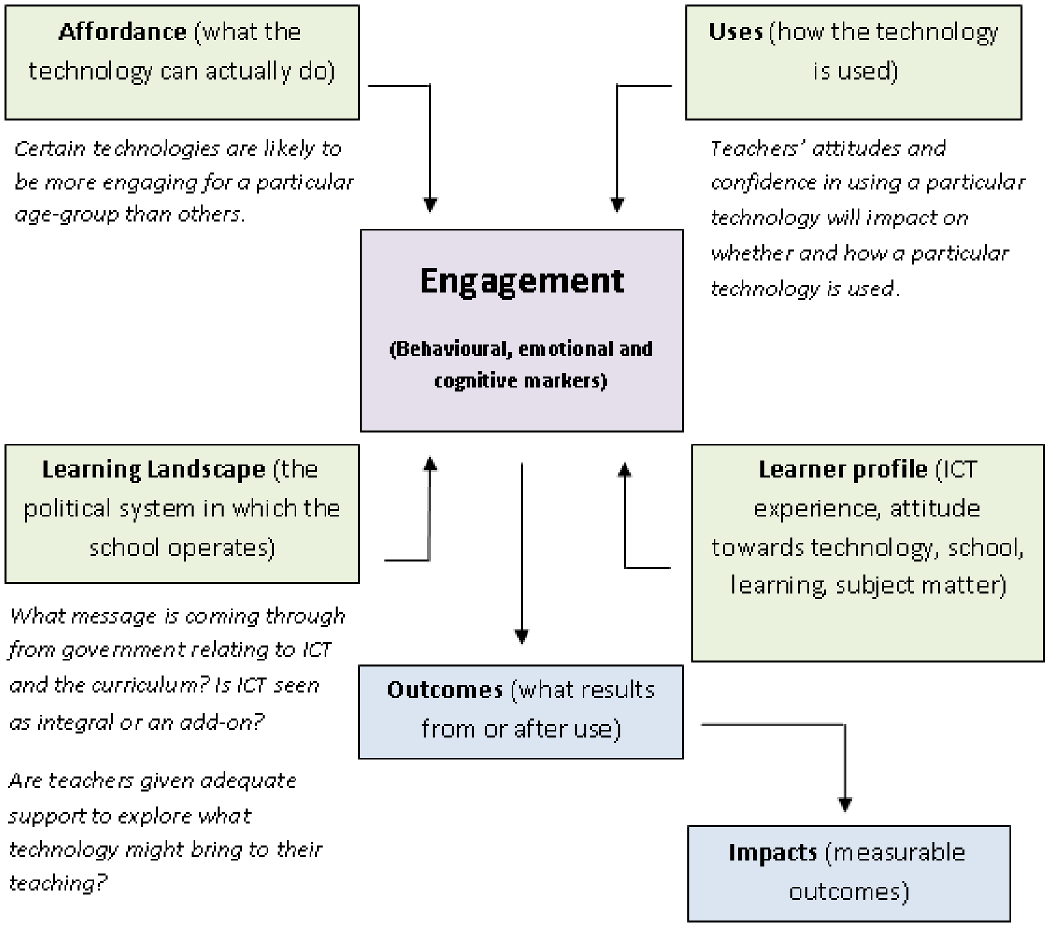


Figure 4.5: Factors impacting on learner engagement with ICT interventions (drawing on Passey, 2013)

This investigation therefore saw the development of a hybrid evaluation framework, employing instruments designed to measure the impact of mobile learning interventions on learner engagement which drew both on Passey's (2013) requirements, as outlined above, and McPhee et al.'s (2013) *Classroom Engagement Checklist,* to help establish levels of emotional, behavioural and cognitive engagement.

Following Yin (2003), findings emerging from evaluations were referred both to teachers in their role as expert witnesses, and, where feasible, to learners in their role as key stakeholders, for challenge and/or corroboration.

4.9 Ethical Approval

Ethical approval to work with primary age children and teachers and youth leaders was granted by Lancaster University Ethics Committee, and the strictures referred to therein were adhered to. Following permission being granted by heads of school/youth groups for their organisation to act as participants for the research, informed consent forms were sent out to parents or carers that included specific reference for permission to use: (i) photographs; (ii) video and audio recordings; and (iii) comments of child participants within the research and its outputs, with edited versions of these forms provided for teachers and youth leaders participating in the research.

Any recordings used in the research were made with an awareness of the sensitivity of issues relating to the recording of children (Vavoula et al., 2009), with any concerns raised with group leaders or teachers. To address issues relating to consent forms not being returned on time, it was agreed with participant teachers that observations should be made on the understanding that any clips or photos appearing to be of interest to the research would be screened by themselves prior to analysis. This was achieved through my providing print-outs of particular photographs or stills from video clips captured during an activity, to enable teachers to speedily identify individual children and to highlight any issues directly on the print-outs, for later referral by myself. On the few occasions where parental consent had explicitly not been given for a child, I was informed at the outset of an activity, in order to avoid filming them.

Any apps used in the research were age-appropriate, and the iPods provided by myself at the start of the research were made 'use-specific' such that children could only access material screened by their teacher or youth leader.

4.10 Summary of Chapter 4

Informed by the evaluation of pilot activities reported on in Chapter 3, this chapter outlined the justification of *design-based research* as the overarching methodological approach underpinning this study, and detailed how grounded theory, and the various concomitant qualitative data collection and analytical approaches, were employed to address the research questions.

The next three chapters describe the design, implementation and evaluation of a series of design-based research cycles relating to the *discovery-based learning* and *production-focused learning* activity streams (see section 4.5), highlighting those findings that were of interest during the analysis phase of each cycle, both in terms of driving the refinement of interventions and in responding to the research questions. Thick description was employed throughout to enable a more complete picture of the research activity steams to be drawn and to strengthen transferability, and emergent findings within each cycle were also highlighted at the point they occurred within the description, to aid clarity.

Chapter 5 Discovery-Based Learning

The previous chapter detailed the methodological approach and methods chosen to answer the primary research question: "*How might mobile learning influence learner engagement of primary school children working in groups on science topic work in outdoor settings?",* where insights gained from the exploratory phase informed decisions relating to both the methodological lens and analytical approach used in the latter part of the study.

This chapter describes four design-based research cycles (DBRC) focusing on the design of mobile learning activities (MLAs) linked to the *discovery-based learning* research activity stream, which aimed to encourage learners to explore particular topics or themes within an outdoor setting. Building on findings from the exploratory phase, collaboration with two Year 2 (Y2), two Year 3 (Y3) and two Year 5 (Y5) teachers over a period of three years resulted in the design, implementation and evaluation of activities for over 170 children from one school, which took place in a local nature reserve.

5.1 Research and Design Context

Findings emerging from observations of the pilot activities described in Chapter 3 suggested that: (i) QR-code trails motivate and engage children aged 6-9 years working together in outdoor settings; (ii) internet coverage provided through mifi devices can be intermittent; and (iii) careful planning of such activities is required to enable learners to get the most out of the experience (cf. Chen et al., 2003; Nouri et al., 2014).

These pilot activities had been designed to assess the feasibility and potential of using QR-code technology for learning. In line with Rikala and Kankaanranta's comment that: "*the focus should be more on the learners and pedagogy than on QR technology, as mobile technologies do not guarantee enhanced learning by themselves"* (2012, p.149), ongoing research into the underlying pedagogies which might underpin future activities encompassed learner-centred, contextualised, authentic, kinaesthetic, collaborative, constructionist and experiential forms of learning. A discussion of these approaches can be found in section 2.3.

As highlighted by Papert (1980) and Zimmerman and Land (2014), providing opportunities for learners to create their own digital artefacts can deepen understanding and increase motivation, and this was echoed by impressions I gained when working with the scouts to develop their digital presentations in the pilot studies.

Recognising the value of providing some sort of repository for learner-generated digital assets (such as photographs or video clips) to empower learners in creating and sharing such artefacts, a web-based review into the potential use of technological platforms, such as blogs, was also undertaken, to enable learners to store and incorporate their digital assets into publishable assignments. The findings from the review are described in sub-section 5.2.1.

5.2 DBRC_D1: Museum QR-code Trail with Year 5 (February 2014)

Following contact with a Year 5 teacher at Upton School (pseudonomised as Miss Hope), an initial meeting was held with herself and her team teacher, Mrs Baxter (who had trialled the Y3 pilot activities), to discuss ideas for mobile learning activities related to their '*Lifecycle of Plants'* science topic. The meeting revealed that Miss Hope had 8 years' teaching experience, felt confident in using ICT, and was prepared to test out new technologies in her class where she felt they were appropriate; Mrs Baxter, in contrast, had started teaching later, had taught for 3 years, and did not feel as confident in using ICT in her lessons, citing her experience of software or hardware issues as barriers to uptake.

5.2.1 Research and Design

Aware of Miss Hope's affinity with art and that a local museum was currently running an art competition for local schools, I suggested trialling an initial QR-code activity as part of a trip to the museum. Whilst my primary focus was on the use of mobile devices in *natural* outdoor settings, having observed children's positive reactions to QR-code trails in the pilots, I felt that a QR-code trail designed around the museum's artefacts could enhance the learning experience for this age-group (9-10-year-olds), harnessing the benefits of both kinaesthetic and exploratory forms of learning (Lai et al., 2013). I also anticipated the potential for useful data to be collected on how children of this age-group interact with mobile devices and with each other in an out-of-school setting, and, given the emergent nature of the methodological approach, hoped to capitalise on this opportunity to deepen my understanding.

Following agreement for the trip, it was also agreed that: (i) the children would use mobile devices to take photographs of the artefacts to act as inspiration for creating their own competition-related artwork once back in class; and (ii) a blog would be trialled as a repository for the photographs (Herrington & Herrington, 2007), with a view to extending this for the proposed '*Lifecycle of Plants'* activities.

While the school had their own *Edublogs* blogging platform, this was not commonly used by staff, and, due to the nature of its security restrictions, would have imposed a heavy administrative burden on the Y5 teachers. Following the web-based review of possible technological solutions, *KidBlog* (KidBlog.org) was selected as the class blogging tool, due to its positive teacher reviews, customisable interface, ability to create new users and groups, and general ease of use.

5.2.2 Activity Specification and Implementation

The activity was designed to address the cycle-specific research questions (CRQs):

CRQ1 - "*How might the use of QR-codes enhance understanding of topic work for 9-10 year old children working in groups in an out-of-school setting?*", and
CRQ2 - "*How might blogs be utilised to act as a focal point and repository for group and individual learner artefacts created during mobile learning activities?*"

The agreed specification of the activity comprised:

- 2 class blogs to be configured by myself, using *KidBlog*;
- 10 QR-codes and associated webpages to be created for the trail, containing text and graphics provided by Miss Hope;
- 2 mifis to be provided by myself (as there was no wifi provision in the museum);

- 8 iPods and a minimum of 4 school iPads to be brought on the day, all with QR-code scanner apps installed;
- QR-codes to be attached on glass surfaces near relevant artefacts;
- Training provided by myself to Miss Hope and Mrs Baxter in using *KidBlog*;
- Children to receive in-class training on using the iPods (for scanning QR-codes and taking photographs), and on using the blog;
- Children to take photographs of the museum artefacts, to feed into class-based activities.

5.2.2.1 In-class Familiarisation Session

During the in-class familiarisation sessions, a significant majority of children (90+%) reported previous experience of using touch-screen devices at home, and demonstrated proficiency in scanning QR-codes and taking photographs.

5.2.2.2 Museum QR-code Trail

Two separate class visits were arranged to the museum, with 8 *iPods* and 4 school iPads distributed between 28 and 30 children respectively, working in groups of 2 or 3. The school-owned iPads were inconsistently configured and two were unable to connect to the internet through the mifis, so text-only versions of the QR-codes were used in these cases.

5.2.3 Initial Evaluation and Findings

Evaluation of the activity and initial findings were derived from analysis of the data sources detailed in section 1.8. Informal conversations with teachers, teaching assistants (TAs) and museum staff highlighted how engaged both classes had appeared during the sessions, with Mrs Baxter, in particular, commenting that she had been impressed with her class's good behaviour, which she described as "*unusual*".

Sharing of devices did not appear to cause problems with this age-group, and children in both classes were quickly observed scanning the QR-codes to launch the information provided by Miss Hope, and taking photographs or making sketches as they viewed the exhibits.

Figure 5.1: Y5 pupils taking in information from QR-code

Logs from the QR-code reader app showed all groups had scanned all ten codes, and no children were observed to have treated the QR-code trail as a race.

While over 90% of the children had indicated during the hands-on sessions that they were experienced in using touch-screen devices, 339 of the 453 photographs taken by Miss Hope's class were blurred or ill-focused and unfit for purpose, and 145 of the 175 taken by Mrs Baxter's class, suggesting that more targeted training would have been useful.

5.2.4 Follow-up Activities

Despite considerable time investment into: (i) sourcing and setting up two dedicated class blogs with individual user accounts; (ii) the provision of training and a customised manual; (iii) conclusive discussions regarding 'policing' of the blog; and (iv) letters sent out introducing the blog to parents, Miss Hope only published three further posts over the following months and Mrs Baxter did not post any.

As the keener user of ICT, it was interesting to note that Miss Hope's class were highly engaged with the blog themselves (see Figure 5.2), using it to respond to Miss Hope's introductory post, to communicate with each other inside and outside school and to upload videos of their pets and other interests.

Figure 5.2: Screenshot from Miss Hope's class blog

Despite initial class-wide enthusiasm, only four of the children from Mrs Baxter's class continued to use it, suggesting that teacher-engagement may have directly influenced pupil-engagement (Luckin et al., 2012).

5.2.5 Evaluation with Year 5 Teachers

Implementing an evaluation strategy which employed semi-structured interviews as the primary vehicle for the collection of qualitative data from participant-teachers, both separately expressed their appreciation of the use of mobile learning in this context, and their desire to use QR-code trails again, with Miss Hope commenting:

> *QR-codes, I liked that, because it takes you on a virtual adventure, which you wouldn't get from paper and pencil, or taking photographs; it can take you off to a whole new world of discovery that goes way beyond what you can just see. Like when we used it in the museum, that was brilliant, because you had links within links, so you could, just from using one QR-code, you could go off and learn so much more about one thing.*

While Mrs Baxter appreciated the motivational aspects of using iPads for teaching, she also raised a concern regarding their novelty value:

> *Mention iPads and they sort of think* 'a bit of a jolly*'. Which is nice if they're not aware that we're learning but we're having fun, I like that aspect. But if they're not seeing it*

as a learning tool as they go up through the school, then I don't think they'll get as much from it. The novelty would wear off. It needs to be thought out.

Miss Hope felt the iPods were more suitable for this activity than the iPads, as they were less intrusive:

> *I thought they were exactly the same before I'd seen them. iPods* [were] *better for the museum trip, because they were small, they could just wear them round their necks, use them to scan the codes when they needed them, bit like a clipboard and a pencil, and then look around the museum. Whereas the iPads, it was like the iPad was guiding them around, it got in the way.*

In terms of ratios of mobile devices to children, both teachers thought a ratio of one device to two or three children worked best; Miss Hope went on to highlight her awareness of the problems inherent in sharing devices while also emphasising her belief in the importance of collaborative learning:

> *Collaborative working is how I tend to teach ...which involves lots of speaking and listening, but when you're using a device, sometimes it's* [just] *you and this device. So that time to talk to somebody is lost, because you're so engrossed in this virtual world that you kind of lose that. Both need to be fostered, I think. Being assertive and safe on your own, using technology, but sharing understanding, knowledge and skills with other people.*

5.2.6 Summary of DBRC_D1

While not situated in a natural outdoor setting, this activity provided valuable experience of working with teachers to develop mobile learning activities related to the primary curriculum, while also yielding useful insights into the use of QR-codes to support school topic work.

Addressing CRQ1 ("*How might the use of QR-codes enhance understanding of topic work for 9-10 year-old children working in groups in an out-of-school setting?"),* the children were observed showing enthusiasm in using the technology for learning, and evidenced high levels of engagement with the activity, with all groups observed taking the time to deepen their knowledge of a particular artefact by reading and looking at the additional material revealed by scanning the codes. This was corroborated by the Y5 teachers both on the day and in their formal evaluation of the activity. Responding to CRQ2 ("*How might blogs be utilised to act as a focal point and repository for group and individual learner artefacts created during mobile learning activities?"),* despite being pleased with how activities had gone on the day, I was disappointed that the blog had not been used more by the teachers, particularly as the children in Miss Hope's class were engaging with it so strongly on a social level, and this research question remained unanswered. Against a background of increasing time pressures felt by teachers (e.g. BBC, 2014), I determined that in order to increase the likelihood of uptake, future activities should be designed to ameliorate assessment commitments for teachers where appropriate.

Although I was expecting some degree of enthusiasm to be shown by the children, I was surprised to see how readily they appropriated the technology into their learning (Ferri & Moriggi, 2017), and particularly the alacrity with which the children in Miss Hope's class embraced the opportunity to communicate with their peers on a social level.

5.2.7 Issues for Feed-forward

The findings that fed into the design of future mobile learning activities are listed below:

- Children aged 9-10 years respond well to the use of a QR-trail in an out-of-school setting, showing high levels of motivation and engagement;
- Children aged 9-10 years are quick to appropriate technology they feel is of interest or value to them;
- Teachers do not always implement agreed courses of actions, and contingency plans should form part of activity designs;
- School iPads may be inconsistently configured, both in terms of installed apps and internet access.

5.3 DBRC_D2: Seasonal Changes Activity with Year 5 (March-July 2014)

Prior to the museum trip, discussions with Miss Hope and Mrs Baxter had also focused on the design of an activity which would respond to the science objectives set out in the National

Curriculum, enabling their classes to appreciate and learn about seasonal changes and the lifecycles of plants by:

- *taking measurements, using a range of scientific equipment, with increasing accuracy and precision, taking repeat readings when appropriate*
- *recording data and results of increasing complexity using scientific diagrams and labels, classification keys, tables, scatter graphs, bar and line graphs*
- *reporting and presenting findings from enquiries, including conclusions, causal relationships and explanations of and degree of trust in results, in oral and written forms such as displays and other presentations*

(Department for Education, 2013, p.166)

5.3.1 Research and Design

It was agreed with both teachers that a staged activity, where the children would visit the nature reserve on three occasions to record changes in plants over time, would respond to the learning objectives for this topic, whilst also providing authentic raw data for the children to work on in class.

Zimmerman and Land (2014) propose design guidelines for 'place-based learning' activities, suggesting that using mobile devices to capture and annotate artefacts can: "*(a) promote reflection on activities as they unfold that might normally be tacit, (b) build connections between disciplinary practices and everyday life, and (c) highlight aspects of a developing explanation that warrant further investigation."* (p.80). Against this background, it was agreed that the children should use iPods and school iPads to take photographs of plants and trees for later upload to group blog areas, with the task augmented by each group completing an activity sheet focused on measuring seasonal changes in the reserve between visits.

Wishing to afford the children autonomy in how they approached the task (Sharples et al., 2005), but also aware of the need to support learning by offering suitable scaffolds (Nouri et al., 2014), I proposed creating an eBook incorporating photographs of selected plants and trees in the reserve to help orientate the children, and to provide them with a contextualised source of topic-related facts (Rikala & Kankaanranta, 2012).

Following visits to the reserve and online research into suitable plants for the children to study, five trees and five plants were identified to serve as 'key species indicators' to bound the activity, which would be included in both the eBook and accompanying activity sheet.

As a follow-up activity, Miss Hope suggested the children could create their own group videos to illustrate their understanding of the *'Lifecycle of Plants'* topic; a brief discussion of this activity is offered in section 6.3.

5.3.2 Specification and Implementation

The activity was designed to address the cycle-specific research questions (CRQs):

CRQ1 - "*How might the use of mobile devices enhance engagement with science topic work for 9-10 year old children, working in groups in an outdoor setting?*" and
CRQ2 - "*How might blogs be utilised to act as a focal point and repository for group and individual learner artefacts created during mobile learning activities?*"

The agreed specification of the activity stipulated the following:

1. Both classes to visit the reserve together, attending on three occasions, lasting approximately one hour each;
2. Activity sheets to be drawn up to enable each group to record changes in size and appearance of buds or leaves over the three visits;
3. Children to work in groups of 3 or 4, using 8 iPods provided by myself, together with a minimum of 7 school iPads;
4. Customised eBooks to be created (one for spring flowers and one for trees), using Apple's *iBooks* app, and downloaded onto iPods and school iPads prior to the visit;
5. iPods and iPads to be used to take close-up photographs of buds, leaves and plants (to be uploaded to blog group areas once back at school);

6. Following each visit, teachers to upload an assignment to the blog, reminding groups to publish a post to present their findings, incorporating the photographs and data from the activity sheets;
7. The best photographs to be printed out to enable each group to create an annotated informative poster to act as a summative assessment piece.

Taking overall responsibility for the design of the activity sheets and eBooks, while collaborating with teachers on specific issues of content within these, I was able to ensure that the eBooks covered those areas queried on the activity sheets (for example how plants and trees pollinate), whilst also including easily-recognisable photographs of trees and plants I had taken in the reserve to help focus the children on their most salient features (see Figure 5.3).

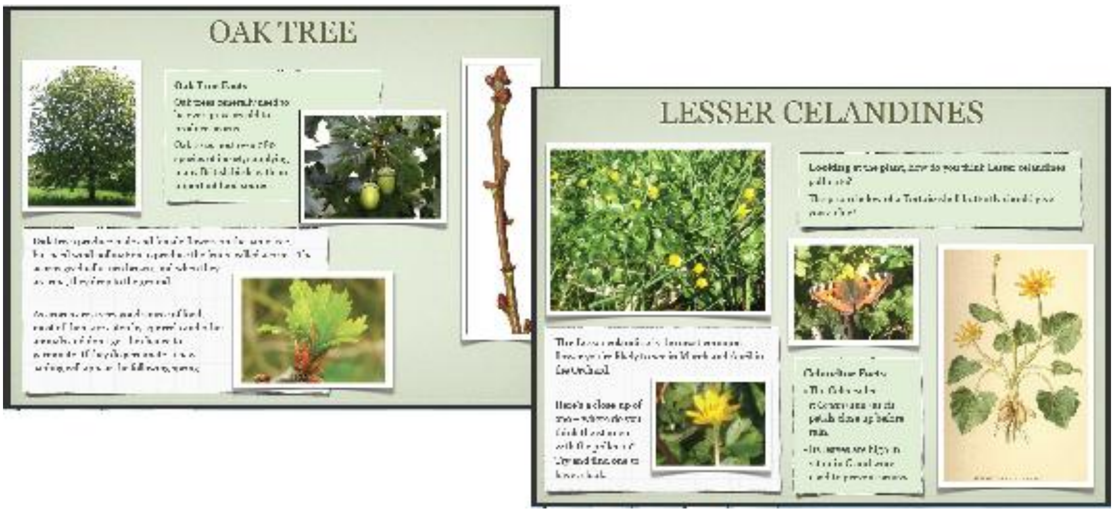


Figure 5.3: Screenshots from *Trees* and *Wildflowers* eBooks

While dates for three visits were scheduled to take place in February, March and April, the second visit was cancelled due to bad weather and could not be re-scheduled before the end of term. The first visit involved 56 children, 2 teachers and 4 adult helpers, while the second involved 58 children, 2 teachers and 3 adult helpers. Given the large numbers involved and the fairly tight time limits for the activity, I determined that, in addition to the provision of eBooks, it would be prudent to fix sheets with the names of the trees and flowers mentioned in the book around the reserve, thereby acting as a starting point for the activity.

Mrs Baxter had forgotten to bring the activity sheets for the second visit, so I suggested the children in her class could record their observations using the camera app on their mobile devices instead. The eBooks were installed on all iPods and iPads; however, I later learned from the teachers that these had also been viewed on the class whiteboards as preparation for the visit. The weather for both the visits that took place was good.

5.3.3 Evaluation and Initial Findings

Evaluation of the activity and initial findings were derived from analysis of the data sources detailed in section 1.8.

From my observations and field notes, I noted that most groups appeared animated enough but I did not see the levels of enthusiasm I had observed in the pilot activities. This was possibly due to the older age of the children, the fact that they had visited the reserve before, or the design of the activity.

Figure 5.4: Y5 taking photographs for the *LifeCycle of Plants* topic

I saw several groups referring to the eBooks as they went around, and noted that all groups were using the iPods and iPads to take close-up photographs (see Figure 5.4); I also observed one member of Mrs Baxter's group using an iPod to record the following: "*The oak tree has grown around 3 or 4 centimetres, the buds are starting to get bigger, and the leaves are showing*", highlighting her understanding of the task objectives.

I observed that it was often girls that were leading the task within groups, with some boys conspicuously less engaged; for example, three boys were overheard discussing the intricacies of the online game *Minecraft* during an observation period of 5 minutes, and this conversation appeared to have continued when I caught up with them approximately 15 minutes later (see Figure 5.5).

Figure 5.5: Y5 boys off-task discussing *Minecraft*

I noticed that this lack of collaboration occasionally resulted in the girls good-humouredly resorting to ‘extreme measures’ (such as tapping a boy in their group with a ruler) in an attempt to get them to take part.

5.3.4 Follow-up Activities

Consistent with the experience of the museum-based activity, neither teacher posted follow-up activities on the blog, with both citing time pressures (cf. Jones, 2004; Harris et al., 2009; BBC, 2014) and technical issues connected with the upgrading of the browser as reasons. I also learned later from Miss Hope that political pressure from the school ICT co-ordinator had resulted in all teachers being asked to ‘do more’ with the school *Edublogs* site. Despite this, the children in Miss Hope’s class continued to engage strongly with their blog on a social level, publishing some 258 posts in the first month.

Fulfilling my intentions to lighten the burden of assessment on teachers, in the early weeks of the activity I created an exemplar poster for display on the class whiteboard to support the summative exercise and to act as inspiration. I also ensured that the best photographs were printed out once the outings had taken place, to enable each group to make up their poster.

5.3.5 Evaluation with Year 5 Teachers

During their semi-structured interviews, I presented both Miss Hope and Mrs Baxter with video evidence that appeared to highlight gender differences in pupil's behavioural patterns during the activity. The observation that the girls appeared to have been more on-task in this activity than the boys was corroborated by both teachers, and highlighted as representative of what went on in the classroom; Mrs Baxter commented that: *"The boys get easily distracted - they look for distraction",* while Miss Hope, echoing the findings of McPhee et al. (2013), expanded on this point:

> *In general, girls can plan ahead, they can identify the steps that are going to lead them there, and they just get on with it; boys can get easily side-tracked by shiny objects* [laughs]*, ICT, they want to just explore, and mess around, and then they go* 'What were we supposed to be doing again?*' So they need time to immerse themselves, so whenever we do something new, say it's using a new technology, it would be '*Go play, go and explore'*, which the girls can't cope with as much as the boys, the girls want to know '*Why, what's the point of this?*'.* (Miss Hope)

In light of this, I determined that the design of future activities should aim to incorporate an approach that could support both these learning patterns, harnessing the motivational pull of using iPods or iPads to guide an activity and act as a focal point for group collaboration (Gray et al., 2017).

Both teachers suggested that the asynchronous aspect of the linked activities helped their pupils gain an authentic appreciation of the topic, and that the eBooks were important in scaffolding the learning by giving the children a focus for what they were looking for before setting out on the visit (Chen et al., 2003):

> *Definitely useful, because they knew what they were looking for, rather than me just talking about plants and flowers, they could look at the close-ups, see where to find them, and all the organisation of it was almost sorted by looking through the eBook before we went, so when we got there, they could really focus on the science.*
> (Mrs Baxter)

In her interview, Miss Hope suggested that other locations schools visit should work with teachers to produce eBooks to help children get the most out of visits:

> *They should send it out beforehand – like "*look out for these things*". They'd have to work alongside teachers ...so they're covering the right skills and prompting children in the right areas. You'd get a lot more out of visits. Some of them are just in awe when they go for a visit, they just don't take it in ...if you've already visited virtually …you can enjoy what's around you ...all the internal mapping's done beforehand, you know where they're going to find the best information.*

In response to my querying the lack of use of the blog, Miss Hope replied: *"We did all this class stuff, we went out, got the evidence using the mobile technologies, we came back, we had a designated slot to get them doing the posts, and consecutively, on four weeks, KidBlog was down, it was blocked, to do with browser upgrade*"; Mrs Baxter stated simply that time pressures had prevented her.

5.3.6 Summary of DBRC_D2

With respect to CRQ1 ("*How might the use of mobile devices enhance engagement with science topic work for 9-10 year old children, working in groups in an outdoor setting*?") and CRQ2 ("*How might blogs be utilised to act as a focal point and repository for group and individual learner artefacts created during mobile learning activities*?"), while this activity was well conceived in theory, in practice it perhaps lacked flexibility and imagination in its conception.

Responding to the needs of the national science curriculum for children in this year group to show ability in measuring and graphing, the original specification intended that the children would incorporate the measurements and photographs taken in the reserve within their own blog posts as a follow-up activity, either in class or at home. This aimed not only to give meaning and authenticity to what they were doing in the reserve, but also to provide a focus for group collaboration, so that each group's work could easily be viewed by others in the class, thereby acting as peer exemplars for inspiration.

As time pressures and software issues had been cited as hampering teachers' engagement with the blog, this core component of the activity was missing, and its capacity to engage children of this age could not be meaningfully assessed. While I considered offering to publish 'kick-start' posts on behalf of the teachers, I recognised at the time that this that would have taken ownership of the activity away from the teachers, thereby reducing applicability.

Reflecting further on whether I could have done more to increase teachers' participation in this activity , I also recognised that, as a researcher, I had no authority to insist that agreements to deliver activities according to specification were adhered to, and that continuing encouragement, support and an understanding of teachers' commitments were likely to prove the best methods of engagement.

5.3.7 Issues for Feed-forward

- With reference to gender, girls appeared more task-focused than boys during these activities, were more likely to prefer clear, well-defined goals, while boys were likely to prefer being given the opportunity to explore first;
- Teacher input is key in determining the ultimate success or failure of a pedagogic technological innovation; this input does not appear to be overly influenced by learner take-up of a particular technology (as in the example of Miss Hope's class's enthusiastic use of the blog outside school), but appears to be more related to intrinsic motivation, such as perceptions of the value of a particular technology, or extrinsic pressures, such as teaching commitments and school politics;
- Although learners were enthusiastic in taking photographs while in the reserve, some of them did not retain information about the state of plants between visits; this highlights the need for some sort of repository of learner artefacts to refer back to, when undertaking mobile learning activities of this nature (Milrad, Wong, Sharples, Hwang, Looi & Ogata, 2013);
- eBooks using contextualised photographs can be an effective support for class preparation for a trip to an outdoor setting, and appear to act as an appropriate scaffold for 9-10-year-olds undertaking mobile learning activities;

- Future activities should aim to explore whether increasing the perceived autonomy of a mobile learning task has any apparent effect on learner engagement.

5.4 DBRC_D3: Explorers Activity with Year 2 (February 2016)

In late 2015, a series of email exchanges and meetings took place with Mr Andrews, a Year 2 teacher, and his team teacher, Mrs Carter, to discuss possible mobile learning activities related to their upcoming core *Explorers* topic. As well as learning about famous explorers and what it meant to be an explorer, the teachers wanted to augment class learning with outdoor activities, including a focus on map-reading skills. I had collaborated with Mr Andrews on designing mobile activities for Y2 classes in 2014, and with both teachers in 2015 (see Chapter 6), so they had a good understanding of what mobile learning entailed and the design-based research process.

5.4.1 Research and Design

Building on lessons learned in the pilots and Year 5 activities, I suggested we should trial the use of text-only QR-codes to support the map-reading skills, harnessing the motivational aspects of a treasure-hunt to encourage the children to learn through play (Wyeth et al., 2008), while avoiding any issues related to intermittent internet coverage.

The '*Living things and their habitats'* unit of the national science curriculum for this year group stipulates that children of this age-group (6-7 years) should be able to:

- *Explore and compare the differences between things that are living, dead, and things that have never been alive.*
- *Identify and name a variety of plants and animals in their habitats.*

(Department for Education, 2014, p.174)

It was therefore decided that this outdoor learning opportunity should also focus on seasonal changes as part of the activity, and that contextualised QR-codes would include questions related to this aspect of the curriculum, such as: *Do all trees and plants go to sleep in winter?*

Mr Andrews proposed two visits to the nature reserve, the first without mobile devices using a printable map of the reserve to frame the activity, the second with mobile devices, using the same map annotated with the location of the QR-codes. It was intended that both classes would come to the reserve at the same time, taking part in three 20-minute activities related to their *Explorers* topic, and that the orienteering activity should therefore be restricted to one half of the reserve. As with activities collaborated on in the previous year, markers for measuring engagement were also discussed, with Mr Andrews agreeing that these should include soft skills such as collaboration, in addition to the more obvious ones such as skills in map-reading and understanding of science concepts.

Following a fact-finding mission to the reserve to see which plants were in evidence, I took photographs of ten locations I considered suitable to secure the QR-codes, and emailed a document with suggested textual content and locations for the QR-codes (see Appendix Two) to the teachers for feedback.

5.4.2 Specification and Implementation

This activity was designed to address the cycle-specific research questions (CRQs):

CRQ1 - "*How might the use of a QR-code trail influence engagement with science topic work for 6-7 year old children working in groups in an outdoor setting?*" and
CRQ2 - "*How might the use of a QR-code trail enhance understanding of mapping skills for 6-7 year old children working in groups in an outdoor setting?*"

The agreed specification for the activity comprised:

- Creation and printing of 9 QR-codes and annotated map identifying locations of QR-codes;
- Securing of QR-codes in pre-defined locations in the nature reserve;
- Markers of engagement to be identified in map-reading skills, collaboration, ICT skills, literacy skills and understanding of science concepts;
- Photographs from each group to be shown on the class electronic whiteboard and printed out for a class activity.

5.4.2.1 First Explorers Outing – without mobile devices (January 2016)

The weather was cold and clear, and there was a ratio of 8 adult helpers to 57 children. The children were split into 3 groups, with each group spending approximately 20 minutes on three activities in rotation.

For the first activity, a tarpaulin and large sheet of paper and marker pens had been placed on the ground and the children in one group were asked by Mrs Carter to find as many objects connected with being an explorer as they could, particularly things connected with winter, and to write what they had found on the paper. The teacher also suggested that if there was anything interesting that was too large to bring to the tarpaulin, they could ask an adult to take a photograph to be printed out at school, which several children did. Another group was involved in an art-related activity, creating collages of space ships, rockets or planets out of natural objects they had spotted around the reserve.

For the map-reading activity, each group had a clipboard with the illustrated map of the reserve and a pencil. Mr Andrews used this to illustrate how maps work, asking the children to follow him while following the map through a section of the reserve.

5.4.2.2 Second Explorers Outing – with mobile devices (February 2016)

The second outing followed a similar format to the first, but this time included a perfume-making activity, a second art activity and the map-related QR-code activity. The weather was again cold and bright, and there were 9 adult helpers for the two classes. I elected to observe the QR-code activities only; Mr Andrews was responsible for overseeing these, and began by demonstrating what a QR-code was, moving on to show the children the map of the reserve annotated with question marks representing the locations of QR codes. He then organised the children into sub-groups of 3 or 4, each of which was given an iPad or iPod and a clipboard with the annotated map; once they had shown they could successfully scan a demonstration QR-code, they were set off on the trail by Mr Andrews.

5.4.3 Initial Evaluation and Findings

Evaluation of the activity and initial findings were derived from analysis of the data sources detailed in section 1.8.

5.4.3.1 First Explorers Outing

I observed all three activities during the first outing, and noted that while children appeared enthusiastic when running around and finding natural objects related to being explorers, they did not appear as motivated by the map-reading activity or the art activity, perhaps due to the cold weather or the nature of the activities themselves. Mr Andrews made efforts to engage the children by asking them where they thought they were on the map as they were going round, and requesting they draw their route back once they had reached the end point of the reserve.

5.4.3.2 Second Explorers Outing

Mr Andrews opened the QR-code activity by holding up a QR-code and briefly describing what it was used for. He then showed the children the annotated map, reminding them that they had used this on the previous visit, but this time he pointed out the question marks and asked the children what they thought they might be for. At least one child in each of the three sessions correctly guessed that these were showing where the QR-codes were hidden.

Given the level of prior experience this year's Y2 children already had in using touch-screen devices, due to increased availability of school iPads, the teachers had not felt it necessary to schedule dedicated in-class sessions to familiarise the children with using the QR-code scanner app. The first few minutes of each session were therefore spent giving them experience in using the app, and once each group had demonstrated that they had scanned the demonstration code successfully, they were able to set off on the trail.

All group members appeared extremely excited when they first spotted a QR-code, vying with each other to scan it, and this enthusiasm did not seem to diminish during the activity (see Figure 5.6).

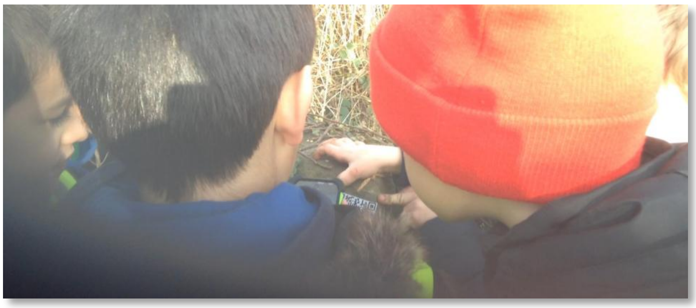


Figure 5.6: Y2 children scanning a QR-code

I observed several children demonstrating a growing understanding of how to use the map to locate the QR-codes, with some indicating they had transcended a threshold concept related to map-reading skills (cf. Hemmi, Bayne & Land, 2009). For example, one child had been looking intently at the map who then commented excitedly:

Figure 5.7: Y2 child showing location of QR-code

"*So this is .... OK. This one* [pointing at the QR-code] *is ...* ***this*** *one!"* [pointing to the relevant question mark on map] (see Figure 5.7), and then went off to share his understanding with his group members: *"Look! I know where this is! I know where this is!"*

The format of the questions shown by scanning the QR-codes appeared to be appropriate for this age group, and instead of rushing to find the next code, as had often happened in the pilots, analysis of the history logs from the scanner app and the photographs taken 'as evidence' indicated that all groups had scanned the 9 codes and had taken the time to take at least one photograph in response to the question posed. Some of these included well-focused close-ups and others were responses to the more open questions, for example, relating to seasonal changes (see Figure 5.8).

Figure 5.8: Photographs taken by Y2 children in response to QR-code questions

The questions on the QR-codes often led the children to ask further questions, for example, one child, having just taken a photograph of crocuses, asked what “*the funny little yellow things inside*” were, zooming out the photograph she had taken on the group iPad to illustrate; another asked whether birds ate rosehips; and another commented that the ‘bug hotel’ (a purpose-built structure to house insects during the winter) was rotting, which prompted a discussion between the children that certain insects, like woodlice, actually eat wood.

In line with Zimmerman and Land’s second design guideline that mobile devices can be useful in “*amplifying observations to see the disciplinary-relevant aspects of a place*” (2014, p.77), these examples all indicate that contextualised QR-code trails can serve as a useful focal point to fire and target this age-group’s curiosity in outdoor settings. It is acknowledged that there is an obvious requirement for the provision of adequate support to enable children to build their knowledge in such learner-centred activities, as highlighted by Reiser and Tabak (2014).

In terms of the general level of environmental knowledge and understanding shown during the activity, it was clear that many children did not know the names of parts of common trees and plants, (for example, catkins, rosehips or ivy), and, echoing Carey’s (1985) findings that young children do not consider plants to be living things, were having difficulty in differentiating between what was living and dead, and what was ‘asleep’. In one group I was observing, Mr Andrews helped scaffold his group’s understanding of this concept by asking them what they thought was different about trees in summer compared to now. After a period of thought, one boy excitedly put his hand up to answer: "*They've got leaves, they've got leaves, and in the winter they don't have leaves!*" Mr Andrews went on to ask the group if all trees and plants go to sleep in winter and asked them to look around. I had placed this particular QR-code near ivy and holly to help contextualise the question, and the children's understanding was therefore further scaffolded in heightening their awareness that only some plants and trees are dormant in winter.

The question that appeared to animate many groups the most was where they were required to spot a well-known landmark on the horizon and draw an arrow on their map to indicate the direction of its location, with excitement often reaching fever-pitch as children noisily chorused to point it out. The response required by the design of this question, i.e. the drawing of an arrow on the map to indicate location, was also useful in terms of the children needing to apply their growing map-reading skills, deepening their understanding of both orientation and perspective.

5.4.4 Follow-up

Following analysis of field notes, video-recorded observations and the learner-generated photographs, I emailed a list of common misconceptions found in the children's understanding of the science topic to Mr Andrews, along with a selection of the learner-generated photographs for display on the class whiteboards, as a basis for follow-up class discussion.

5.4.5 Evaluation with Year 2 Teachers

Impromptu conversations held with Mr Andrews during the activity indicated that he was both impressed with the distinct learning opportunities offered by QR-codes in this context, and with the high levels of collaboration within groups taking part in the activity. Noting that all groups were highly motivated and engaged, he also commented that this level of co-operation was unusual in the group of girls he was overseeing and cited them as an example in his introduction to the final session as the key to successful location of the QR-codes: *"The group I was with in the last session were amazing - they all took turns finding them, they all took* *turns using the scanner, they all took turns taking photographs, and they found stacks that way."*

When asked for his evaluation of the activity during the semi-structured interview, Mr Andrews responded:

> *I really liked them* [QR-codes]*. One of the reasons I wanted to take them to the nature reserve wasn't just to learn about minibeasts, it was also to teach them about using maps. It's quite an interesting place to have a map of - you can orientate yourself quite well because there's a circle, so when I did my initial one, they were kind of mildly interested,* "I can see where we are"*, not overwhelmed, and then when it was the QR-codes, and with a map showing where the codes were located as well, it was like:* "Yeah, this code was here, so that code must be there". *It gave more purpose to using the map.*

Aware that Mr Andrews had telephoned Mrs Carter during one of the sessions to negotiate a later end time, I mentioned that one TA and a parent helper had also said they felt the activity was a bit rushed; Mr Andrews agreed that future sessions should be extended to 30-40 minutes to enable the children to get the most out of the activity, depending on the 'challenges' posed by scanning the QR-codes.

In response to a question relating to his perceptions of learner engagement with the activity, Mr Andrews commented: "*The QR-code one is probably the most enthused I've seen them - they were excited about what they were doing, because of the challenge of finding something."*

This view was corroborated by Mrs Carter, who, while not being involved in running the activity herself, had seen how excited her class had been in the reserve both during and after the QR-code sessions. She had also followed-up by asking the children once back at school which of the six Explorer activities they had enjoyed the most and reported that the QR-code activity had come out as the clear winner, with children stating "*It was really fun!*" and "*It was like a treasure hunt!*"

5.4.6 Summary of DBRC_D3

This activity was successful on a number of levels. The combination of the annotated paper map, location of the QR-codes and nature of the contextualised questions, together with the scaffolding provided by adults and the children themselves, provided an appropriate platform for the children to:

- deepen their learning and application of map-reading skills;
- hone their ICT skills;
- focus in on seasonal changes in their local environment (as specified in the national science curriculum);
- work together in building their understanding; and
- importantly for this age-group, 'let off steam' in a conducive setting.

Findings also addressed the primary research question, highlighting that mobile devices can be used to mediate learning in natural outdoor settings, not only providing a focal point for learner groups collaborating on science topic work, but also enabling them to easily generate high-quality digital artefacts to refer to once back in class (Zimmerman & Land, 2014).

5.4.7 Issues for Feed-forward

It is acknowledged that the success of this activity was impacted by a number of issues, which should be taken into account in the design of similar activities:

(i) The prior map-reading activity which took place in the reserve without mobile devices was useful in familiarising the children with both the map and the reserve;

(ii) The fact-finding visit to the reserve was crucial in ascertaining which plants were in evidence and therefore determined the locations and questions of the QR-codes;

(iii) The input of adults to scaffold the learning was key in ensuring the children were able to build on their knowledge of the science topic.

5.5 DBRC_D4: Changing Seasons Activity with Year 3 (April/May 2016)

The design of the previous Y2 'Explorers' activity overlapped the design of a similar activity for Y3, and the findings emerging from DBRC_D3 were therefore able to feed into the final stages of design for the Y3 activity as detailed below.

Following contact by Miss Hope and Miss Brown (both of whom I had previously collaborated with in 2014), a series of email exchanges and meetings took place to collaborate on the design of several activities focusing on the core '*Lifecycle of Plants'* topic of the Y3 science curriculum, which stipulates that pupils should understand how to:

- *identify and describe the functions of different parts of flowering plants: roots, stem/trunk, leaves and flowers;*
- *explore the requirements of plants for life and growth (air, light, water, nutrients from soil, and room to grow) and how they vary from plant to plant;*
- *explore the part that flowers play in the life cycle of flowering plants, including pollination, seed formation and seed dispersal.*

(Department for Education, 2015)

Miss Brown had previously identified herself as an experienced teacher and advocate of outdoor learning and environmental education, but had indicated that she was under-confident in the use of ICT within her teaching.

5.5.1 Research and Design

In an early email discussion, Miss Hope informed me that the classes had visited the reserve in March to plant some wildflower seeds, with the aim of watching these grow over the next few months; she also mentioned that they had taken part in an orienteering activity while there. Building on the positive experience of using QR-codes in the museum trail, and taking note of my comments relating to the Y2 QR-code activity, Miss Hope was keen to improve the children's map-reading skills by adopting a similar format, suggesting that the QR-code trail could pose a bank of questions focusing on decomposition:

> *The children struggled to use a map (a key skill for year 3!) and could not understand why it* [the reserve] *was so messy (just with natural leaf matter). When we returned to*

class we discussed why it's a good thing the dead leaves were still there etc. For composting, bird nests etc. This was a totally new concept to them, so any questions that encourage them to look for signs of decay & the minibeast role & obviously anything that really highlights the life cycle of plants (which is the main learning concept in science). *(*Miss Hope*)*

With both classes likely to attend the reserve at the same time, ideas for a further activity, ideally with a real-world science focus, were also discussed. Responding to the curriculum requirement to involve children in "*gathering, recording, classifying and presenting data in a variety of ways to help in answering questions"* (Department for Education, 2015), and following recent reports concerning a proliferation in the numbers of invasive Harlequin ladybirds in the region, both teachers agreed to the suggestion of running a ladybird survey, to take place while the other class was involved in the QR-code activity.

5.5.1.1 QR-code Trail

As with the Y2 QR-code activity, this activity was to take place in one half of the reserve, leaving the other free for the ladybird activity. Keen to employ learner-centred, contextualised, kinaesthetic and outdoor learning principles where feasible, while also providing opportunities for the children to 'let off steam', a visit to the reserve enabled me to identify nine appropriate locations and associated topic questions for the QR-codes. An annotated map highlighting these was emailed to the teachers for comment, resulting in the six in Table 5.1 being selected.

QR-code	**Question Text**
QR 1	*Where might you find woodlice? What do you think they eat and why do you think this might be important?*
QR 2	*Why do you think it is important that things decompose (die down)?*
QR 3	*Can you see any signs of things decaying (or dying down) in the* [nature reserve]*?*
QR 4	*What do you think is important to help a new shoot to grow? Think about its design.*
QR 5	*Do you think ladybirds are useful to plants or not? What about bees?*
QR 6	*Can you find any seedpods or other examples of plant life-cycles, left over from last year?*

Table 5.1: Questions for '*Lifecycle of Plants'* QR-code Trail

Building on the initial findings from the Y2 activity, it was agreed that learner groups would use the map to help them locate the QR-codes while improving their map-reading skills. This time, however, and responding to Miss Hope's email comment that '*the children were very keen to respond via video*", they would record a video answer to the text question posed by scanning the QR-code, with a view to both engendering deeper thinking about the topic while encouraging the children to look for (and show) contextualised evidence to back up their responses. The teachers confirmed that they would be able to borrow iPads from other year groups, and it was agreed that a minimum of ten should be brought to the nature reserve.

Mindful of the need for scaffolds, particularly when considering answers to the more open questions, I suggested the creation of an accompanying eBook to support the children as they went around the trail, to provide contextualised information linked to a particular QR-code. Miss Hope indicated that enough topic material should have been covered in lessons before the outing to obviate the need for this.

In line with Kearney and Schuck (2005), I also suggested that a digital presentation incorporating some of the children's video clips could be created for a follow-up class-based session, to act as a focal point for class discussion and to embed learning. Research indicated that the online presentation software *Prezi* (https://prezi.com/) would fulfil the requirements for creating the presentation, and, following a demonstration to the teachers, this approach was agreed.

5.5.1.2 Ladybird Survey and Minibeast Hunt

Research into suitable learning materials for this age-group identified those provided on the BBC 'Breathing Places - Schools' website (www.bbc.co.uk/breathingplaces/ladybird-survey/) as the most appropriate for this age group, particularly given the true-to-scale representations of ladybirds on the ID sheet. Despite suggestions that late spring would be an ideal time to spot ladybirds, two fact-finding trips to the reserve uncovered very few, perhaps due to the unseasonably cold weather; an alternative minibeast activity sheet was therefore designed as back-up. The activity sheet focused on insects common to the reserve, and, in keeping with the topic theme, required learners to indicate whether they thought a particular insect was beneficial or harmful to plants, giving reasons why.

Responding to Miss Hope's desire for the children to take part in authentic activities such as C*itizen Science (*cf. Vitone, Stofer, Steininger, Hulcr, Dunn & Lucky, 2016), it was agreed that iPods would be brought to the reserve to enable the children to take photographs of any ladybirds or other insects they found, and suitable images uploaded to the dedicated 'UK Ladybird Survey' website once back at school.

5.5.2 Specification and Implementation

The QR-code activity was designed to address the cycle-specific research questions (CRQs):

CRQ1 - "*How might the use of QR-codes influence engagement with science topic work for 7-8-year-old children, working in groups in an outdoor setting?"* and
CRQ2 - *"How does the creation of learner-generated video responses impact on engagement with science topic work for 7-8-year-old children working in groups in an outdoor setting?"*

The agreed specification for the QR-code activity comprised:

- QR-code scanner app to be downloaded onto 10 school iPads;
- Children to work in groups of 3 or 4, sharing a school iPad to scan QR-codes and record video responses to questions;
- Teacher-led familiarisation sessions to be held prior to outing;
- 6 QR-codes and annotated map to be created and printed;
- Markers of engagement to be identified in map-reading skills, collaboration, ICT skills, literacy skills and understanding of science concepts;
- *Prezi* presentation incorporating learner video clips to be created by myself for follow-up class session.

The outing to the reserve took place on a cold spring day, with both classes attending at the same time. Miss Hope's class were the first to take part in the QR-code trail and were divided into 10 groups of 3, with one school iPad per group and one clipboard with annotated map showing the locations of the QR-codes. Miss Hope, one TA and two adult helpers were also present. Having secured the QR-codes in the pre-defined locations prior to the classes' arrival, I was asked if I could initially help start off the Ladybird/Minibeast Survey with Miss Brown's class, on the understanding that I would then be free to float between groups and activities to observe. Miss Brown's class were divided into groups of 3 or 4, with one student teacher and three adult helpers also present. Each group had a clipboard with a printout of the ladybird survey and the minibeast activity, with 7 iPods handed over to the adults at the beginning of the session as not enough were available for each group.

5.5.3 Initial Evaluation and Findings

Evaluation of the activities and initial findings were derived from analysis of the data sources detailed in section 1.8.

5.5.3.1 Familiarisation Sessions (April 2016)

As with previous familiarisation sessions, initial analysis of the learner-generated clips showed all groups in both classes appearing highly motivated and excited by the activity, with the emphasis on experimentation through fun. Children felt free enough to put on funny accents and pull silly faces to make each other laugh, and it was clear from the clips that all groups had a good grasp of filming, with most working well together, as illustrated in Tables 5.2 and 5.3.

ID	**Video file name, timings & transcript**	**Research notes**
	IMG_0549.MOV (0:00:00.00 [0:01:43.57])	
G1:	*We went to the park today and I was disappointed how many minibeasts there were.*	Children seated at desk, G1 and B1 have their heads leaning on hands. G1 appears tired.
G2:	*And we found a centipede!*	Very excited.
G1:	*Yeah, that was good, I wish we could touch it though.*	Starts getting more animated.
G2:	*It was on a tree, but it was too sticky.*	G1 sits on top of desk and other group members join her.
B1:	*We found a few woodlice.*	
Group:	*Yeah* [chorusing] *...a few.*	
G1:	*And we saw a blackbird eating a minibeast!*	Slight horror.
G3:	*And we found a worm.*	
G1:	*And this one guy from another class picked up some litter and just threw it away, which could harm something. Thumbs down to you!*	Imitates boy throwing something on floor, and then gesticulates a thumbs-down sign. Protective of nature.

Table 5.2: Extract from video-recorded discussion (Group 1) during familiarisation session

The group presented in Table 5.2 was made up of 4 girls (one of whom was filming) and 1 boy, who were discussing what they had seen on their visit to the small park near their school. One girl (referred to as G1) appears to be highly-respected by the other group members, who can be seen (seemingly unconsciously) imitating her gestures as they spoke.

Another group, comprising 3 girls and 2 boys (one of whom was filming), created a video with one girl taking on the role of interviewer who asks each group member in turn what they saw on their trip to the local park. It was clear from watching the clip that they had worked out who was going to say what (and how they were going to say it) in advance, as all group members were eager to say their piece and carried out actions imitating the movement of a different minibeast they had seen when they said its name. The girl interviewing took on a very adult tone and manner, which added to the amusement of the group; an extract from their clip is shown in Table 5.3.

ID	**Video File name, timings & transcript**	**Research Notes**
	IMG_0943.MOV (0:00:00.79 [0:01:53.29])	
G1	*Hello and welcome to our video all about minibeasts! Now,* [name of B1], *what did the woodlice look like?*	Jumps and spreads her arms wide to introduce the video
B1	*…It looked a bit like a ball that had yellow and black stripes.*	Thinks before answering.
G1	*Thank you. And how did it move?*	
B1	*They had little legs, they scuttled about, scuttle, scuttle, scuttle.*	Puts fingers to face imitating scuttling.
G1	*Thank you. And what did the worm look like? And how did it move?*	
B1	*It looked like ... really, really pink sausages, that wiggle about.*	Does action of worm wriggling (trying to make other group members laugh).
G1	*Thank you very much, that was very amusing.*	Lots of laughter.

Table 5.3: Extract from video-recorded discussion (Group 2) during familiarisation session

Highlighting a possible example of social learning, this interviewing technique was something I had noted being closely observed by a member of another group, and was something that subsequently appeared to have been adopted by several other groups in this class (see sub-section 5.5.3.2).

5.5.3.2 QR-code Activity

From my observations out in the field, most groups appeared to collaborate well in following the map to locate the QR-codes, taking it in turns to scan the codes and then working together to come up with video responses to the questions. One group, however (made up of one girl and one boy only), appeared unable to work together, resulting in constant friction. For example, on one occasion, the boy snatched the mobile device from the girl, who had been monopolising it, who then became visibly upset: “*I need it* [name of child]*! I didn't finish videoing!* [shouting and angry] *Now you just wrecked it!”* This negative atmosphere appeared to continue throughout the session, despite the adult helper’s best efforts to improve relations, confirming the work of Blatchford, Kutnick, Baines and Galton (2003) that group selection can impact heavily on the value of a learning experience.

While acknowledging the emphasis on learner autonomy in the design of this activity, I also noted that input by adult helpers was often lacking, particularly in terms of scaffolding as learners had no eBook to refer to, resulting in lost opportunities for correcting misunderstandings as they occurred. This highlights a need for balance in enabling learners to learn from each other, while providing adequate scaffolding to enable them to make connections and move through Vygotsky’s *zone of proximal development* (1980).

From initial analysis of the learner-generated video responses, I noted some children tended to race through their video clips, sometimes giving just one sentence answers; in response to what makes plants grow, for example, one girl’s comment was: "*You have to give it a lot of water and sunlight for it to grow. Bye*!", and in response to why woodlice might be useful, a boy said: “*Because they eat rotten wood, and it's not useful anymore because we can't use it. Done.*” Two groups employed the interviewing technique referred to in sub-section 5.5.3.1, while some took more of a conversational approach in their video responses. Analysis of the children’s comments from both classes also revealed some apparent misconceptions of the underlying science concepts, which are highlighted in Tables 5.4 to 5.8.

The following tables provide a purposive selection of responses to the various questions posed by scanning the QR-codes, with the group name made up of the leading initial(s) of the teacher's surname followed by a number representing the group (e.g. H1 or Br1), and the child's name made up of 'H1_G1', representing the first girl who spoke in the extract, 'H1_B1', the first boy and so on, where referred to in the main text.

Question 1: "*Where might you find woodlice? What do they eat and why might this be important?"*

The QR-code for this question was placed near a rotting log where I knew woodlice could be found, providing the children with an opportunity to make use of contextualised and kinaesthetic learning approaches in building their understanding (e.g. Zimmerman & Land, 2014). The extracts are shown in Table 5.4.

ID	Video file name, timings & transcript	Research Notes
H1	***woodlice1.mp4 (0:00:00.06 [0:00:11.48])***	
B1	*You would find woodlice under rocks and wood. They would eat wood.*	Noticeably more thoughtful and focused in outdoor setting than in classroom familiarisation session.
Br1	***woodlice1.mp4 (0:00:12.75 [0:00:24.81])***	
G1	*Where do woodlice live?*	Employs interview technique using questions from QR-code.
G2	*Woodlice live under rocks or damp wood.*	
G1	*What do they eat?*	
G2	*They eat wood.*	
G1	*What's so important about them?*	
G2	*Nothing, because if they kept eating trees and wood, we wouldn't be able to ...logs would be everywhere!*	Changes her mind while speaking and appears to grasp some of science concept mid-way through.
H2	***woodlice4.mp4 (0:00:00.60 [0:00:16.88])***	
B1	*It is important for woodlice to eat because obviously they will need to live. And that [pointing at tree stump] is where they live. They live in there, and also eat their own habitat!*	Demonstrating understanding of science concepts and vocabulary.
H3	***IMG_0292.MOV (0:01:10.63 [0:00:23.34])***	
B1	*I've got it, I've got it! [excited] To survive, because you can't eat the wrong thing, that makes them healthy, it's like a diet, or an allergy that can make you poisoned and you die. So it's best if you eat the right thing.*	Misconception of what the question was asking. Need for scaffolding; TA standing nearby, but none offered.
Br2	***IMG_1621.MOV (0:00:00.24 [0:00:14.02])***	
G1	*I think that woodlice might live in logs because we always find woodlice in logs.*	Touching and looking at log, kinaesthetic learning.
G2	*I think they eat logs.*	Socio-constructivism
G1	*See you later - and they eat logs by the way!*	

Table 5.4: Extracts from video-recorded responses to 'Woodlice' question

While the majority of the responses indicated that children knew that woodlice ate wood, they were less clear about why this might be important. This may have been due to the wording of the question, or that the material had not been covered in class.

Question 2: *"Why do you think it is important that things decompose (die down)?"*

Most children appeared to understand that there was a connection between decomposition and new plants growing, but there was often a lack of clarity around what the connection was. The extracts are shown in Table 5.5.

ID	Video File name, timings & transcript	Research Notes
Br3	***decomp.mp4 (0:00:27.32 [0:00:19.60])***	
B1	*Spring is ending, and summer is coming through, isn't it?*	Boy sitting on log - looks around for inspiration, and smiles before speaking.
G1	*And it's summer, and we're saying why things are dying down. It's because there is not enough water for them in the summer time.*	Filming. Misconception.
H4	***IMG_0240.MOV (0:00:00.03 [0:00:04.09])***	
G1	*Plants decompose so other plants have life.*	
Br4	***decomp.mp4 (0:01:14.47 [0:00:17.33])***	
B1	*If they didn't decompost, we wouldn't have flowers, grass or trees, and if we didn't have any trees, we would die.*	Skipping while filming and talking.
	decomp2b.mp4 (0:00:00.34 [0:00:12.01])	
G1	*Because it makes food for the other plants to grow*	Gesture towards plants, indicating upward growth.
H5	***IMG_1015.MOV (0:00:00.25 [0:00:20.10])***	
G1	*Ermm, because, ermm, I don't really know*	Thinking, but unsure.
Br5	***IMG_0960.MOV (0:00:07.39 [0:00:09.07])***	
G1	*They leave their seeds and new plants can grow. And they leave ...nuu ...nutrients inside the mud.*	Unfamiliar, recently-taught word; some understanding shown.
Br6	***decomp.mp4 (0:00:00.15 [0:00:21.75])***	
G1	*The question on the log was "*Why do you think it's important for things to decompose?" *And the answer is...so snails, slugs and stuff like that get food.*	
G2	Corrrrect!	Adopts television quiz format.
H6	***IMG_0232.MOV (0:00:00.13 [0:00:07.83])***	
B1	*It's important for things to decompose so that other insects and wildlife need it to make homes.*	
H7	***IMG_0240.MOV (0:00:00.03 [0:00:04.09])***	
G1	*Plants decompose so other plants have life.*	Understanding of lifecycle.

Table 5.5: Extracts from video-recorded responses to 'Decomposition' question

Question 3: "*Can you see any signs of things decaying (or dying down) in* [the reserve]*?"*

In line with contextualised and outdoor learning principles, this question was intended to harness the natural assets of the reserve to build understanding, while also providing opportunities for kinaesthetic learning and for the children to show and share what they had found (cf. Passey, 2010). The extracts are shown in Table 5.6.

ID	Video File name, timings & transcript	Research Notes
Br3	***decomp.mp4 (0:00:27.32 [0:00:19.60])***	
G1	*We can see lots of things dying down in the* [name of reserve]. *We can see them ... over here … some things are not dying, and some things are dying.*	Speaking while filming decaying tree trunks and fallen leaves.
B1	*Like winter things.*	
G1	*Yeah, like winter things.*	
B1	*Some things are arriving, like daffodils, and these nettles.*	Points at nettles and daffodils.
H5	***decompose_see2.mp4 (0:00:00.00 [0:00:11.77])***	
G1	*I think the leaves are dying because they're brown and starting to de …decompose*	Pauses over unfamiliar, recently-taught word; has understood concept.
Br7	***decompose_see2.mp4 (0:00:11.83 [0:00:07.36])***	
G1	*[Name of child], can you see anything that's dying?*	Interviewing technique.
G2	*Yes, this tree has been cut down and it's getting mouldy.*	Understanding shown. Slight disgust.
Br4	***decompose_see3.mp4 (0:00:00.27 [0:00:17.57])***	
B1	*What might we find in the [nature reserve] that's dead ….we might find dead flowers …dead trees …dead plants …dead leaves, sticks and other dead things. The end.*	Picks up some leaves and thinks before he speaks, looking around for inspiration.
H2	***decompose_see6.mp4 (0:00:07.79 [0:00:08.48])***	
		
B1	*Awesome leaves decaying. And I found them here! There's millions of them! Tonnes here. Look!*	Kinaesthetic learning and displaying flow – continues picking up handfuls of leaves.
Br8	***IMG_0110.MOV (0:00:03.28 [0:00:04.33])***	
G1	*The plants die because people have been stepping on them. And the leaves have been falling off over the winter.*	Misconception.
H8	***IMG_0154.MOV (0:00:00.02 [0:00:04.07])***	
B1	*You can see things decaying on the ground. Can you see it too?*	Showing evidence, while speaking.

Table 5.6: Extracts from video-recorded responses to 'Evidence of decay' question

Question 4: *What do you think is important to help a new shoot to grow? Think about its design."*

Given the topic work done in class, I was surprised to see how many children appeared to find this question difficult to answer. It may have been that: (i) the wording of the question needed to be revised (although all question wording had been agreed with the teachers prior to the outing); (ii) the concept of 'design' is a difficult one to grasp for this age-group; or (iii) their reticence corroborated Carey's (1985) observation that children under the age of 11 years do not consider plants to be 'living' in the traditional sense. The extracts are shown in Table 5.7.

ID	Video File name, timings & transcript	Research Notes
Br1	***plant2.mp4 (0:00:08.49 [0:00:12.43])***	
G1	*What helps a new plant grow?*	Interview technique. Filming while asking questions.
G2	*Insects are important because they eat all the leaf litter, otherwise there wouldn't be any space for the new plants to grow.*	Some understanding of science concepts.
G1	*Think about its design.*	
G2	*It can have yellow petals, purple petals, pink petals, blue petals, white ones like this and they can, and also, they can have green stalks.*	Question needed re-wording?
Br3	***plants4.mp4 (0:00:00.30 [0:00:58.84])***	
G1	*Now we are trying to talk to you about these, the question marks on the board.*	Have taken turns, so B1 now videoing. G1 highlighting location of QR-codes on paper map.
B1	*They are QR-codes, which are where we get our ideas from.*	Have appropriated technology for learning.
G1	*In this episode, we are going to talk to you about this one here. It said: "*What do you think plants need to grow*" …We think maybe it's the water and the sunshine, together, that make them grow.*	Points to correct location on map, showing map-reading skills. Understanding shown.
B1	*But with sunflowers, sometimes water kills them.*	Bringing in experience gained elsewhere.
G1	*Not always.*	Experiential learning; socio-constructivism.
B1	*Not always, but too much water kills them.*	
G1	*Yeah too much. Well byeeee!*	Smiling and appearing pleased with what they have produced and enjoying activity.

Table 5.7: Extracts from video-recorded responses to 'New shoots' question

Question 5: "*Do you think ladybirds are useful to plants or not? What about bees?"*

Many groups responded as if the question were asking which insect was more useful, as illustrated in Table 5.8; misconceptions relating to the roles of bees and ladybirds also indicated that the children might have benefited from an eBook or some other scaffold when coming up with their answers.

ID	Video File name, timings and transcript	Research Notes
Br9	***IMG_1622.MOV (0:00:00.04 [0:00:12.82])***	
G1	*We think that bees are useful on flowers like this, but not ladybirds, because ladybirds just scatter around.*	Misconception.
Br10	***IMG_0233.MOV (0:00:00.20 [0:00:16.71])***	
G1	*Bees and ladybirds are helpful to flowers because the bees ...I mean the ladybirds eat all the bad bugs that eat the flowers.*	Only child to demonstrate understanding of role ladybirds play (perhaps bringing knowledge from home or adult helper)
H9	***IMG_0405.MOV (0:00:00.88 [0:00:46.25])***	
G1	*I do think bees are because they make honey for us ...once they collect some nectar, they go to the next flower, and they drop a bit of the nectar they've just got off the first ...and ladybirds, they're really cool ...they have loads of spots.*	Mixes up nectar and pollen; some understanding shown of science concepts.
H10	***IMG_1018.MOV (0:00:00.10 [0:00:15.32])***	
G1	*I think bees are more useful because they make honey with some flowers, and ladybirds do not do that!*	Group laugh as cow moos in adjoining field. Enjoying nature.
H1	***IMG_1623.MOV (0:00:16.92 [0:00:03.11])***	
B1	*If we didn't have plants, we wouldn't be able to breathe.*	This group of 3 boys spent some time 'letting off steam', but did relay some science facts relating to plants.

Table 5.8: Extracts from video-recorded responses to 'Ladybirds and bees' question

Question 6: "*Can you find any seedpods or other examples of plant life-cycles, left over from last year?"*

The QR-code for this question had been secured at the bottom of a sycamore tree which had many 'helicopter' seed pods still connected to its branches, which were not spotted by some children as they did not tend to look upwards. The extract is shown in Table 5.9.

ID	Video file name, timings and transcript	Research Notes
H5	***seedpods_sm.mp4 (0:00:00.71 [0:00:12.84])***	
G1	*Today I'm here to show you some re-cycled logs and stuff from last year. And here they are.*	Shows large wood pile while speaking.
H9	***seedpods_sm.mp4 (0:00:16.15 [0:00:04.54])***	
G1	*Here are some seed pods dried out from last year.*	Kinaesthetic learning - holding seed pods in hand while speaking.
Br2	***seedpods_sm.mp4 (0:00:27.11 [0:00:10.96])***	
G1	*Here are some seed pods - I've seen millions of them in my life, so they are pretty boring, but they actually grow into flowers and stuff.*	Filming sycamore while speaking; some understanding shown.
G2	*I've seen trillions.*	
G3	*I know, we have.*	
Br7	***oldjunk.mp4 (0:00:00.04 [0:00:10.81])***	
G1	OK, [name of child], *can you find any old junk left over from last year?*	Interview technique – uses her own 'version' of the wording.
G2	*Yes, we have found looads of junk!*	Smiles at use of 'old junk' and points at pile of dead wood.

Table 5.9: Extracts from video-recorded responses to 'Seedpods' question

5.5.3.3 Ladybird/Minibeast Survey

Perhaps because the children had not seen many insects on their familiarisation outing, they appeared extremely excited when coming across minibeasts during this session. Disappointingly few ladybirds were found, probably due to the on-going cold weather. Analysis of data on the iPods revealed some good close-up photographs of insects had been taken by the children, including some of ladybirds (see Figure 5.9); the activity sheets, however, highlighted varying levels of understanding about the role insects play in plant life-cycles, a fact corroborated by later analysis of the learner-generated video responses.

Figure 5.9: Examples of photographs taken by Y3 children during Ladybird/Minibeast Survey

While more of my observations were focused on the QR-code trail sessions during this outing, some illustrative excerpts resulting from my recorded observations of this activity are included in Table 5.10, to illustrate the high level of engagement with this activity.

ID	Video File name, timings and transcript	Research Notes
	IMG_0336.MOV (0:02:27.24 [0:01:38.16])	
B1 and others	*Whoah!! A slug, a slug!!! Look, look!!*	Lots of children shouting with excitement to see insects when tree stump turned over. Noise makes it difficult to differentiate what is being said.
TA	*Take your photograph.*	More excited shouts from other children.
B2	*Mr [name of TA], can I have the iPod?*	
TA	*So these are woodlice, aren't they? What are these?*	Lots more noise.
G1	*A centipede!!!*	Very excited.
TA	*What's that?*	Also enthusiastic.
G1	*A golden centipede!*	
Miss Brown	*Do you think these minibeasts might be helpful to plants? They eat dead things, don't they? Draw a picture of it underneath.*	Using contextualised, kinaesthetic learning.
	IMG_0336.MOV (0:08:45.38 [0:02:11.62])	
B1	*I made a discovery! I found a millipede!*	Child excited and on-task for the duration of the activity.
	IMG_0337.MOV (0:00:09.12 [0:00:23.29])	
B1	*Is a millipede good or bad for plants?*	Directly asked whether a specific insect was good or bad for plants.

Table 5.10: Extracts from video-recorded group discussion during Ladybird/Minibeast session

5.5.4 Evaluation with Year 3 Teachers

Teacher evaluation of the activity was carried out through analysis of comments they made in the reserve, email exchanges with Miss Hope and from their individual semi-structured interviews.

Impromptu conversations held with both teachers during the QR-code sessions indicated they were pleased with how their classes had responded to the activities, with Miss Hope commenting near the end of her session: "*They've thoroughly enjoyed it!",* and asking how complex QR-code trails were to set up. Some of Miss Brown's time had been taken up with overseeing the more fractious group, but she did note how obviously motivated all groups had been in finding the QR-codes and said that she was looking forward to seeing the video clips they had created.

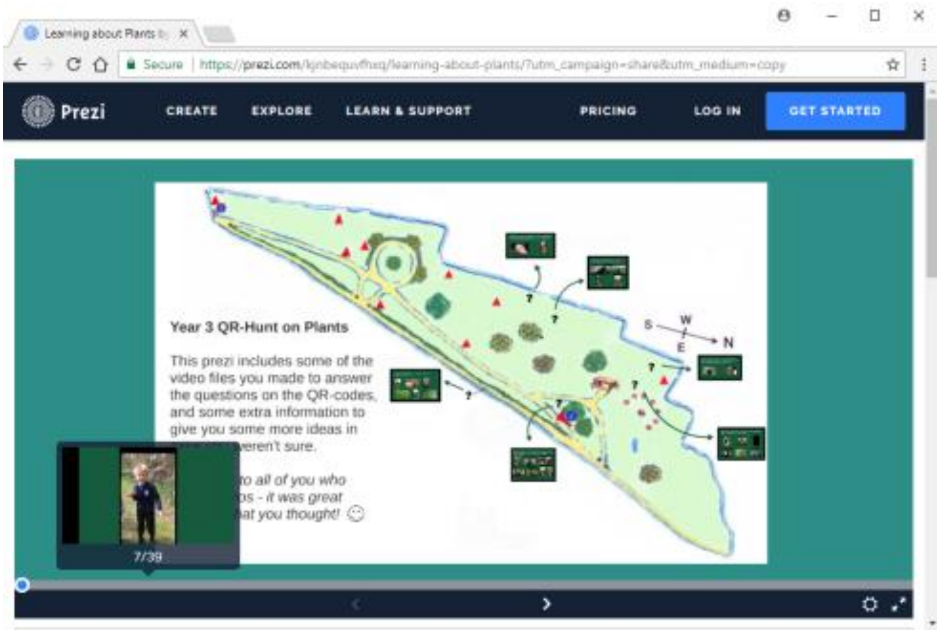


Figure 5.10: Screenshot of *Prezi* with embedded learner-generated video responses

Following initial analysis of the learner video responses, I created a *Prezi* using the map of the reserve as a background and embedding a selection of the clips (see Figure 5.10) to act as a focal point for a follow-up class discussion. As agreed with the teachers, clips were chosen either to highlight common areas of misunderstanding or to act as exemplars of showcasing science knowledge.

In an email exchange with Miss Hope where I queried the children's reaction to the *Prezi*, she noted that some children had been a little embarrassed at seeing themselves on the class whiteboard, especially where they had given an incorrect response to a QR-code:

> [Some children] *did comment on how their answers did not reflect what they actually know. They loved the whole experience though & I would def do it again. In fact they*

asked if they could do it again (or a similar task) so they could improve their answers (& get on the big screen if they hadn't!)

Miss Hope also commented on how the activity had increased the children's awareness of what QR-codes were:

...before the project, when I asked the class who had seen a QR code 1 child had but couldn't tell me what it was. None of them had used them. After the project they could all tell me what a QR code was. About half could explain what they were used for/ where you might find 1 and a third of the class had since used them at home (mostly out shopping). When they saw an image of a QR code on the prezi a few chn shouted 'a QR code!' and mimed scanning it!

During the semi-structured interview with Miss Brown, I asked for her thoughts regarding the QR-code activity. While reiterating the high levels of engagement she had observed in her class during the activity, Miss Brown noted that some of the children had forgotten to record video responses in their eagerness to find the codes:

*I had to send some of them back. They came up and said "*We've done them all!*"* [excited voice]*, I said: "*And? Where are all your clips*?" and they said: "*Oh, we forgot to do some of those.*"*

Following this up, Miss Brown went on to highlight that this was the first experience the children had had of QR-codes, and that finding them using the map and scanning them had been a reward in itself:

*They'd just been so into doing the codes, scanning them, they'd been to each one, that I don't think they'd always answered the question. It was the first time they'd done it, so there's all sorts of skills going on, you know, looking at a map, running round and the very finding of the QR-code was for them: '*We found it on the map*!" If they'd had more practice at those sort of skills before then ...it was just excitement, you know* [laughs].

Miss Brown agreed with Miss Hope that in hindsight, an eBook would have "*helped them through*" the activity, and spontaneously went on to suggest other uses she could see for QR-code trails:

> *In PE we do 'track and trails' in Y3 as part of our Outdoor Ed curriculum ...if I'd had* [QR-codes] *that would have been brilliant because I had to do them on my own ...it was in the school grounds ...that would have been a great starter to do ...if they'd done it around school first, and then gone to the* [reserve] *after that, then they would have known it. It's just practising, but that would have been good.*

I explained to Miss Brown how straightforward QR-code trails were to set up, and she commented that it was her lack of awareness that had prevented her from trialling them before: "*It's just not knowing about them. I didn't know anything - to me it's like, how has she done all this? It's really very simple, well there you go."* She also noted that she had found the *Prezi* clips useful in enabling her to gain a quick snapshot of which of the science concepts children were having most difficulty with.

Following up on a comment made to me by a child during the Y2 activity that they preferred videoing responses because: *"I don't have to write anything down*", I asked both teachers separately whether they felt this technological affordance gave certain learners more of a voice, with both confirming they did:

> *Yes, definitely. All of those that you wouldn't usually engage well in writing experiences; they were all on task and engaged with this activity. Video-making was the favourite.* (Miss Hope)

> *Certain children will thrive on that opportunity to use technology. They don't have to go through the motions of writing. You see different children shining. You can get all their knowledge down, with this activity, with the science, without them having to record it [by writing], but they can do it in a really interesting way. It appeals to them.*
> (Miss Brown)

5.5.5 Summary of DBRC_D4

With reference to CRQ1 ("*How might the use of QR-codes influence engagement with science topic work for 7-8-year-old children, working in groups in an outdoor setting*?"), all groups appeared highly engaged with the activity, with all but one collaborating well to locate the next QR-code and create video responses. As with the Y2 activity, the annotated map was useful in deepening map-reading skills, with all groups demonstrating an understanding of how to use them by the end of the session. In their obvious eagerness to find the next QR-code and the question it was posing, some group members did give brief responses (for example, one sentence) or had to be sent back because they had omitted to record a response the first time around.

In keeping with the child-centred design of the activity, I observed no examples of adult help being requested and saw several groups playing back the video clips they had taken, deleting those they were not happy with, and taking another as replacement. I also saw plenty of examples of learners looking around to get inspiration from nature to answer their QR-code question, and videoing or picking up natural objects such as seedpods or leaves to illustrate what they were saying in their video voice-over; this directly responds to the primary research question of how mobile devices might influence the engagement of primary-aged children with science topic work in outdoor settings.

With reference to CRQ2 ("*How does the creation of learner-generated video responses impact on engagement with science topic work for 7-8-year-old children working in groups in an outdoor setting?")*, the children showed varying levels of understanding of the science concepts relating to the core 'Lifecycle of Plants' topic in their video responses; when Miss Hope demonstrated the 'showcase' Prezi to the classes, she fed back that some children felt they had not demonstrated their true knowledge in certain clips, and that this resonated with what she had observed. This also echoed certain findings from the production-focused research activity stream and will be explored further in Chapter 8.

5.6 Summary of Chapter 5

This chapter described four design-based research cycles focused on the design, development, implementation and evaluation of mobile learning activities related to the *discovery-based learning* research stream. Activities encompassed a Y5 QR-code museum trail, two linked activities focused on the Y5 '*Lifecycle of Plants'* topic, one seasonally-focused QR-code nature trail with Y2, and one '*Lifecycle of Plants'* QR-code trail with Y3. Findings derived from the analysis informed the development of a set of mobile learning design principles, which are detailed in Chapter 8.

The following chapter describes the design, development and evaluation of a series of mobile learning activities focused on the *production-focused* activity stream, where learners used iPods and iPads to create their own movies focusing on insects and plant life-cycles.

Chapter 6 Production-Focused Learning (Video Clips)

The previous chapter detailed the design, development and evaluation of a series of mobile learning activities (MLAs) focused on the *discovery-based learning* research activity stream, which aimed to support primary-aged learners in exploring themed topic work in outdoor settings. This chapter describes the design and development of MLAs linked to the *production-focused learning* research activity stream, aiming to support children in creating their own video clips, primarily within the outdoor setting of the nature reserve. Collaboration with three Year 2 (Y2) teachers resulted in the design of activities for around 120 children.

Building on the findings from the exploratory phase, this activity stream encompassed two design-based research (DBR) cycles which took place over a period of two years, where findings from one iteration fed into the design of the next. The description of the first cycle (DBRC_P1) is covered in greater detail to enable a more complete picture of the research activity stream to be drawn.

6.1 Research and Design Context

Zimmerman and Land (2014), in line with Papert (1980), Sharples and Pea (2014) and Figueiredo et al. (2016), argue that children's critical thinking and deep learning is enhanced when they construct digital artefacts in outdoor settings that they can refer back to once in class. One affordance of iPods and iPads that I took advantage of in the design of activities for the pilot studies was the provision of the built-in camera app, which enabled the capture of high-quality photographs and video recordings. From my subsequent experiences of working with the Y5 teachers on the Museum QR-code activity (see sub-section 5.3.6), and in line with my research aim to avoid the use of bespoke hardware and software (see sub-section 2.1.2.1), I was also aware that the design of any MLA should acknowledge the time commitments of teachers and obviate the need for in-depth training, where possible.

As mentioned in the introduction to this thesis, I had watched my own children (then aged 9 and 6 years) enthusiastically use mobile technology to create their own documentaries of the Topkapi Palace in Istanbul, and, in line with Lai et al.'s study (2007), had noted that the process of taking the video and providing a voiceover had appeared to focus them in on what they were seeing at the time, as well as being a valuable reminder of what they had seen when they got home.

Having been surprised by the depth and richness of the video clips spontaneously created by children in the second pilot (see sub-section 3.2.3), and inspired by the approach taken in the children's BBC *Nature Detectives* series (where children presented their own minibeast hunts), I determined that trialling the use of learner-generated video clips in outdoor settings should play a key part in the design of these activities.

6.2 DBRC_P1: Film-making with Year 2 (2014)

An initial meeting was set up with Mr Andrews and his team-teacher, Miss Brown, to describe the research and its terms of reference, and to start exploring suitable curriculum areas, if agreed. Both teachers suggested the core science topic from the National Curriculum: *'Living things and their habitats'* as a promising candidate for the activity, with a particular focus on the following statutory learning objectives:

- *identify that most living things live in habitats to which they are suited and describe how different habitats provide for the basic needs of different kinds of animals and plants, and how they depend on each other*
- *identify and name a variety of plants and animals in their habitats, including microhabitats*

(Department for Education, 2013, p. 151)

It was subsequently agreed that I should design a prototype MLA focusing on insects to act as a starting point for discussions. Aware of the importance of working in tandem with practitioners in design-based research undertakings (Barab & Squire, 2004; Wang & Hannafin, 2005), a meeting schedule was also agreed with the two teachers, both to promote a sense of ownership of the activity, and to help ensure that any educational intervention would be fit for purpose.

6.2.1 Activity Design

At this point in the research, I was unable to find any literature focusing on the use of mobile devices in outdoor settings that did not use bespoke hardware or software (see sub-section 2.3.1) to inform the design of this prototype activity. I therefore revisited the literature related to child learning, as well as also considering the requirements of the National Curriculum, activities run by nature charities such as the Woodland Trust and my own experiences in running the two pilots.

Following the tenets of experiential (e.g. Dewey, 1938; Kolb, 1984), authentic (e.g. Herrington et al.*,* 2008) and outdoor learning (e.g. Dillon et al. 2006), I wanted to encourage autonomy in the children (Brown, 1992) in exploring the natural environment, while also providing some structure to help them get the most out of the learning opportunity (e.g. Kurti et al., 2008; Melhuish & Falloon, 2010). Keen to harness the motivational aspects of using mobile devices (Burden et al., 2012), I was hoping the activity would lead children into experiencing aspects of Csikszentmihalyi's flow (1997), where they were so immersed in the activity that they forgot it was 'work'.

6.2.1.1 Opal **Bugs Count** *app as 'More Knowledgeable Other'*

In order to explore whether a 'digital tool' might be able to act as a scaffold (Säljö, 2010), I evaluated existing free educational apps that provided information about insects in a suitable format for primary-aged children, and, mindful of the experience relating to wifi provision in the nature reserve, one that did not rely on internet connectivity.

Bugs Count, created by an environmental charity, Opal, in collaboration with the Natural History Museum, provided both an easy-to-use interface and the appropriate level of detail for the target audience (see Figure 6.1).

Facilitating identification of insects, *Bugs Count* enables users to select how many legs an insect has (e.g. ‘None’, ‘Six’, ‘Lots’), then, depending on the selection made, presents photographs to aid further identification.

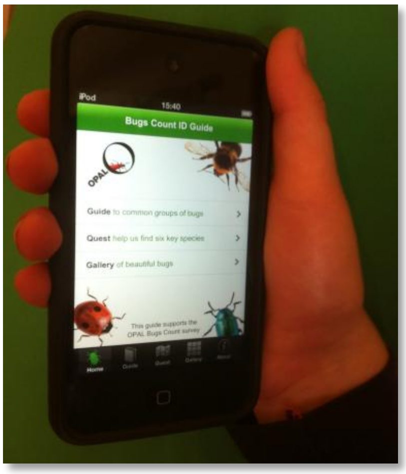


Figure 6.1: Opal’s *Bugs Count* app on an iPod

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6.2.1.2 Initial Design Conception

In keeping with the principles of both learner-centred and authentic learning, the initial design of the activity required children to think of themselves as nature documentary-makers, and included:

1. Watching extracts from insect-related documentaries created by famous naturalists (such as Sir David Attenborough) or other sources to act as inspiration;
2. Familiarising themselves with the skills required for minibeast-hunting;
3. Familiarising themselves with the skills required for recording video documentaries using mobile devices;
4. Collaborating in groups to coax minibeasts into collecting jars and then creating their own insect documentaries while in the nature reserve.

I subsequently received confirmation from Mr Andrews that they were keen for me to proceed with this design: “*The film idea is brilliant! It'll build on the activities they've done already and also give a real sense of purpose to the visit.”*

Regular communication over the next three months helped to ensure that: (i) teachers had continuing input into the planning and design of the activity as it evolved; (ii) expectations of how the activity would run were in alignment between myself and the teachers; and (iii) teachers fully understood the purpose of the observations and how these would be carried out during the sessions.

Building on my experience in running the pilots, I suggested that an activity sheet could be used to support the activity, which required the children to fill in details of minibeasts that they came across in their hunt. Anticipating that these details could then act as prompts for the video voiceover, I envisaged the activity sheet being divided up into two discrete sections: one that could be answered by observing the insect that they had in a collecting jar, and the other made up of two or three 'Interesting Facts', to be gleaned from the app or some other authoritative source.

It was agreed that existing 'table groups' (i.e. groups of learners previously organised by teachers to sit together for class-work) would also be used as learner groups in the nature reserve, as these were generally made up of children that worked together amicably, and that the ideal ratio of adult helper to learner group would be 1:1. It was further agreed that, in line with socio-constructivist (Vygotsky, 1980; Bruner, 1979) and constructionist (cf. Papert, 1980; Zimmerman & Land, 2014) principles, the activity should be learner-led as far as possible, and that adult helpers should hold back unless they were asked for guidance or it was obvious that learners were not engaging with the activity.

6.2.2 Secondary Research Questions and Activity Specification

This activity was designed to address the cycle-specific research questions (CRQs):
CRQ1 - "*How might the process of creating insect documentaries using mobile devices engage 6-7 year old children with science topic work, working in groups in an outdoor setting?*", and
CRQ2 - "*How might the process of creating insect documentaries using mobile devices enhance understanding of science topic work for 6-7 year old children working in groups in an outdoor setting?*"

The final agreed specification of the activity comprised:

- One-hour minibeast hunt session to take place in the nature reserve prior to the mobile learning session, led by the reserve Education Officer, giving tips on where to find insects;
- 8 iPods to be provided by myself, along with a minimum of 2 school iPads (all with *Bugs Count* pre-installed), giving a ratio of one mobile device per learner group of 3-4 children;
- Ideal ratio of one adult helper per learner group to be aimed for, with adults primed to provide help where necessary;
- Hands-on classroom sessions led by Mr Andrews and supported by myself, to familiarise the children with the iPods and iPads , and the *Bugs Count* app;
- Video excerpts from the BBC *Nature Detectives* series or documentaries by well-known naturalists to be shown in class prior to the outing;
- One activity sheet and video plan document to be printed out for each learner group to support the activity;
- 1-hour mobile learning session to be held in the nature reserve, to enable children to explore the environment, find and collect insects in collecting jars, complete activity sheets about the insects using observation and the *Bugs Count* app, and create their own video documentaries of insects;
- The best documentaries to be shown in school assembly and/or the school blog.

6.2.3 Observation Plan

With the schedule for the MLA agreed, I revisited my research questions to re-focus on what I was hoping to learn from the observations, and, mindful of my experiences from running the pilots, to clarify what measures I could take to ensure collection of the most valuable data in the messy conditions of the nature reserve. My key aims for the observations included collecting data to help me explore:

- How the children worked in groups (e.g. how they organised themselves, what impact relationships children had with each other had on their engagement);
- What impact the adult helper had on how the children approached the activity (be it teacher, TA, parent helper);
- What impact having a mobile device appeared to be having on group dynamics;
- How engaged the children were at different points in the activity;

- How well the activity sheets served their purpose;
- How well the app served its purpose as a scaffold;
- How the children dealt with the process of filming.

While determining that I would remain flexible on the day and follow the most promising leads as they unfolded, my aim was also to observe one group right through the process, from finding and collecting their insect to creating their video, rather than constantly moving between groups.

6.2.4 Nature Expert-led 'Minibeast Hunt' Session

This session took part in the nature reserve on a cold, overcast day in late February, and involved both classes attending separately, one in the morning, one in the afternoon. The session took the format of the expert introducing the subject of insects and their importance in environmental terms, and describing the sort of habitats that might be found. Tips were given on using brushes to coax the insects into collecting jars, in order not to harm them. Following the introduction, children ran off to find and collect as many minibeasts as they could in their collecting jars, and to carefully release these into a large communal tray so that they could be observed. Following a concluding talk by the expert on what had been found, the children were asked to release them carefully back where they had found them.

The session lasted approximately 30 minutes, with the majority of the children appearing enthusiastic and engaged during the hunt itself, but less so during the preliminary and concluding talks. Children worked in small groups of 3 or 4, and the ratio of parent helpers to groups was around 1:2.

6.2.5 Classroom Familiarisation Sessions

Familiarisation sessions took place three weeks later to give the children practice with using the iPods to record videos and the *Bugs Count* app. I had asked if children could be allocated to the same groups for this session as they would be for the outdoor session, to help me compare their behaviour across both settings. I brought along the 8 iPods, while Mr Andrews had 2 school iPads ready for use.

6.2.5.1 Familiarisation Session - Mr Andrews's Class

When I arrived at the first session, the children were engrossed watching a video clip of David Attenborough talking about worms from his BBC 'Life Stories' series. I noted Mr Andrews had put out a variety of plastic minibeasts on tables as props for this session, and had also created an activity sheet covering the key aspects of using the iPods and iPads.

Children sat on the floor while Mr Andrews demonstrated using one of the iPods, illustrating in real-time on the whiteboard the results of what would be captured if they moved while trying to take a photograph or video. This approach appeared to work very well, with much laughter ensuing as Mr Andrews showed them an example of one such video he had taken earlier where he got over-excited and swung the camera in all directions. At the end of the demonstration, I took the opportunity to ask the class how many of them had had experience of using touchscreen handheld devices, and was surprised to learn that as many as 22 out of the 28 present had.

During the session, the majority of children appeared to have taken on the information regarding using the camera app, but what came through most strongly was that all groups appeared excited and motivated to try out creating their own documentaries using the plastic insects (see Figure 6.2), demonstrating their emotional, behavioural and cognitive engagement with the activity.

Figure 6.2: Y2 learning to film using plastic insects as props

In all, this 40-minute session achieved its aims, with children sitting patiently in their table groups after the demonstration to be given their iPod or iPad. Some 'hogging' and snatching of the iPods was noticed between group members once the devices had been handed out, but most children worked together to complete their group activity sheet equitably.

6.2.5.2 Familiarisation Session - Miss Brown's Class

Mr Andrews ran this session following the format of the first, with the addition of the introduction of the *Bugs Count* app during the demonstration. This class did not seem as calm as the first, and after the demonstration I was surrounded by children trying to get an iPod rather than sitting in their table-groups, and getting visibly upset if they did not get one quickly. This fractious atmosphere continued for a short while, but settled down once the children realised they were all going to get a chance to use a device if they sat in their table groups. As with Mr Andrews's class, the children appeared enthusiastic, excited and engaged throughout the session. Responding to the question of who had previously used touchscreen handheld devices, 25 of the 29 children present indicated they had.

After the session, I collected all iPods and transferred the video clips and photographs the children had taken to a PC, keeping each group's data in separate encrypted folders. Analysis of the data showed that Mr Andrews's class had taken a total of 93 photographs and 52 videos during these sessions, amounting to some 16 minutes of footage, with Miss Brown's class taking some 70 photographs and 45 videos, amounting to 23 minutes of footage.

I had asked the children to take a *selfie* of their group at the beginning of the session, to aid identification should I need to discuss anything with their teachers, and to help me track levels of engagement across the two sessions. Once the photographs and video clips were copied from the iPods into group folders on the PC, I cleared all data from them and ensured they were fully-charged, ready for the outdoor mobile learning activity the following Monday.

6.2.6 Outdoor Film-making Sessions

The two classes visited the nature reserve separately in late March, with each mobile learning session scheduled to last around 1 hour. The weather was clear and sunny, but as the nature reserve has a variety of habitats, including wooded, shaded areas as well as grassy sections, the prospects for a productive insect hunt were good. The equipment required for the activity consisted of brushes and collecting jars, clipboards with the Activity Sheet and Video Plan sheet, 2 school iPads and 8 iPods with the Opal *Bugs Count* app pre-installed.

In the following section, learner groups are referenced using the notation “A1_1”, where A refers to the initial capital of the teacher’s surname, the first numeral refers to the number of DBR cycles the teacher had participated in at this stage of the research, and the final numeral identifies the specific group. Children within that group are then referenced using the group identifier appended by a G1, B1 for the first boy and so on.

6.2.6.1 Observation and Initial Analysis - Mr Andrews’s Class

This class came in the morning, and the ratio of adult helpers to children was one per learner group (two TAs, three student teachers and one parent), with Mr Andrews himself taking responsibility for overseeing two groups. The TAs were those that normally worked with this class, and there was an obvious rapport between them and the children. Each group was allocated one mobile device, to be handed over once they had found and collected their first insect. I was free to move around all groups observing as the session progressed.

Mr Andrews opened the session by reminding the children of the purpose of the activity, giving tips on collecting and filming their insects, and re-iterating that they could re-take any video clips they were not happy with.

The children were extremely enthusiastic to get on with the activity, and once each group had picked up their equipment, they ran off in various directions to find some insects. The nature reserve has a number of designated areas for minibeast hunts where old logs and sections of tree trunks have been placed, and these became a hive of activity, with learners excitedly shouting to others what insects they were finding.

Although it had been agreed with the teachers that this should be a learner-led activity, I saw two examples of adult helpers taking charge from the start, one student teacher and one TA. This may have been down to a lack of direction from the teacher before the activity started or the implicit expectation that adults take charge in these scenarios. While this appeared to have been carried out in an inclusive, encouraging manner, it did make for a more passive experience for the learners involved in those groups, and observation and later analysis of the video clips created with these groups confirmed initial impressions that the children appeared less animated in their video voiceovers than those in learner groups who were left to direct their own videos (see Table 6.2 for an illustrative extract).

While the children were occupied in finding insects for their documentaries, I made my way around all groups to get an overview of how well groups appeared to be working together and how engaged they appeared. Rather than settling on those groups who were being strongly led by adults, I eventually chose to follow one group (referred to as A1_1) made up of 4 girls, and overseen by a TA who had placed herself on the periphery.

6.2.6.1.1 Observation of Group A1_1

Although this group initially needed a little help in understanding: (i) how the activity sheet related to the making of the documentary; and (ii) how to navigate within the app, these issues were easily solved by either asking the TA (with reference to filling in the activity sheet) or another group who were nearby (with reference to using the app), who showed them, explaining: "*Press that*" (see Figure 6.3).

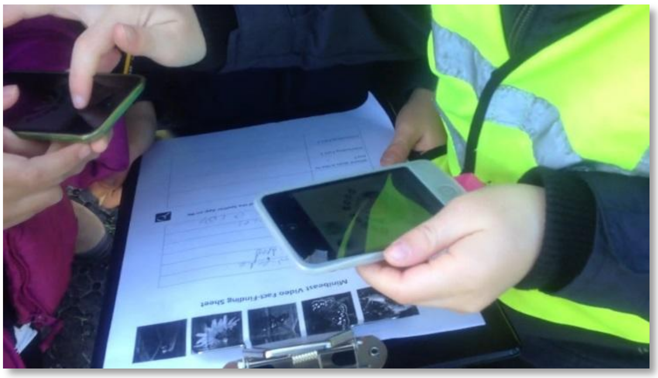


Figure 6.3: A group member shows another group how to use the app

The group proceeded to create an informative documentary about centipedes lasting 1 minute 37 seconds, having worked together to fill in the activity sheet using their own observations and the app, and then taking turns to either film or speak about their centipede's characteristics, such as number of legs, colour and habitat: "*This is the centipede group with me,* [A1_1_G1] *and* [A1_1_G2]. *And this is our centipede. We have found out that they have* *at least 15 ...pairs of legs, but can have more. Usually orange or yellow.* [A1_1_G3]'s *going to speak next."*

The TA only felt obliged to intervene once, which related to encouraging one child who was initially reticent to speak on camera. The group used both sections of the activity sheet to good effect as prompts while making their documentary.

Having borrowed a collecting jar from another group that contained a millipede, they used this as a further learning opportunity to contrast the appearance and feeding habits of both (see Figure 6.4), accessing the *Bugs Count* app for further information, concluding: *"This one's a meat-eater and this one's a vegetarian!"*

Figure 6.4: Group A1_1 creating a film comparing characteristics of centipede and millipede

Two of the girls then moved off to create another film where they gathered leaves for the millipede and released their centipede, which gave every impression of their being immersed in the activity and also showed a protective attitude towards creatures: "*Is that better, little one?*" (A1_1_G1). This behaviour was highlighted as highly unusual by the TA when she saw them, who went on to say to me that one of the girls was often disengaged and disruptive in the classroom setting, and that it was good to see her enjoying herself in a natural setting. She also commented that both girls had strong characters, which is why they had been allocated to her group, and that they generally did not get on; she was surprised to see them being compatible, and speculated that being outside in a stress-free setting had helped with this. I was unable to follow up whether this behaviour had continued on into the afternoon, but flagged it as something of interest to follow up with Mr Andrews as teacher.

6.2.6.1.2 Observation of Group A1_2

I observed another group (referred to as A1_2) made up of three boys who had found a millipede. This group had filled in the majority of their activity sheet without adult supervision, although one boy, A1_2_B1, did ask an adult helper if he was right to have put down 'crawl' relating to how their insect moved. They had also completed the videoing task without adult help or supervision, and when I later analysed the videos they had taken, I noted that they had created 7 versions of their film. In one of the early clips, A1_2_B1, who was doing the voiceover using the activity sheet as a prompt, has difficulty in reading the writing of the other, making comments such as: "*What does that even say?!*"

During the activity, while I was not present when they were filming the clip mentioned above, I had observed A1_B2 taking charge of the iPod, requesting that A1_B1 did the writing and speaking in the video because he was "*better* " at it, which was accepted by A1_2_B1; this allocation of roles was presumably (in part, at least) in response to that comment, and was supported by the time of the observation recording (10:44:07) and the earlier learner-generated video clip (10:42:15) referred to above. A1_2_B2, who was controlling the mobile device, was obviously adept at using it, both in gleaning facts from the app (it was he who had helped Group A1_1 above) and in the recording, reviewing and re-taking of video clips.

Later analysis of all clips taken by this group did not reveal any 'taking turns', as had been requested by their teacher in the session introduction. The boys had appeared very engaged and task-focused, occasionally lapsing into laughter when they made mistakes in the voice-over or at the antics of their millipede doing 'roly-polies' (meaning forward rolls), but did allow themselves to 'let off steam' once they had completed their documentary.

6.2.6.1.3 Observation of Group A1_3

Another group, consisting of 2 girls and 1 boy, also completed the task without adult supervision. This group had a slug in their collecting jar, and one girl in particular (referred to as A1_3_G1) spent the majority of the session off-task, giggling and distracting other group members by recording made-up facts about the slug. This resulted in some 28 video clips, ranging from 1 to 58 seconds, following the pattern: "*This is a slug, it's got no legs, 4 noses*".

A1_3_G1 was also unwilling to share the mobile device, which resulted in the boy (A1_3_B1) eventually prising it away from her by force (see Figure 6.5), while saying: "*Hey - you're always getting it - we're always waiting for you!*"

Figure 6.5: One group member prising iPod away from another

Although A1_3_G1 was observed and heard reading from the app, none of this information appeared in the final group documentary, which consequently lacked depth.

When video clips recorded by this group were later analysed, it was noteworthy that they seemed far more animated and engaged in a recording they made later on in the session, where they were filming a large group of slugs and other insects in their natural surroundings, for example, A1_3_G1 excitedly exclaiming: "*There's loads of them!"* and A1_3_B1: "*There's a centipede coming to eat them - take photographs!*" This change in attitude may have been due to a number of reasons; perhaps seeing how engaged the rest of their peers were in the activity may have motivated them to engage more, or perhaps they were relieved to have finished the initial task. Given the genuineness of the exclamations heard, however, it appeared more likely that filming these insects in their natural environment was intrinsically more rewarding for these learners, and therefore led to the group members undergoing aspects of Csikszentmihalyi's (1997) concept of flow, where they were so immersed in what they were seeing that they temporarily forgot they were already holding an iPod and filming.

6.2.6.2 Summary - Mr Andrews's Class

An analysis of video clips on the iPods taken by the learners in this session was carried out a few days following the activity, but are reported on here for clarity. In all, around 26 minutes of video clips were analysed and 120 photographs were taken, although 97 of the latter were taken by one group (see Table 6.1).

ID	No. of Videos	Total length	No. of Photos	Research notes
A1_1	17	07:06	8	On task, identified collaboration, clear videos about centipedes.
A1_2	10	03:37	1	On task, identified collaboration, clear videos about millipedes.
A1_3	28	09:23	3	One child distracting other group members for majority of session, but engaged with last 3 videos.
A1_4	9	03:44	3	Student-teacher led video about slugs.
A1_5	2	00:47	4	Identified collaboration and clear facts about woodlice.
A1_6	4	00:57	4	Identified collaboration, clear facts about worms but brief.
A1_7	8	02:11	97	Off task for majority of session; one boy created a song about worms.

Table 6.1: Details of videos and photographs on iPods taken by Mr Andrews' class

The content for most video clips from this session followed the format of the activity sheet, i.e. the children began by saying the name of their insect, how many legs it had, where they had found it and so on. Analysis of the photographs and video clips taken by the children revealed that all groups were successful in creating films of their insects, with some showing they had mastered photographic skills such as zooming in and taking close-ups. From analysis of the recorded observations and learner-generated clips, it was clear that all groups had accessed the *Bugs Count* app, but only six made obvious reference to facts from the app in their voiceovers. While all groups had appeared highly enthusiastic and engaged when taking part in the minibeast hunt, some video clips came across a little brief or prosaic; it was noted that this most often occurred when the insect being filmed was in a collecting jar rather than its natural habitat, or when an adult helper had taken control of the activity.

Table 6.2 includes a transcript of an illustrative extract where a student teacher (ST) has led her allocated group (referred to as Group A1_4) to a bench. The student teacher asks the questions posed by the activity sheet, and fills it in on the group's behalf with the answer given (see Figure 6.6). One member of the group is answering in monosyllables, one is watching and the other is filming.

Figure 6.6: Student teacher holding collecting jar and filling in activity sheet for her group

ID	Video file name, timings & transcript	Research Notes
A1_4	***IMG_0184.MOV (00:00:19)***	
ST:	[Name of child], *how many legs has the slug got?*	Enthusiastic, trying to engage.
A1_4_B1	*Zero.*	
ST:	*Zero legs* [fills in activity sheet]. *And has it got wings?*	
A1_4_B1	*No.*	Looking around at other groups
ST:	*And what colour would you describe it as?*	
A1_4_B1	*It's yellow.*	
ST:	*With a bit of?*	Points to slug with pencil.
A1_4_B1	*Slime.*	
ST:	[laughs] *Lots of slime. And how does it move?*	
A1_4_B1	*Slow*	
ST:	*Slow**ly**.*	Emphasises 'ly'
A1_4_B1	*Slowly.*	
ST:	*And where did we find this one?*	
A1_4_B1	*Log.*	
ST:	*Oo, he's moving now, have you got* him [name of child filming]? *He's moving, zoom in, get him close. Look how he moves, you can see all the stuff inside his body!*	Trying to enthuse.

Table 6.2: Extract from a learner-group strongly led by a student teacher

Most groups appeared to have collaborated well, evidenced by their enthusiasm and the respect shown to each other when creating their videos, and were on-task for the majority of the activity, with one example of children appearing to work together better in this outdoor setting than at school (see sub-section 6.2.6.1.1). Some examples of children hogging the mobile device or being off-task were noted, particularly in Group A1_7 who, while they had been observed creating and filming a song about worms, had made no real attempt at creating a documentary-style video. From my observations, all the children appeared to have enjoyed being outdoors and were enthusiastic and excited to be using mobile devices as part of a school activity (cf. Law & So, 2010).

6.2.6.3 Observation and Initial Analysis - Miss Brown's Class

This class visited in the afternoon; the ratio of adult helpers to children was around one per learner group, with the teacher, Miss Brown, taking responsibility for overseeing two groups. Each group was to be allocated one mobile device, once they had found their first insect. It was discovered once we were in the reserve that the collecting jars and brushes had been forgotten.

Miss Brown opened the session by explaining the purpose of the activity, and gave similar instructions to those from the earlier session, but also highlighted that as they had not got collecting jars, children would need to observe and film their insects in their natural habitat.

The children had been very exuberant on the walk to the reserve, and this enthusiasm, bordering on over-excitement in certain individuals, continued once in the reserve, with the teacher occasionally having to shout to make herself heard. As there were no collecting jars, mobile devices were given out at the same time as the clipboards with activity sheets, i.e. before the children scattered.

As with the earlier session, children appeared highly motivated to get on with the task and ran off to various areas within the reserve to begin their search for insects as soon as they had picked up their clipboards and mobile devices. Two of the three student teachers that had attended the morning session also attended this session, and appeared more focused on speaking to each other than supervising their groups; the student teacher that had strongly led her group in the morning session was not present. The TAs present were those that normally worked with this class, both of whom also appeared to have a good rapport with the children. I took the opportunity to ask Miss Brown if she wanted a quick demonstration or reminder of how to access and use the camera and *Bugs Count* app, which she did. This appeared to alleviate any concerns she had in her ability to advise the children, if they came to her with technical queries.

As had been noted in the initial impressions, the student teachers themselves were not on-task during this session and had allowed their groups to disperse while they continued their discussion. I noted that both these groups (primarily made up of girls), while appearing to be filling in their activity sheets, were more focused on ‘letting off steam’ and enjoying each other’s company than observing insects. Other groups, however, appeared highly engaged in both seeking out insects and making documentaries, and I initially opted to follow these.

6.2.6.3.1 Observation of Group B1_1

This group was made up of 3 boys, and I noted that they had already accessed the app to come up with interesting facts about slugs to complete their activity sheet, in this case that Leopard slugs grow up to around 20cm in the UK; the boy tasked with giving the voiceover for the video was using the activity sheet as a prompt and I observed him using his pencil to emphasise the length of the leopard slug while telling us his fact (see Figure 6.7), linking his numeracy knowledge with the information gleaned from the app: "*They're as long as this pencil!*"

Figure 6.7: B1_1_B links size of slug to numeracy knowledge

The boys appeared highly animated and engaged in the activity during the observation, and had no adult input during the making of their video.

6.2.6.3.2 Observation of Group B1_2

This group was made up of 4 boys and had one adult helper. When I came to observe them, one boy was filming with a school iPad (B1_2_B1), one was on the ground holding up an insect to be filmed (B1_2_B2), another was moving between 'directing' the action and finding more insects himself (B1_2_B3), and the other was looking for insects (B1_2_B4).

The boys had already filled in their activity sheet and were now wholly focused on the filming process. They appeared immersed in what they were doing ('in flow') and did not seem at all disturbed by being observed, as if they were barely aware (see Figure 6.8).

What stood out, aside from the quality of their observations, was: (i) how well this group appeared to be collaborating, evidenced by respectful listening and turn-taking; and

(ii) how genuinely motivated by the activity they appeared, evidenced by their laughter, the timbre of their voices and the language they were using, both when they were discussing the insects they were finding and when they were creating their video.

Figure 6.8: Group B1_2 on task creating their video

My direct observation of group B1_2 lasted nearly 11 minutes, and this cohesion and engagement was evident throughout, including when they moved to a different spot and found a variety of other insects. The group did not feel the need to consult the adult helper, who remained encouraging but on the periphery, but did use the app to gain extra facts about their insect, for example: "*It says there are 57 different types of centipedes, they live on damp ground, eat dead or damaged plants, and they've got a pair of poison claws near their head!"* *(*B1_2_B2).

Later analysis of their clips further confirmed their deep engagement with the activity, particularly in the excitement they showed when they were communicating with each other, and the obvious pride they felt in what they had produced (see Figure 6.9), calling to a child in another group who was walking past:

Figure 6.9: Group B1_2 reviewing their video

"[Name of child] – *you've got to see our video. It's really funny!*" (B1_2_B3);

"*Yeah, it's really funny, come and see it - it's about a slug!"* (B1_2_B1);

"*Come and sit down and watch it!"* (B1_2_B3).

6.2.6.3.3 Observation of Group B1_3

This group was made up of three boys. There did not appear to be an adult helper working with this group during the period of the observation, and the boys had already filled in their activity sheet by the time the observation took place. These boys were a little more argumentative than Group B1_2, but did take turns in using the mobile devices and speaking to camera. All appeared genuinely interested in insects, and for the majority of the observation, were wholly engaged in finding and then placing insects on their hands and arms, and filming each other, as illustrated in Table 6.3.

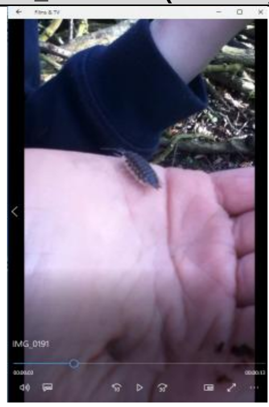
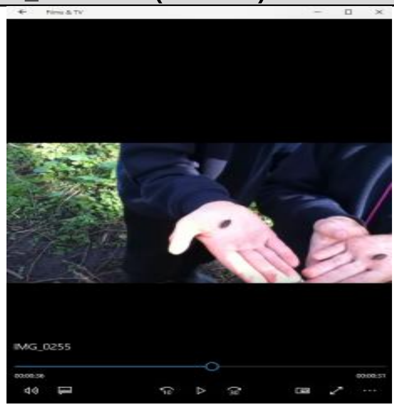
IMG_0187.mov (00:00:19)	**IMG_0191.mov (00:00:03)**	**IMG_0255.mov (00:00:36)**
		
They are fat, so fat - I will get one on my hand! (B1_3_B1)	*These are woodlice, and as you can see, I've got them on my hands! (B1_3_B2)*	*These are awesome woodlouse ...they have 2 antennae, 6 legs, and when they get scared, they roll into a ball, and …and …when they get so scared …they go somewhere else and roll into a ball! (B1_3_B1)*

Table 6.3: Group B1_2 engaged in kinaesthetic learning

Kinaesthetic learning appeared to play a major role in engaging this group, as illustrated in the captured stills and associated transcripts of extracts shown in Table 6.3. It was clear from the clips and activity sheet that the *Bugs Count* app had been accessed, where, for example, B1_3_B2 used facts gleaned directly from the app: "*In the UK, there's 150 species of them!",* but while this app provided some interesting facts and answers to key questions, such as habitat and feeding, it is accepted that a pre-programmed piece of software will not be able to provide answers to all questions that come up in the messy conditions of a nature reserve.

I noted that the boys were respectful with the insects, as conveyed in the way they spoke during their video clips, but sometimes struggled for words, as exemplified in the third extract in Table 6.3 above, suggesting a need for targeted support to enable learners to get the most out of the experience (cf. Nouri et al., 2014).

The depth of engagement observed both during the session and when analysing their videos highlighted the level of flow enjoyed by these three in this session, with some 5 minutes 42 seconds dedicated to filming.

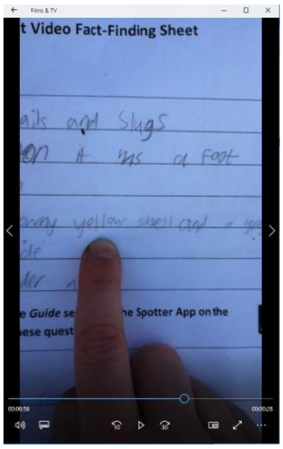


Figure 6.10: B1_3_B2 filming and discussing his group's activity sheet

This was further underlined by one member of the group, B1_3_B2, heading off and making two of his own films. One clip (with a duration of 90 seconds) focused on the activity sheet his group had completed, which he also linked into literacy work by highlighting that "*yellow"* (see Figure 6.10) was a "*very good describing word*". In another clip (with a duration of just under two minutes), he talks about snails while walking through the reserve: "*Some of them are actually massive ... like the land snail that lives in Africa!",* concluding with*:*

"And look at the sky! [pans to show blue sky above] ...*Soon we'll be going home, but one day ...I'll be able to go to the Greendale Reserve...any time!",* with the timbre of his voice illustrating his love of being outdoors in this spot. During his clip, he also encounters a child from another group (heard but not seen in the clip) who is excited to have just spotted a butterfly. Table 6.4 contains a transcript of the conversation that ensues between B1_3_B2 and 3 other children from other groups, highlighting tenets of outdoor learning, socio-constructivism and issues relating to a lack of scaffolding.

ID	**IMG_0245.mov (00:00:49)**	**Research Notes**
ChildA	*I saw a butterfly!*	Yelling, very excited, others join in as they see it.
B1_3_B2	*Yeah, I saw it as well!*	Filming and following the action.
ChildB	*There's a butterfly! ... Ahh, it's gone!*	
B1_3_B2	*Who saw a butterfly?*	Yelling.
ChildC	*I saw it - it had big brown circles on its wings!*	
ChildD	*How many wings did it have?*	
B1_3_B2	*Errmm.*	
ChildD	*If you see a butterfly with 2 wings, it's a moth.*	Lack of scaffolding leading to spreading of false information.
B1_3_B2	*You've just talked and scared it away!*	Angry.

Table 6.4: Transcript of conversation between B1_3_B2 and other children

When I checked on the other groups, I discovered that two, both overseen by student teachers, had not completed the activity; one, while they had gone some way to completing their activity sheet, had not included any interesting facts, and both, while obviously enjoying being outdoors, had not started on making their videos. As there were only 15 minutes remaining of the session, and mindful that the intention had been for all groups to get the chance to be represented in an assembly or on the school blog, I made the decision to encourage their adult helpers to help their groups complete the videoing task. While this went against my initial plan of observing rather than participating, on this occasion I felt justified for the sake of parity of experience for those learners who had not had adult input for the majority of the session.

6.2.6.4 Summary - Miss Brown's Class

On the walk back to school with the class, I was able to spend a few minutes discussing with Miss Brown how she felt the session had gone. We both agreed that adult input had been lacking for certain groups, and that the children, while having had an enjoyable afternoon in the outdoors, were likely to have got more learning out of the session if adult supervision had been more focused.

What was interesting to me as researcher was that, on subsequent analysis of the videos created by this class alongside those I recorded for observation, the most in-depth videos appeared to have been made by learners during this session. What had on the surface seemed somewhat chaotic at times, may, in fact, have been the better learning environment for this type of activity, perhaps as children had felt less constrained and more in control of their learning and, as a corollary, more motivated (cf. Wang and Eccles, 2013), or because they did not have access to collecting jars so were more inspired by filming the insects in their natural surroundings. It could also be argued, however, that this was more to do with the make-up of particular individuals within the class, so this area was flagged up as something for follow-up with the teachers and in subsequent cycles.

In contrast to learners in Lai et al.'s (2007) study, where no learners with a mobile device expressed an interest or liking for the 'sensory' phase of their plant-studying activity (compared to the control group without devices, who did), many boys in this class chose to pick insects up for the filming, despite having access to a mobile device.

While I had observed some learners deleting clips they were not happy with, an initial analysis of the learner-generated clips after this session identified just over 26 minutes of video clips and 84 photographs, broken down as shown in Table 6.5.

ID	No. of videos	Total Length	No. of photos	Research notes
B1_1	6	01:49	19	Uses ruler to show length of slug, linking with numeracy.
B1_2	6	05:52	4	Collaboration and flow evidenced and informative video created.
B1_3	7	09:38	37	On-task, highly engaged using kinaesthetic learning; need for scaffolds. 2 solo videos made.
B1_4	6	03:31	3	Enthusiastic but needed adult help to complete video.
B1_5	11	02:59	12	On-task, included an informative solo video of ladybirds.
B1_6	1	02:34	4	Adult help needed to complete video.
B1_7	7	02:14	5	Off-task videos made - group dynamic caused problems.

Table 6.5: Details of videos and photographs taken by Miss Brown's class

6.2.7 Follow-up to Outdoor Film-making Sessions

Having written up field notes for these sessions, I selected one clip (or a series of shorter clips) from each group, to enable the children to showcase what they had learnt. I edited the recordings using *Camtasia* software, cutting them down or merging them to a length of around 30-60 seconds footage per group and then converted them to MP4 format suitable for viewing as part of a school presentation or on the school *Edublogs* website.

My motivation for suggesting the learners' clips should be showcased was two-fold: (i) on a basic level, I was aware that the children had been promised that the best of their clips would be showcased and should not be disappointed in this; and (ii) in line with Kearney and Schuck (2005), I was also aware that seeing themselves on-screen was likely to further embed what had been learnt, as well as giving them some justifiable kudos and satisfaction for the work they had put in, both within the school and at home.

The activity of writing up the field notes and going through the learner-generated video clips served as a useful starting point both to feed into the next iteration of the design cycle for this activity, and to help guide the formulation of questions for the semi-structured interviews with teachers.

6.2.8 Evaluation with Year 2 Teachers

As previous meetings with teachers had primarily focused on the design of the mobile learning activity, I took the opportunity to use semi-structured interviews to gain more in-depth information about the day-to-day commitments and teaching approach of the individual teachers, as well as to evaluate the activity.

6.2.8.1 Semi-structured Interview with Mr Andrews

The following section includes selected questions from the interview plan (re-numbered here for clarity), with responses from Mr Andrews summarised, together with illustrative transcribed extracts from the audio-recorded interview.

Background: Mr Andrews is an experienced teacher, having taught various classes for some 12 years in the same school from Year 6 downwards, but indicated that this was his first time teaching a class *“as young as Year 2”*. He spent around 50 hours per week teaching and carrying out administrative duties, including work undertaken at home in the evenings and at weekends.

Q1: <u>How much flexibility is there in what you teach?</u> - Mr Andrews suggested that as long as curriculum targets were met, he had “*as much flexibility as I want”,* and that he tried to tailor his teaching to his class by using a ‘topic-theme’ approach, where *“you try and weave everything in together to cover a theme”.*

Q2: <u>How do you personally think children learn the most?</u> – echoing tenets of experiential learning (Dewey, 1938; Kolb, 1984), Mr Andrews said that he believed children of this age learn best “*by doing*”, and when *“you’ve captured their interest, and they’re engaged from the start.”*

Q3: <u>How integral a part do you feel technology plays in your teaching today? What technology do you currently use in your teaching</u>? - Mr Andrews indicated that while he used the digital whiteboard every day, he was still exploring the potential of using the iPad for learning with his class: "*Still finding my way with the iPad ...apps-wise, I've only really used them with one child at a time. My next step is to use them with small groups of six*." Mr Andrews went on to say that the school currently had around fifteen iPads available for class work, and that he found they were especially useful for reluctant writers in his class (Cooper, 2016).

Q4: How confident are you in using ICT in your teaching*?* - Mr Andrews commented that he was confident, and that he used ICT primarily to "*stimulate, engage and make it a lot easier to get ideas across"*. Echoing Zhao and Frank (2003) and more recently Young (2016), Mr Andrews highlighted concerns around keeping pace with the speed of change, citing time pressures as an obstacle to exploring its use in the classroom: "*It's just being given the time to learn and finding a way that makes it useful"* (cf. Harris et al., 2009); he also expressed his frustration with apps that he had spent time evaluating turning out to have wrongly advertised themselves as free to use.

Q5: Before you'd used mobile learning, what was your understanding of what it meant and what were your views about it? - Mr Andrews replied: "*I hadn't done it before - hadn't heard of anyone taking kit out either ...having done it once, I'd definitely do it again. It was great!"* He commented that the session had brought observation skills, experience in accessing apps for information and that creating their video clips had appeared to help the children retain the information while also feeding into literacy targets.

Q6: Looking back at the activity we did outside, was there anything you think might have improved the learning experience? - Mr Andrews confirmed he wished to collaborate on the activity the following year, and said he would aim to give the children more practice beforehand: *"I'd probably have a little bit more of a go at taking turns and organising a group into a film crew before we went.*" He also confirmed that he thought the timing of around 1-1.5 hours for the activity was about right, to give the children time to focus in, and that he considered the ideal ratio would be 1 adult per learner group, and 1 mobile device to be shared between 2 learners. His preference was for iPods to be used for this activity, rather than iPads, due to their more manageable size.

Q7: Are there any barriers you can identify to your using ICT effectively in the classroom? **-** Recounting how the digital infrastructure within the school had improved over the last year due to regular visits by an ICT contractor, Mr Andrews highlighted his frustration with the current configuration of the iPads, which had left most teachers unable to download apps: "*I don't know what the system is for the school ones ...they're so locked down."*

Q8: What are your views of the value of teaching children about the environment, and how confident are you personally in teaching children about it? - Mr Andrews acknowledged the limited emphasis on environmental education, and science in general, within the National Curriculum (Department for Education, 2013), indicating that his focus was primarily on the local environment: "*It's kind of why I like teaching and living in the same place, and understanding where you grow up. And from there you can go a bit more global."* This echoed tenets of Zimmerman and Land's 'place-based' learning activities, where learners are supported in building connections *"between disciplinary practices and everyday life"* (2014, p.80).

6.2.8.2 Responses from Miss Brown

Miss Brown was absent from school during the last week of term, but did pass on her thoughts on the session to Mr Andrews for him to convey to me.

During our initial meetings to discuss the design of the MLA, Miss Brown indicated that she under-confident in the use of technology, mentioning that she usually 'swapped' classes with Mr Andrews when the focus was on ICT.

In conveying Miss Brown's response following the outdoor session, Mr Andrews said that while she had initially felt her class had '*run a little wild'*, she was impressed both by how quickly they had picked up using the mobile devices (including the use of the app for learning), and the quality and depth of some of the video clips produced. With reference to the possible reasons as to why the clips made by children in her class had appeared more in-depth, she had acknowledged that forgetting the collecting jars may have been a contributory factor, as the children had not been constrained to one area.

6.2.9 Summary of DBRC_P1 and Issues Arising for Feed-forward

Evaluation of this cycle and initial findings were derived from analysis of the data sources detailed in section 1.8. Findings directly addressed the research questions CRQ1 (*"How might the process of creating insect documentaries using mobile devices engage 6-7 year old children with science topic work, working in groups in an outdoor setting?"*), and CRQ2 (*"How might the process of creating insect documentaries using mobile devices enhance understanding of science topic work for 6-7 year old children working in groups in an outdoor setting?"*), highlighting that using mobile devices to create their own documentaries of insects can be highly-motivating for children aged 6-7 years working in groups in outdoor settings, particularly where they are given the freedom and time to explore their environment and deepen their understanding.

As cautioned by Kurti et al. (2008), Sharples and Pea (2014) and Nouri et al. (2014), however, it is acknowledged that carefully-thought out pedagogy needs to underpin such 'messy' activities to ensure that appropriate scaffolding is provided at the point of need, with particular consideration given to distributed scaffolding, wherein *"a variety of material and social tools with different affordances and constraints can be employed strategically"* (Reiser & Tabak, 2014, p.193) to support learners in building their understanding. In this activity, for example, the provision of a human MKO in addition to the *Bugs Count* app could have provided the appropriate support to clear up misunderstandings as they arose.

Findings that fed into recommendations for the next cycle therefore included:

- The need for better priming of adult helpers, with an emphasis on their position as MKO rather than overseer;
- The ratio of one adult/learner group to be aimed for;
- More practice sessions at speaking to camera and taking turns;
- Activity sheets to be edited with the aim of encouraging increased learner autonomy;
- Further research to determine how learner engagement might best be measured in complex socio-technical learning environments.

6.3 iMovie Trailers with Year 5 (2014)

This outdoor activity was developed by Miss Hope and Mrs Baxter as an assessment piece for their Y5 classes, who had previously participated in the Museum QR-code trail (see section 5.2), and the '*Lifecycle of Plants'* Staged Activity (see section 5.3). As I had little input into the design of the activity, it did not form part of the core DBR cycles for this research stream, although I did take the opportunity to observe and collect data. Children had worked together in groups to develop storyboards in class, as preparation for creating iMovie Trailers to showcase their understanding of seed germination and dispersal.

6.3.1 Evaluation of Outdoor Film-making Session

The session took place in the reserve in mid-May, with both Y5 classes, comprising about sixty children aged 9 to 10 years, working in groups of four or five, with each group having one of the eight iPods or one of the school iPads. The children were supervised by two teachers, three TAs and two adult helpers, and the duration of the session was around 45 minutes. Children had brought their storyboards, together with props and costumes (see Figure 6.11) to the reserve.

Key findings were that all groups observed appeared highly-engaged and enthusiastic throughout the session, with none noted as seeking any support from adults. The majority of groups appeared to be collaborating well, although there was evidence of conflict in one group, where a boy came across as over-bearing in terms of directing the action.

Figure 6.11: Props created by Y5 group

All groups appeared highly-motivated by using the iMovie app, which enabled them to add professional sound and video effects to their clips and heightened the authenticity of the activity, as corroborated by Mrs Baxter's comment: "*They're excited about it, about using the technology, being out there and showing their learning through technology ...I think it's the ownership ...the fact that it's self-publishing"*.

Several bizarre examples of the germination and seed dispersal process were observed, including a carnivorous flower and a talking fish, although science facts were relayed in this latter case in this manner:

"I am a talking fish, and sometimes I eat too much. Especially of these seeds! Luckily these seeds are not digested inside my stomach, so when I ...go ...then they get dispersed and seedlings grow."

Five groups were observed showing pride in what they had produced (see Figure 6.12), and sharing their trailers with friends in other groups.

Figure 6.12: Y5 group creating and evaluating their iMovie video clip

Three groups were observed as straying from the '*Lifecycle of Plants'* topic, focusing on dance moves or other off-task behaviour. This latter behaviour was also highlighted by Miss Hope in her interview: "*Some of them concentrated on show-casing and not the science, so now we're going to go back to those and edit them, and make sure the science is in, because they did have the science knowledge ...it was in their storyboard, but they got a bit excited about being on film.*"

6.3.2 Issues Arising for Feed-forward

This session served to highlight the importance of the relationship between learner autonomy and flow (Csikszentmihalyi, 1997). All groups had worked together on their storyboards, and, as a corollary, had taken full ownership of the activity, resulting in high levels of engagement and collaboration; it is accepted, however, that this degree of ownership may not be possible with younger learners.

The fact that their iMovie trailers were going to be showcased on the class digital whiteboard appeared to act as a further motivating force for the children (Kearney & Schuck, 2005), although the teacher's comment relating to a tendency towards superficial showcasing by some while in the reserve was also noted.

6.4 DBRC_P2: Film-making with Year 2 (2015)

Email contact was initiated with Mr Andrews at the beginning of the year to arrange a meeting to discuss the next DBR cycle. I had been informed by Mr Andrews that Mrs Carter (pseudonym) would be taking over as the new Y2 teacher. I therefore used this first meeting to introduce the research to Mrs Carter, describing how the activity ran previously. Having examined the activity sheets, the *Bugs Count* app and clips filmed by the children the previous year, Mrs Carter confirmed her interest in being involved, whereupon informed consent sheets were handed over and further meetings set up.

6.4.1 Refinement of Research Questions and Mobile Learning Activity

A review of the literature failed to identify any studies focused on measuring engagement of primary-aged learners with mobile learning activities in outdoor settings; however, a few areas of interest were re-visited, notably McPhee et al.*'s* (2013) Classroom Engagement Checklist and Shernoff et al.'s work on flow theory (2003). Recognising that markers (or indicators) for engagement, particularly in the area of cognitive engagement, were likely to vary depending on the nature of the activity, I understood that teacher input would be key to developing meaningful criteria for this activity and the cycle-specific research questions were therefore augmented to include a third:

CRQ1 - "*How might the process of creating insect documentaries using mobile devices engage 6-7 year old children with science topic work, working in groups in an outdoor setting?*",

CRQ2 - "*How might the process of creating insect documentaries using mobile devices enhance understanding of science topic work for 6-7 year old children working in groups in an outdoor setting?*", and

CRQ3 - "*How might engagement of 6-7 year old children using mobile devices in groups for science topic work in outdoor settings be assessed?"*

Following a series of email exchanges and two meetings where findings from the previous DBR cycle were discussed; agreement was reached that the original activity specification and observation plan (sub-sections 6.2.2 and 6.2.3 respectively) would be used for this activity, with the following additions:

(i) Teachers to work with me to define criteria to measure engagement;

(ii) Time to be allocated in class for children to prepare and practise making videos in their table groups;

(iii) Duration of outdoor mobile learning session to be 45 minutes.

During these exchanges, it emerged that the teachers wished to merge the outdoor mobile learning sessions for the two classes for logistical reasons (namely upcoming paternity leave), and to edit the activity sheets to create just one sheet containing basic instructions for making the video.

While highlighting concerns that having 60 children participating in the activity rather than 30 was likely to impact negatively on the quality of the learning experience, I was aware of the emphasis in design-based research endeavours on working *with* practitioners, and that I needed to be flexible in my approach to get the most out of the opportunity, both for the children taking part in the activity, and for data collection purposes. Dates for the minibeast hunt, hands-on and mobile learning sessions were duly set, and some useful work was done on defining markers for engagement, such as assessing the level of collaboration and enthusiasm, the science vocabulary used, the understanding shown of science concepts and whether and how the app was accessed to enhance knowledge.

6.4.2 Nature Expert-led 'Minibeast Hunt' Session


Figure 6.13: Nature Expert showing a newt

This session took place on a sunny day in early May, and was led by the same expert as previously (see sub-section 6.2.4), following a similar pattern but with the addition of a creative activity at the end. Children were in groups of 4 or 5, with a 1:2 adult to group ratio. I observed the session, taking photographs for comparative analysis purposes.

Children appeared enthusiastic and on-task for the duration of the session, with yells of "*Look – I found a …*", as they searched for insects, bringing any of particular interest to the attention of the Nature Expert (see Figure 6.13). Some children appeared less motivated by the follow-up creative activity, where they were asked to create their own insect out of sticks, leaves and any other natural objects they found in the reserve.

6.4.3 Familiarisation Sessions

Two sessions were run by Mr Andrews and followed the same format as the previous year. As only 1 or 2 children in each class indicated they had not used a mobile device before, most of the session focused on introducing them to the *Bugs Count* app and encouraging them to work together to make a video, using the plastic insects as props. As with the previous year, one class appeared more argumentative than the other, with children attempting to grab devices from each other and arguing over whose turn it was.

All children were observed as being engaged and on-task for the entire session, with all appearing to have had the opportunity to use a device and practise filming.

6.4.4 Outdoor Film-making Session

This session took place on a dull, chilly morning in mid-May, with both Y2 classes, comprising about 60 children, taking part, working in groups of 4 or 5, and with each group having one of 7 iPods or one of 7 school iPads; the children were supervised by 2 teachers, 3 TAs and 4 adult helpers, with the teachers and TAs nominally overseeing 2 groups each, and the remaining adults a group each. I was able to move between groups, but was also asked if I would help out should the need arise. The activity was scheduled to last for 45 minutes.

Following an introduction to the activity by Mrs Carter, the groups dispersed with their collecting jars, clipboards with activity sheets and iPods or iPads.

Individual children and learner groups are referenced using the same notation outlined in sub-section 6.2.6.

6.4.4.1 Observation and Initial Analysis

Following the Observation Plan set out in sub-section 6.2.3, I began by circulating amongst the groups to see how they were collaborating.

Exacerbated by the doubling-up of classes, there was a noticeable bunching of children around those areas highlighted in the expert-led session as likely to be rich in insect-life, with some children pushing past each other to get to the front (see Figure 6.14).

Figure 6.14: Children crowding around an area of interest

This had repercussions for data-collection, notably the video capture of group interactions was more problematic due to the increase in numbers, and there was only one, shorter session in which to collect data.

A few children did not seem to be as enthusiastic or inspired as in previous sessions, and having noted similar behaviour in two of these individuals during one of the hands-on sessions, I flagged this as something to discuss with the teachers. The activity as a whole felt a little more fragmented, again perhaps influenced by the increase in the number of learner groups wishing to access the same areas, or by the make-up of the individual groups. While the same sense of relaxed discovery and flow found in the previous year's sessions was present, this did not appear to be as prevalent, which may also have been influenced by the weather conditions.

What did emerge through observations, however, was that children in this year's classes demonstrated a better grasp of the science concepts about the insects and were more able to articulate relevant facts in their videos. In one example, a girl (A2_7_G1) looks intently at her insect before describing it: “*its body is divided into about 30 body segments* ...*and it has pincers*”, while moving the collecting jar closer to the girl filming to enable her to zoom in, as shown in Figure 6.15.

Figure 6.15: A2_7_G1 showcasing her science vocabulary to describe a centipede

This development may have arisen as the teachers had a better understanding of what the activity entailed, as one had trialled it the previous year, and the children in both classes had consequently done more preparatory work.

6.4.4.1.1 Observation of Group A2_1

This group was made up of 4 girls. Confident and talkative, A2_1_G1 quickly took charge of the iPod, while one child did not speak at all during the observation, and two others appeared engaged but passive. The group had used the app, practised and then made several brief but informative videos on insects they had caught, including one on woodlice: “*This is a woodlouse, and it has 7 pairs of legs, 2 antennaes* [sic], *and antennaes* [sic] *are used for feeling, and when it's scared, it can roll into a ball*" (A2_1_G1). I earlier observed that A2_1_G1 had been informed by an adult on the function of antennae, and showed that she had absorbed and retained this knowledge when she spoke about beetles later on in the session: "*This is a beetle - it has 6 legs. We think this is a lily beetle which eats lilies. It has 2 antennaes* [sic] *for feeling and ...it's red.”* This may support LittleDyke’s (2004) and Dillon et al.’s (2006) findings that outdoor learning experiences can deepen learning and increase cognitive retention.

The dynamic of this group was interesting to observe, providing some insights into social learning in practice (cf. Bandura, 1977), with the more passive girls appearing outwardly content to follow the lead of the more confident girl, A2_1_G1, as illustrated in the following extract in Table 6.6, where A2_1_G2 is being encouraged to speak by A2_1_G1.

ID	Video file name, timings & transcript	Research notes
	IMG_0396.MOV (0:00:05)	
A2_1_G2:	*...Usually they're grey.*	Waits before speaking very quietly.
A2_1_G1:	*We found it under a log*.	Whispering a prompt.
A2_1_G2:	*We found it under a huge log.*	Adding her own descriptive word.
A2_1_G1:	*It nearly had a fight with a centipede, and we think it was trying to eat it*.	Whispering another prompt.
A2_1_G2:	*It nearly had a fight with a centipede which was trying to eat it!*	Her voice demonstrating a little more confidence.

Table 6.6: Group A2_1 collaborating on video voice-over

This was all carried out with equanimity on both sides, a behaviour I observed in other groups during this session, where the child with wider vocabulary or greater confidence prompted other group members with no obvious sense of superiority or bossiness.

An example of socio-constructivist learning was also observed, when this group were crouched around the iPod in an attempt to view the *Bugs Count* app, to try and identify a beetle (see Figure 6.16).

Figure 6.16: Crowding to view *Bugs Count* app on an iPod

Another group approached, obviously interested in what Group A2_1 had in their collecting jar, and one boy suggested it was a "lily bug". A conversation ensued about why he thought this: "*My mum said that's what it was when I found one in our garden, just up there,*" pointing to his house. Both groups then asked me for my opinion, and, having checked that the insect was not listed in the app, I used mobile data to confirm its species. I noted on this and other occasions that sharing one iPod between 3 or 4 children was inadequate in terms of screen viewability.

One example of the setting providing unique learning experiences came soon after this clip had been recorded, when the lid of the collecting jar was opened and the beetle flew away to excited shrieks from the group (see Figure 6.17).

The girls had not been aware their beetle had wings, and having worked hard on producing their videos, they enthusiastically gave chase to see where it went.

Figure 6.17: Learning lily beetles have wings

6.4.4.1.2 Observation of Other Groups

My observation of group A2_1 had lasted some 13 minutes and I therefore spent the remainder of the session observing other groups to enable me to triangulate outdoor observations with subsequent analysis of a specific group's video clips. The bunching previously commented on, while not as intense as at the beginning of the session, did impact on my ability to observe individual groups, as it was not always clear which child belonged to which group; however, this was later mitigated by accessing the 'group selfie' photos. Most groups appeared focused and engaged in the activity, although pockets of negativity were apparent; for example, some children were heard complaining to their adult helper that they could not find any insects and others that a group member was not sharing the mobile device.

As well as displaying on-task behaviour during the hunt (see Figure 6.18) and when creating their films, most children interacted well with each other and the adult helpers, who were observed providing useful scaffolding during the session.

Figure 6.18: Group C1_3 collecting their minibeast

Some children were excited to have found a frog, which resulted in a dash by around 15 children hoping to catch a glimpse. A member of one group (C1_1_B1) was particularly keen to show me a video his group had made, but was disappointed to find that the boy holding the group iPod had deleted all but two videos taken during the session. While aware of the implications this had for collaboration in this particular group, it also underlined an ongoing conflict between my needs for data collection and my desire to promote learner autonomy, as discussed in the summary.

6.4.4.2 Summary and Initial Evaluation

As highlighted above, having two classes participating in the activity at the same time had implications for the quality of the learning experience, as did the reduction in time allocated. While the adult helpers did their best in terms of encouraging the children to take ownership of the video-making process, the sheer volume of numbers impacted negatively on the session, necessitating the use of larger learner groups and resulting in children vying with each other to get access to areas of particular interest. Subsequent analysis of the clips revealed that many clips were quite short, with an average length of 19 seconds and, judging from the speed of delivery and tone in some, indicated that certain learners, though by no means all, found making them a chore; for example:

> A2_5_B1: "*So we've got a millipede, a woodlice, a snail and another millipede. And some dirt*."
>
> A2_5_B2: "*And some mud. And something green. Done."*

This may have been attributable to a range of factors, including: (i) the children having recently completed intensive Y2 national assessments (BBC, 2017); (ii) the dull, cold weather (Knez, Thorsson, Eliasson & Lindberg, 2009); (iii) there being two classes; and (iv) the children having recently visited the reserve for the expert-led minibeast session. This was flagged for later discussion with the teachers.

In terms of the conflict between data collection and deletion of videos mentioned above, while recognising that valuable data might be lost, I determined that any further restrictions would limit the learner autonomy that was intended to underpin this activity, and that the freedom to delete and re-take videos should continue.

An analysis of video clips taken by the groups using iPods is summarised in Table 6.7.

ID	No. of Videos	Duration	No. of Photos	Research Notes
A2_1	10	04:06	2	Confident girl leading others. App used.
A2_2	4	00:36	30	App used.
A2_5	6	02:17	0	Sounded eager to get videos done. App used.
A2_7	3	01:18	1	Good science vocabulary. App used for info.
C1_1	5	00:27	14	High quality photos, child mentions most videos having been deleted. Videos v brief, e.g. *"Snails have one foot and a hard shell, a swirly shell."*
C1_3	2	01:08	1	Good clear video, took turns and had obviously practised: *"When we found the millipede, it was curled up and we thought it was a snail."*
C1_6	5	01:15	12	Clear video, with good understanding shown of science concepts (e.g. highlighted that worms compost vegetation). App used.

Table 6.7: Details of learner-generated videos and photographs on iPods

6.4.5 Follow-up to Outdoor Film-making Session (DBRC_P2)

After field notes were written up and initial analysis of the clips completed, an opportunity arose to create a *Prezi* presentation showcasing some of the video clips the children had made (see Figure 6.19), as part of a BBC competition focusing on primary schools' use of technology to convey environmental issues.

Figure 6.19: Award-winning *Prezi* featuring clips from DBRC_P2

The school was subsequently delighted to be awarded 1st prize (one of only four schools in the country to receive this award) as recognition of the ‘outstanding digital skills’ they had shown in their entry. This was a great boost to the teachers and children involved, particularly after what had been a very busy term, and an assembly was held in school both to act as a focal point for class discussions on what had been learnt and to provide an opportunity for the children to showcase their work (cf. Kearney & Schuck, 2005). Aside from this, no other follow-up activities were known to have taken place.

6.4.6 Semi-structured Interviews with Year 2 Teachers

In light of what I had learned the previous year, and responding to findings emerging from analysis of the observational and learner-generated videos, I adapted the questions for the semi-structured interviews to align more closely with the refined research questions. In addition to hearing more about Mrs Carter’s teaching approach, I also wanted to learn how the use of mobile devices had impacted on the learning experience, if at all. With the ramifications of the introduction of the new curriculum and its increased emphasis on numeracy and literacy, I also included questions related to what impact, if any, this might be having on the time available for teaching of science topics, and trips outside school.

As in DBRC_P1, the following section includes selected questions from the interview plan (re-numbered here for clarity), with responses from both teachers summarised, together with illustrative transcribed extracts from the audio-recorded interviews.

6.4.6.1 Semi-structured Interview with Mrs Carter

Background: Mrs Carter is an experienced teacher, having taught for eight years at the time of the interview. She had spent the previous two years teaching Year 1 at this school, and had previously taught her current Y2 class. She said that she arrived at school most mornings at around 7:30, characterising herself as: “*quite conscientious, committed*”. In planning their teaching, she commented that she and Mr Andrews would work most evenings after school: “*we sort of break down what we’ve done* [that day]*, change things, add things in that we think the children are going to be interested in as well”,* with Friday afternoons reserved for

‘Planning, Preparation and Assessment’ activities, where the “*nitty-gritty stuff*” for the next week was decided.

Q1: <u>How much flexibility is there in what you teach?</u> – Mrs Carter suggested that there was “*Less breadth, more depth”* in the new curriculum, but that she had “*a lot of flexibility*” in how she taught it. She highlighted that her teaching approach was “*to make it quite child-centred*”, commenting: “*If they come up with something they want to learn, I’ll try and go down that avenue.”*

Q2: <u>How do you think children learn the most?</u> - In alignment with other teachers I had interviewed the previous year, Mrs Carter suggested children learned most through experiential and collaborative learning: “*By doing. And from each other,”* going on to highlight the use of distributed scaffolding in her classroom (cf. Reiser & Tabac, 2014): *“...they don’t come to me until they’ve tried to do it themselves, they go to the board, they go to their buddy, they have like different strategies they use, and then they come to the boss, like they’ll come to me.”* Asked if that was her own particular strategy in teaching, Mrs Carter suggested it was quite widely-used in the school, and, conforming to socio-constructivist principles, also said that the children were encouraged to “*provide the method rather than the answer*”.

Q3: <u>How integral a part do you feel technology plays in your teaching today?</u> - Mrs Carter responded that she used the digital whiteboard “*a lot*”, and the class computers “*daily*” for numeracy-related websites. She also commented that having to share iPads across classes sometimes caused access issues which led to her using iPads less than she would like: “*iPads I want to use a bit more, but we’ve only got 6 for the whole of Key Stage 1 and Reception, so you have to book them out, and it doesn’t always work ...it tends to be like, you have to borrow them from other groups, so you have to block-out a time.”*

I went on to ask Mrs Carter what her thoughts were on each child having access to their own iPad that they were able to take home: “*I’d love to have more - I’d love to have more. The amount of things you can do on them. Compared to the workplace, schools are still very underfunded. There’s a big emphasis on coding now, though.”* Following up with a query relating to whether her class was learning to code, Mrs Carter stated: *“Yeah, I don’t do it, though.* [Mr Andrews] *does it while I do PE. Scratch, I think.”*

Q4: How confident are you in using ICT in your teaching? – Highlighting a possible inconsistency, Mrs Carter replied*: “Oh yeah, definitely. I think I sometimes panic if it goes a bit wrong like* ‘Arrgh, what do I do?’ *It always seems to go wrong for me, when it’s not supposed to, so, like if I’m about to show them something, the computer will break.”* [smiles]

Q5: Could you tell me what engagement means to you, in terms of child learning, and how you might go about assessing it? – While not directly responding to the question, Mrs Carter suggested that observation played a great part in her assessment of the children in her class: *“I’m always sort of looking at and talking to the children and just seeing, I think a lot of the time I don’t even talk, I just sit back and watch, see them talk to each other and then step in when they’re getting things wrong and try and feedback the right way of doing things.”*

Following up on this, I queried whether it was the questions the children asked in class, or whether it was her asking the questions that helped assess their engagement. Mrs Carter reiterated that, for her, observation was key: “*When they did the SATs, I found it really interesting watching them, I could tell automatically who I thought would be a Level 3 child just by watching the way they answered the questions”.*

Q6: Had you heard of mobile learning before? - In her response, Mrs Carter highlighted her appreciation of the value of outdoor and experiential learning, emphasising that her ideal would be for children to experience something before doing class-work on it:

> *Not really, no. Not with such a focus. I thought it was brilliant! I’ve done a lot of outdoor activity types, and done loads of stuff locally ...I think it’s good for them, and I think people are too quick to make children just sit and do, and it’s better to experience and then do ...if that makes sense?*

Echoing what I had heard from teachers in other classes, Mrs Carter acknowledged that it was sometimes difficult to get enough adult helpers to support outings: “*It’s harder for us, trying to get enough adults to help, as people are working more, TAs are slightly less.”*

Q7: What were your views on the mobile learning activity you took part in? – Mrs Carter commented that using the mobile devices had focused her class in on the activity, and that accessing the app had deepened their knowledge:

> *It really focuses them, and actually the amount of learning that was going on, they weren't just going and finding these insects and saying: "*I've got a ladybird*", they were actually learning about the facts about the ladybird, with the app that they got, and I think that just takes it to another level.*

Echoing Rikala and Kankaanranta (2014) and Law and So (2010), she also suggested that the children had enjoyed the mobile learning activities more than others they had taken part in: *"I think they demonstrated a huge amount of learning, and they had the best time. We've been down that way* [the nature reserve] *for various things, and that's been the best session. They loved it …they were buzzing."*

Q8: Looking back at the activity we did outside, what do you think might have improved the learning experience? - While Mrs Carter's response did not highlight anything in particular that she would do differently, she did stress the importance of selecting the right groups to work together and the 'learning skills' her class had focused on that year:

> *This year we've had quite a big focus on learning skills, so collaboration, questioning, empathy, which is a bit harder, and listening has been a real focus ...I know that if I put the right groups together, they would take it in turns, and they would do the right things together.*

Following up by asking Mrs Carter whether she thought this was particular to her class, she responded: "*I don't really know if Mr Andrews's class has got it as well as this class. They're a bit louder, there's more girls."* This latter comment corresponded to what I had noted in both the familiarisation and outdoor sessions.

Bringing Mrs Carter back to the original question, I asked whether there was anything she would do differently the following year. Mrs Carter acknowledged that the session could have been a little longer, going on to say:

> *Do you know, I just think it needs time, really; giving ourselves that little bit more time down there. It all just went a bit mad this year, with* [Mr Andrews] *and the new baby, and this new curriculum and moderation ...but generally I think it was great!*

In contrast to Mr Andrews, Mrs Carter felt iPads were more appropriate than iPods for this group: ***"**as some of the children have got motor issues",* suggesting that the ideal ratio of iPad to child would be 1:2 *"for what we did, four worked because they each had different roles ...If they had one each, they might not communicate with each other and would just look at the screen."*

Q9: Are there any barriers you can identify to your using ICT effectively in the classroom? - Mrs Carter replied that the class PCs "*seem to break a lot*" and that their physical location in the corner of her class caused issues in collaborative working, as the children: "*can't get round them*", suggesting that she would prefer a set of laptops that groups could use around a table.

Echoing Sharples (2003), Mrs Carter went on to describe the disruptive element technology sometimes brought to her class:

> *If I say* 'You've finished, you can go on the computers for a bit,' *they all start piling over there, and I'm like* 'No'*. It's so distracting. I think it's getting that mindset - no, it's not a game, you're learning, if you did have more iPads that you were using regularly, I think, it's a learning tool as opposed to a games tool, and you can have some free time where you play on it, but* 'Now it's learning time'*, it's getting that mentality for children.*

Q10: Given the current demands of the curriculum, what are your views on the value of teaching children about the environment and how confident do you feel in teaching children about it? - In her response, Mrs Carter stressed the value she placed on environmental education: "*Huge. I think we've got a world that is actually quite damaged, and is getting more and more damaged, and I don't think children realise the cause and effect of just little things like recycling";* highlighting her learner-centred approach, Mrs Carter indicated that she would use the internet to research with the children if there was anything she was unsure of: "*I feel* *quite confident on the whole. If I don't know anything, I'd be open about it, I'd look it up with them on Google and try and find the information online together, and I think they quite like that."*

Emphasising that this would also be teaching the children useful internet research skills, Mrs Carter concluded by saying: "*I think it's important to let them know you don't know everything and there are ways to find it out, and with the technology we've got, it's on our fingertips really, you can find out really easily and you can show them the ways to do it as well."*

6.4.6.2 Semi-structured Interview with Mr Andrews

As I had interviewed Mr Andrews the previous year, I opened by asking a question relating to his class's ICT experience this year.

Q1: <u>Last year we discussed the level of IT experience amongst this age-group, particularly with tablet devices. I think we both felt it had increased this year – do you think that's correct?</u> - Responding that he had noticed that most of them appeared to be proficient with using touchscreens this year, Mr Andrews also commented that some children preferred to use a pencil for writing: "*It's still a novelty and still an excitement, yeah, though it depends what it is. Say it's a written piece, those who enjoy writing with a pencil will probably choose not to do it on a computer because they find it slower ...But those that don't particularly like writing do seem to prefer it."*

Q2: <u>Can you see any difference in how motivated the children are when they're using the PC's compared to the iPads?</u> - Mr Andrews suggested the children were more motivated when using the iPads, as: *"There are more possibilities …You can kind of sit on the floor and use it. You can sit wherever."* This touched on a similar point made by Mrs Carter, who had mentioned the restrictive aspect of groups in her class needing to sit at the bank of computers.

Going on to highlight that using iPads opened up exploratory forms of learning, where learners could be given "*free rein*" to explore in a safe environment, Mr Andrews suggested that access to them was sometimes given as a reward, echoing Zhao and Frank (2003): "*For* *example, you might say:* 'You've done really well with that,*' could be a spelling thing or something, '*You've got 5 minutes, see what you can do'".

Q3: Do you feel you've used ICT more this year than last year, or about the same? - Mr Andrews highlighted that having ready access to the iPads in his room had increased his usage, going on to describe how apps like *Lego Movie* were added to his 'repertoire' if they impressed him: "*You kind of add to your repertoire, if you keep the things you used the year before, like* 'I'll keep that going*', and then you just find new ones".*

Mr Andrews went on to demonstrate what it was about this particular animation app that he liked, mentioning the school PCs had been unable to cope with a similar software application and describing how its use linked into other aspects of the curriculum:

> *Whereas this* [pointing to iPad]*. Lego movie is really, really simple. You can use effects, to speed it up, slow it down, all sorts. It seems to be able to cope with the amount of photographs we were taking. So, I was using them to teach them how to animate. ICT skills, new curriculum, animation, it's all there.*

Q4: Could you tell me what engagement means to you, in terms of child learning, and how you might go about measuring it? - Acknowledging that learner engagement was not easy to define, Mr Andrews used words like "*learning buzz*" in an attempt to explain what he meant. Using an illustrative example from another school that echoed Csikszentmihalyi's (1997) concept of flow, Mr Andrews described how he felt the children there had demonstrated engagement in a performance poetry session:

> *...they were so enthralled with what they were doing, they were happy, they were going further than you might have expected them to, just general enjoyment, and excitement with the activity.*

Q5: Could you give me some examples of how you might measure cognitive engagement in your teaching? - Mr Andrews noted that while we had agreed some initial markers of engagement for the last MLA, more work needed to be done to come up with meaningful markers for the following year's activity. Showing me a few of the learning objectives from the new curriculum, he commented how some appeared superficial, highlighting that they were measuring behavioural rather than cognitive engagement:

> *Some of it's quite woolly, like when you look at the reading things* [objectives]*, it's like it's important they can listen to the teacher telling a story; they can sit there and be quiet, but it doesn't mean they're listening.*

Q6: Do you think the mobile learning activity had any impact on what the children in your class learned? - Mr Andrews suggested that, aside from giving the children an opportunity to practise group-working skills, it had also increased their knowledge of insects and that the act of describing them had required the children to hone observation and literacy skills:

> *They wouldn't have learnt as much about the creatures, such as the interesting facts ...and other factors like working in groups. Co-operating and taking turns - I think it makes you observe them* [the insects] *more. The practice of having to describe what's in front of you in the style we were trying to get them to do.*

Q7: I noticed that the video clips they made this year were generally shorter – what do you think might have been the reasons for this? - Mr Andrews responded that less time had been available in the reserve this year, and that filling in the activity sheets the previous year had given the children "*more words*". Acknowledging that the dull weather may also have played a part, he commented that he and Mrs Carter had been concerned it would rain, which may have led to the session feeling a "*little rushed"* towards the end.

Q8: If you do this activity next year, what might you do differently? - Mr Andrews indicated that he was keen to run the activity the following year, and also to try out QR-codes: *"I'm definitely up for doing some QR-code stuff next year too, I'd love to do that",* commenting that the only things he might want to do differently for the following year were: *"Probably just take more time. And practise more in the playground or in* [name of small park near school]*. They'd probably come up with higher-quality stuff than they did in the nature reserve."*

This latter comment appeared to echo Miss Hope's comment (see sub-section 6.3.1) and Nouri et al.'s (2014) findings that too many sensory inputs in complex outdoor settings may be detrimental to conceptual learning (the playground and small park were places the children were very familiar with). As the interview was drawing to a close, I flagged this as something I needed to discuss further.

My concluding question was connected with nature deficit disorder (Louv, 2009), which Mr Andrews had not heard of, and his views on the importance of outdoor learning. Highlighting that science topics continued to be neglected due to pressures from the new curriculum, Mr Andrews commented that topic work on seasons was "*meant to be going on all the time* ...*but because it isn't a set topic, it might not get done*." Despite the curriculum pressures, however, Mr Andrews confirmed that he and Mrs Carter would continue to take the children out regularly, as they both felt outings were much more "*memorable*" learning experiences for children.

6.4.7 Summary of DBRC_P2 and Issues Arising for Feed-forward

Evaluation of DBRC_P2 and initial findings were derived from analysis of the data sources detailed in section 1.8. In addressing the research questions CRQ1 ("*How might the process of creating insect documentaries using mobile devices engage 6-7 year old children with science topic work, working in groups in an outdoor setting?") and CRQ2 ("How might the process of creating insect documentaries using mobile devices enhance understanding of science topic work for 6-7 year old children working in groups in an outdoor setting?")*, the findings corroborated those which emerged through DBRC_P1, namely that creating documentaries of insects using mobile devices can motivate and engage children aged 6-7 years working in groups on science topic work in outdoor settings, supporting collaborative, kinaesthetic, experiential and exploratory forms of learning, consistent with Zimmerman and Land (2014) and Rikala and Kankaanranta (2014).

Evidence was found of children independently using the *Bugs Count* app to increase their knowledge and understanding of insects while in the outdoor setting, and subsequently showcasing their science vocabulary and understanding within their video clips. While the teachers and TAs participating had overseen two groups each, this did not appear to have had any obvious detrimental effect on the learning experience of the groups involved, perhaps due to the better priming of adults prior to the outing.

Analysis of observation and learner-generated video clips suggested that weather and session duration may have impacted negatively on the learner experience, along with the number of children accessing the outdoor setting at one time. No examples of superficial showcasing were noted in either the outdoor session or the learner-generated video clips, unlike the Y5 iMovie Trailer session, which may have been due to the shorter duration of the session or the younger age of the children.

While acknowledging that weather was a variable I had no control over, I was keen to explore whether the design of the next MLA could incorporate greater involvement of the children to increase their sense of ownership, while lightening the assessment burden on the teachers, an aim first mentioned in sub-section 5.2.6.

With reference to CRQ3 ("*How might engagement of 6-7 year old children using mobile devices in groups for science topic work in outdoor settings be assessed* ", during his formal evaluation of this cycle, Mr Andrews acknowledged that more work needed to be done to finalise the existing set of initial markers for engagement, and agreed for this to take place during the design phase of the following year's activity.

The following recommendations informed the design of the next cycle for this activity:

- Promote a stronger feeling of ownership of the learning activity for the children;
- Factor in more practice in speaking and taking turns;
- Have a smaller number of children participating in the activity at one time;
- Aim for learner groups of no more than 4 children;
- Agree final markers for measuring engagement;
- Create more opportunities for follow-up class activities to embed learning;
- Design activities to act as assessment pieces for science curriculum.

6.5 Summary of Chapter 6

This chapter described two design-based research (DBR) cycles focused on the design, development, implementation and evaluation of mobile learning activities relating to the *production-focused learning* research stream, and the evaluation of a further Y5 mobile learning activity designed solely by the Y5 teachers.

Spanning two academic years, the mobile learning activities for Y2 involved learners creating films about minibeasts as part of their '*Living things and their habitats'* curriculum topic, while Y5 learners produced iMovie trailers linked to their '*Lifecycle of Plants'* topic. Findings derived from the analysis informed the development of a set of mobile learning design principles, which are detailed in Chapter 8.

The following chapter describes the two final DBR cycles related to this activity stream, wherein findings from the cycles in this chapter informed the design, development and evaluation of mobile learning activities using eBooks.

Chapter 7: Production-Focused Learning (eBooks)

The previous chapter detailed the design, development and evaluation of two mobile learning activities (MLAs) focused on the *production-focused* research activity stream, which aimed to support primary-aged learners in creating their own video clips of insects in an outdoor setting.

This chapter builds on those findings and describes two design-based research cycles (DBRC) focused on the design of mobile learning activities (MLAs) which supported children in creating their own eBooks, primarily within the outdoor setting of the nature reserve. Collaboration with two Year 2 (Y2) and two Year 3 (Y3) teachers resulted in the design, implementation and evaluation of activities for around 120 children.

7.1 DBRC_P3: Film-making with Year 2 using eBooks (May/June 2016)

Email contact was initiated at the beginning of the year to discuss ideas for activities, including the use of QR-codes for the Y2 ‘Explorers’ topic (described in section 5.4), and refinements relating to this activity-type.

Following analysis of the findings from DBRC_P2 and the recommendations highlighted in section 6.4.7, my subsequent research focused on the use of techniques and technologies that might promote a stronger sense of ownership of their learning in the children, whilst also addressing issues relating to the use of preparatory and follow-up sessions to enhance learning gains (Nouri et al., 2014).

7.1.1 Refinement of Mobile Learning Activity and Research Questions

One educational app attracting high praise in UK primary schools that was part of the software bundle on the school iPads was *Book Creator*, an easy-to-use app that enables users to create pages incorporating text (typed or ‘written’ using styli), graphics (either drawn or pasted from the internet), photographs and easy recording or embedding of sound and video files.

Mindful of Kearney's (2011) work on 'digital storytelling' (see sub-section 2.3.4), where he suggests that learner-generated videos can become '*things to think with'* (p.11) that both encourage dialogue and foster authentic learning, and also cognisant of Pilkington's (2012) study on the importance of developing *multi-modal literacy* in children (see sub-section 2.4.1), I evaluated the app and noted its intuitive interface and error-free functionality. The fact that it also provided a variety of simple options for teachers to facilitate sharing (including saving in PDF or video file format) suggested that it could also answer issues relating to assessment and the motivational aspects of learners showcasing their work, something highlighted as valuable by Zimmerman and Land (2014) to promote learner engagement.

Following email exchanges, a series of meetings was set up to demonstrate the *Book Creator* app, discuss the design of the next MLA and formalise the markers for engagement. Both teachers were unfamiliar with the app and considered it highly appropriate for Y2 children.

While defining markers for engagement was previously acknowledged by both teachers as complex, the experience of running the MLAs in the previous cycles, combined with prior research into learner engagement (e.g. McPhee et al., 2013) enabled an initial set of markers to be agreed that I felt confident were representative of some key aspects of engagement I was hoping to measure, as shown in Table 7.1.

	Positive Markers	**Negative Markers**
Emotional Engagement	Enthusiastic/positive attitude Enjoying company Enjoying nature	Apathetic/negative attitude Arguing Complaining
Behavioural Engagement	On-task Collaborating Listening Sharing Respectful	Off-task Distracting Not listening/ignoring Not sharing Disrespectful
Cognitive Engagement	Concentrating/focusing in Asking good questions/using app for learning Showcasing understanding/science vocabulary	Distracted Relying on others Superficial showcasing

Table 7.1: Initial markers for engagement agreed with Y2 teachers

As highlighted in sub-section 4.7.2, these markers served as *a priori* categories for the purposes of data collection and analysis, with the expectation that they would be amended and supplemented during the coding process as part of adopting an approach based in grounded theory (Glaser & Strauss, 1967). Both teachers agreed to be mindful of these markers during the outdoor sessions, to enable cross-comparison of observations using the same lens, and to help improve the trustworthiness of findings (Lincoln & Guba, 1985).

The cycle-specific research questions for this activity were therefore refined as follows:

CRQ1- "*How might the process of creating eBooks using mobile devices engage 6-7 year old children with science topic work, working in groups across classroom and outdoor settings?*"
CRQ2 - "*How might the process of creating eBooks using mobile devices enhance understanding of science topic work for 6-7 year old children working in groups across classroom and outdoor settings?*"
CRQ3 - "*How might engagement of 6-7 year old children using mobile devices in groups for science topic work in outdoor settings be assessed?"*

The final agreed specification of the activity comprised:

- Classroom sessions to be organised to familiarise the children with using *Book Creator;*
- Children working together in learner groups of no more than 4 to create a book about insects, with each child having ownership of at least one page;
- A minibeast hunt session to take place in the local nature reserve prior to the mobile learning session;
- School iPads with the *Bugs Count* app pre-installed to be provided, giving a ratio of one mobile device per learner group of 3-4 children;
- Adult helpers to be primed to provide support where necessary;
- Online video clips of famous naturalists or other appropriate resources to be shown on class whiteboards prior to the outing, to act as inspiration;

- A mobile learning session to be held in the nature reserve, enabling children to incorporate photographs and video clips of insects into their eBooks, while in the outdoor setting;
- Engagement to be assessed by myself and the teachers, using agreed markers.

7.1.2 'Minibeast Hunt' and iPad Outdoor Practice Sessions

The Nature Expert was not available to lead a minibeast hunt session on this occasion; the Year 2 teachers therefore elected to run this session themselves, and, following the format for the 'Explorers' sessions that took place earlier in the year (see sub-section 5.4.1), organised three 20-minute activities for the end of May, one of which was the hunt (led by one of the TAs), another creating artwork out of natural resources (led by Mrs Carter), and the third giving children practice in using the iPads to access the *Bugs Count* app and film in an outdoor setting (led by Mr Andrews). Due to a lack of volunteers, there were only enough adult helpers for a 1:2 ratio with learner groups in the hunt and with iPad sessions. I had the freedom to move between groups throughout the sessions, with a request to help if the need arose.

For the minibeast hunt, children had their usual collecting kit and an activity sheet to fill in. The children using the iPads had no collecting jars and were filming insects in their natural surroundings, being encouraged to access the app to find out further details of any insects they came across. The weather was fine. The sessions felt a little rushed and at times crowded (as one group of about 20 children was taking part in the hunt at the same time as one group of about 20 practising with the iPad), with up to 10 children gathering around areas considered to be of particular interest.

Both sessions, however, came across as positive learning experiences, with enthusiastic but generally calm children showing high levels of behavioural and cognitive engagement in both. In Figure 7.1, children can be seen looking under logs, observing insects in a collecting jar and filling in activity sheets, without requiring any adult input.

Figure 7.1: Y2 busy looking for and observing insects

I noted one group of girls as highly engaged, exhibiting flow both in their observations of the insect, a centipede, in its collecting jar (see Figure 7.2), and in their discussions when filling in the activity sheet, with one commenting with horror: *"I actually saw it eating another minibeast!"*

Figure 7.2: Focusing in on a centipede

When a boy approached to have a look and asked if he could take the insect to show his mother (who was supporting the activity), group members were reluctant to part with what they considered a prize, and accompanied him to show her.

Two TAs appeared to be particularly instrumental in helping: (i) scaffold the children's learning (for example, explaining why a newt the children had found was in fact a minibeast); and (ii) deepen their engagement, often simply by showing enthusiasm and interest in what the children were finding, providing what could be termed 'social' scaffolding. These sessions also included many examples of children yelling: "*I've found a …*", and excitedly running from place to place to find insects, with a lot of good humour and very little arguing. One of the TAs commented that the children's enthusiasm may have been connected with their enjoying the freedom of being outdoors, having recently finished the annual round of SATs.

7.1.3 Outdoor Film-making with eBooks Sessions

As agreed, children had been working in class in groups of 3 to 4 children to create an eBook about insects, using the *Book Creator* app, with the intention that one page would be created by each group member on their chosen insect to strengthen the sense of ownership. Three TAs, three adult helpers and the two teachers accompanied 57 children on this outing. Both classes came to the nature reserve together in mid-June, but on this occasion, one class worked on the iPad/eBook activity for 30 minutes led by Mr Andrews, and then swapped with the other to do a story-based activity led by Mrs Carter. Learners working on the iPad activity were allocated to their original 9 groups, with each having the iPad they had worked on in school. The weather was warm with no rain.

7.1.3.1 Observation and Initial Analysis of Session

Mr Andrews introduced both sessions by highlighting respect for minibeasts, and reminding the children the objectives for the activity. He also reiterated the skills required to make good videos and that learners could re-take videos if they were not happy with those they had recorded.

Once the children had picked up their group iPads, I was free to observe. Certain group members seemed fractious at the beginning of the first session: "*She just snatched that off me! And this pencil is dirty!*", but seemed to engage more strongly as they focused in on finding insects and taking videos and photographs to complete their eBook pages.

There was strong collaboration between groups in both sessions: "*I've got a woodlouse - anyone need a woodlouse?*", but I observed some children voicing irritation either because they had not found the insects they had made pages for in their book, or because they were unable to take videos of them (see Figure 7.3).

Figure 7.3: A Y2 boy hoping to film a bee before it flies off

A few children in Mr Andrews's class also expressed frustration relating to taking videos or photographs of insects that they did not have pages for: "*But we haven't got a page for that!*", a concern I had not envisaged; following my suggestion, Mr Andrews and the adult helpers advised them to create extra pages there and then for any insects they wanted to add, something which was taken up by several groups.

There were plenty of insects in evidence during both sessions, but I observed with interest that several children were highly-focused on 'Harvestmen', an insect similar to a spider, and appeared to know many facts about them. When I queried this with Mr Andrews, he let me know that some of the video clips they had watched in class had involved a BBC show, '*Minibeast Adventure with Jess'*, whose main character aims to enthuse younger viewers to learn about insects. One such episode had focused on harvestmen, which explained the degree of excitement many groups showed when finding the harvestmen and why they had stated their 'Harvestmen facts' with such authority when making their videos. This highlights the potential for digital media to support social learning and cognitive retention (cf. Kirkorian, Wartella & Anderson, 2008).

During both sessions, I took the opportunity to speak to adult helpers about their views on the activity. One mentioned how motivated and engaged the children appeared, commenting: "*They'd be happy doing this all day!";* this reflected my observations, and suggests the children may have been experiencing Csikszentmihalyi's concept of flow (1997), wherein their immersion in the activity was resulting in their losing track of time. She also commented that sharing of the iPad appeared to be the main obstacle to learning, with the more forceful children taking control of the device early on in the session which resulted in arguments and resentment. This view was also corroborated by some of my observations and echoes the findings of Henderson and Yeow (2012).

Another parent highlighted that noise from surrounding groups had affected the ability of the group he was with to make high-quality recordings of insects; he agreed that one solution would have been for the group to coax an insect into a collecting jar (where possible), and to find a quiet spot to practise and make their recording, something which some groups had spontaneously done in previous sessions.

7.1.3.2 Summary and Analysis of Learner-generated eBooks

Following the sessions, I saved each group's eBook as a video file to aid analysis within *ATLAS.ti*, looking both for the markers of engagement detailed in Table 7.1 as *a priori* categories, and for any others that might arise from examination of the data. An additional advantage of being able to analyse the eBooks was that I was easily able to compare and contrast behaviour in the classroom and in the outdoor setting, where groups had elected to incorporate photographs or video clips taken in both settings. Tables 7.2 to 7.6 present illustrative stills and transcripts of extracts from these video files, using the same identification notation as defined in sub-section 6.2.6.

Analysis of the clip presented in Table 7.2 highlights the import Group C2_1 placed on their authentic role as 'producers' of knowledge (Multisilta & Niemi, 2014), not only in their enthusiasm for the film-making process itself, but also in their focus on the insects in their jar, with C2_1_G2 expressing delight when she sees the 'face' of a snail for the first time.

C2_1	Transcript	Research Notes	IMG_0567.mov (0:00:56)
C2_1 C2_2 C2_1 C2_2 C2_1	*Action!* *I already started it.* *Cut!* *One, two, three ...* *Look at these two – they ...they're friends – the snail is saying* 'Wakey, wakey, rise and shine' *to the worm!'*	In role as film-maker. Does 'Cut' action. Is filming. Counts them in.	
C2_3 C2_2	*Look at it! I never seen that before!* *Arhh! You can see its <u>face</u>!* *Wow, isn't it amazing!*	Focusing in on insects using magnifier on collecting jar. Laughs with delight.	
C2_3	*Can I ... ?*	Moves to take collecting jar for another look.	

Table 7.2: Excerpt from Group C2_1's eBook illustrating their role as film producers

As mentioned previously, both teachers had used the *Minibeast Adventure with Jess* episodes to inspire their classes, and it was obvious that this had permeated the outdoor learning session, both in the facts the children were using in their video voiceovers, and in the highly enthusiastic intonation and mannerisms which several members of different groups employed in their video presentations. One example of this is illustrated in the transcript of an extract from a clip taken by Group A3_1, as shown in Table 7.3.

A3_1		**IMG_0569.mov (0:02:13)**	**Research Notes**
A3_1_G1	*Welcome to my '<u>Minibeast Adventure</u>'!* *Today, we're going to learn all about worms. This morning I found some. Do you want to have a closer look? They are sooo amazing. If you want, if you couldn't see, I could take the lid off ...Look how they moove! They haven't got <u>any</u> legs! So they just use their bodies to slide along [makes sliding motion].*		Accurate representation of the 'Jess' character's style and language, demonstrating social learning. Leads into focusing-in on insect.

Table 7.3: Details of eBook created by Group A3_1

The next group was made up of 3 boys, and the first page of their eBook contained a 26-second clip of two of them wrestling, with one (A3_3_B1) holding the other (A3_3_B2) in a head-lock, and the third filming. When I came to view other embedded clips that were taken in the reserve, however, I noted that both of these boys appeared highly-engaged with the activity, as shown in Table 7.4, something which I flagged to follow up with teachers.

A3_3		**IMG_0568.mov (0:02.47)**	**Research Notes**
A3_3_B1	*A snail has a foot inside it, a snail carries its shell around, and a snail, when it's scared, it goes into its shell.*		Engaged and on task, exhibiting behaviour in contrast to that shown in classroom.
A3_3_B1	*Let us have a closer look.*		Formal language. Collaborates and brings jar forward when asked by child filming.
A3_3_B2	*This is a larva ladybird type of thing, and it has six legs, and it's a baby ladybird. It's a child ladybird.*		Has retained knowledge passed on by TA about ladybird larva. Does not respond when boy filming starts complaining loudly that he is not holding the jar correctly.

Table 7.4: Extracts from video clip in eBook created by Group A3_3

As highlighted in sub-section 5.5.3.2, a lack of scaffolding can perpetuate misconceptions held by children in child-centred activities (cf. Brown, 1992). This is exemplified in Table 7.5, where a child reveals their misunderstanding of the difference between slugs and snails, but is not corrected by other group members or the adult helper.

C2_4		**IMG_0573.mov (0:01:13)**	**Research Notes**
C2_4_B1	*They call them slugs, but when they're hiding, they go into shells and then they call them snails.*		Adult helper does not correct misconception, highlighting a need for scaffolding.

Table 7.5: Extract from video clip in eBook created by Group A3_4

The TAs in both classes had worked with groups to find appropriate photographs on the internet; some groups also included 'hand-drawn' diagrams using a stylus or photographs they had taken while in the reserve. All groups had included at least one or two facts about their minibeasts, and one group, C2_1, had annotated their photographs (see Figure 7.4).

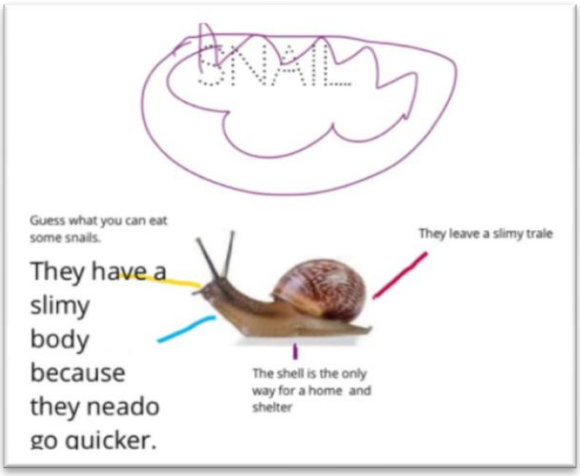
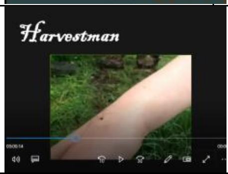
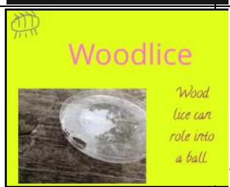


Figure 7.4: Annotated diagram created by C2_1

Table 7.6 summarises details of eBooks developed on the school iPads. All groups had included an introductory page with a photograph of themselves and their names, with some also adding video and audio clips to introduce themselves, suggesting a sense of ownership. The table serves to illustrate the extent to which learners engaged with the process of creating their eBooks, something corroborated by both the interviews with teachers and the child focus groups described in the next sub-sections.

ID	File/Length		eBook Details
Group A3_1	IMG_0569 (0;02:13)		• 3 pages for millipedes, woodlice and spiders, incorporating photographs and facts; • 2 pages incorporating video clips, one for worms and one for newts. *Note: High standard of presentation (see Table 7.3 above for details)*
Group A3_2	IMG_0571 (0:02:55)		• 3 pages for earwigs, beetles, millipedes incorporating facts and internet photos; • 3 pages incorporating video clips, one for harvestmen, one for woodlice and one for moths, which flew off while being filmed. *Note: Noise from child filming made it difficult to hear child speaking.*
Group A3_3	IMG_0568 (0:02:47)		• 6 pages for bees, spiders, beetles, flies, wasps, and slugs incorporating facts and internet photos; • 3 pages incorporating video clips, one for snails, one for woodlice and one for ladybird larva. *Note: More engaged in outdoor setting (see Table 7.4 for details)*
Group A3_4	IMG_0575 (0:00:47)		• 4 pages for beetles, spiders, earwigs, caterpillars incorporating facts, 'hand' drawings and internet photos; • 1 page incorporating video clip of harvestmen where boy (A3_4_B1) counts insects legs and uses 'Jess' facts. *Note: Observed throughout session being highly engaged in finding and showing harvestmen*
Group A3_5	IMG_0570 (0:00:41)		• 4 pages for butterflies, woodlice, ladybird and earwigs incorporating facts and internet photos; • 1 page incorporating good video clip of harvestmen: "*it tickles a bit, it's got a small body, like its head is its body*".
Group C2_1	IMG_0567 (0:00:56)		• 3 pages for woodlice, snails and spiders incorporating annotated photographs and facts; • 1 additional page for snails incorporating a video clip. *Child shows delight at seeing snail's face (see Table 7.2 for details).*
Group C2_2	IMG_0574 (0:00:50)		• 3 pages for ladybird, firefly and earwigs incorporating facts, their own and internet photos; • 2 pages on spiders and slugs, incorporating video clips but no insect facts in video clips.
Group C2_3	IMG_0577 (0:01:51)		• 3 pages for spiders, bees, snails and butterflies, incorporating audio clips, 'hand' drawings and internet photos; • 1 page on woodlice incorporating video clip exemplifying social learning. Audio clip excerpt: "*Butterflies get hurt when people touch their wings as their wings are very, very delicate ...so don't touch them".*
Group C2_4	IMG_0573 (0:01:13)		• 5 pages for spiders, harvestmen, bees, ants and worms incorporating facts and internet photos; • 2 pages on slugs and woodlice, incorporating video clips. *Scaffolding lacking (see Table 7.5 for details).*

ID	File/Length		eBook Details
Group C2_5	IMG_0572 (0:01:01)		• 5 pages for spiders and worms incorporating audio, facts and internet photos; • 2 pages on harvestmen and other minibeasts, incorporating audio and video clips. *Social learning. Sometimes too much noise to hear.*

Table 7.6: Summary details of Y2 *Minibeast* eBooks

7.1.4 Evaluation with Year 2 Teachers and Learner Focus Groups

Having worked with both teachers in previous years, my questions in these interviews focused on their thoughts regarding the pedagogic value of learner-generated video, their views on the MLA and eBooks in particular, their use of iPads in their teaching and what impact the curriculum was having on their teaching and time commitments.

7.1.4.1 Semi-Structured Interview with Mrs Carter

While Mrs Carter had not taken part in the outdoor mobile learning sessions herself, due to temporary mobility issues, she did re-iterate that, as with the previous year, the children in her class had appeared far more enthused by the mobile learning activity than other activities she had led without mobile devices, and that she felt bringing the "*outdoors learning in*" using the eBooks had worked well in terms of embedding the learning (cf. Vavoula et al., 2009; Zimmerman & Land, 2014).

Indicating that she felt the markers for measuring engagement in the MLA outdoor sessions were appropriate, Mrs Carter acknowledged that she had not used these herself as she had not participated in those sessions. Mentioning that certain boys in her class were reluctant writers, she did highlight that creating the eBooks had motivated them to engage more with the topic than they would have otherwise and that her class as a whole had "*thoroughly enjoyed*" the process and were proud of what they had created. Following on from findings emerging from my observations of the outdoor sessions, I asked whether there were any children in her class who preferred hand-writing to using iPads - Mrs Carter suggested that the majority of her class were more motivated by creating the eBooks than hand-written pieces, and that they had collaborated well on these.

In terms of the quality of the eBooks, she had also noticed a few of her class imitating the BBC presenter *Jess*'s intonation and language in their clips, which she found amusing. Suggesting that she had found the eBooks useful for assessment of their science curriculum learning objectives, Mrs Carter concluded that she would 'definitely' do the activity again, commenting that 35-45 minutes would have been more appropriate for the outdoor film-making sessions.

7.1.4.2 Semi-structured Interview with Mr Andrews

Following a brief informal discussion on the quality of the eBooks produced, with specific reference to differences between the various groups' eBooks, I opened by referring to an exchange in one of the outdoor MLA sessions, where a member of Mr Andrews' class had commented they preferred using eBooks because "*I don't like writing*".

Q1: <u>Do you feel making video clips gives certain learners more of a voice?</u> – Echoing Cooper, (2016), Mr Andrews responded: "*Definitely. It makes assessing them a bit easier as well - you can kind of have a better understanding of what they know rather than forcing them to write it down."*

Q2: <u>What were your views on using eBooks with this age-group?</u> - In his response, Mr Andrews highlighted his appreciation for what the app had brought to his class, and their emotional, behavioural and cognitive engagement with it:

> *Ahh, it's absolutely amazing. To see a kid like* [name of child], *he really struggles with writing, he's coming on, he's improved, but it's still a struggle. Part of writing is you're sharing with people, he's not keen. But Book Creator, he'll do it for fun!* [laughs] *He's typing, he's putting words in, pictures in, he's asking* 'Can I make a book about my friends, can I make a book about this, can I make a book about that*?' They've all really enjoyed it.*

Noting that many of his class choose to use the app during 'Golden Time', when children are free to select their own activities, Mr Andrews commented: "*They're just blown away by fonts* *and colours and pictures, and as long as I go:* 'Just write some things to go with the pictures, write some captions'*, and there they are, checking spellings."*

In line with his observations from previous DBR cycles, Mr Andrews also referred to the soft skills he felt the children had gained from the activity: *Confidence, seeing themselves, sort of self-reflection, when they watch themselves back:* 'Oh - I'm quite good at this' *or* 'I could do that better'*; watching each other's videos as well, it seems to engage them more watching it on the screen than just watching a presentation in class. Definitely useful for group skills too.*

Acknowledging that he had seen but not used *Book Creator* before, Mr Andrews also highlighted the cognitive skills he felt his class had gained from participating in the activity, and, in line with Kearney and Schuck, (2005), that having an audience for what they had produced had motivated them further:

> *Using the apps, learning facts from the app about the insects so you can say something interesting about it in your video. I don't under-estimate the engagement aspect - if it wasn't for the video stuff, if we were just going to make a fact-file about woodlice, for example, that no one was going to see and it was just going to be in your book for the sake of it, they'd be a lot less engaged and put a lot less effort into it. The audience aspect - the fact that they're creating something that will be shown makes a huge difference. They show it to each other in class all the time.*

Moving on to express his appreciation of the learner-centredness of using *Book Creator* in his class, Mr Andrews commented:

> *The difference this year is that previously, even though they had created the videos, you or we shaped how they were presented, whereas this year, they had to do it themselves using the app, which I'm happy about. They're not necessarily going to win any competitions but they've got more skills out of using that app than I taught them last year. They love it!*

In accord with Mrs Carter, Mr Andrews also felt that 35-45 minutes was appropriate for a session of this nature, otherwise he felt the children "*might get a bit fed-up and start climbing trees and stuff!"*

Q3: <u>Did you find it useful to create the pages before they went out to [the nature reserve] or a little constraining?</u> – In his response, Mr Andrews suggested that there were advantages and disadvantages in this approach:

> *Bit of both - it was useful before but then it also meant ...I think it would have been easier to make films when you were there about whatever you found and then put them in when you got back ...because they were kind of looking around for a specific insect which took up a lot of the time. So, film whatever you find, I didn't realise at the time how easy it would be to put the movies into Book Creator at a later date.*

Due to the shared nature of the school iPads, Mr Andrews acknowledged that this could have implications in terms of video files being overwritten by other classes, clips being difficult to locate at a later date and other issues relating to embedding of over-long video clips in *Book Creator*. In addition, he accepted my recommendation that, at a school level, a system needed to be put in place to ensure that school iPads were regularly checked for storage limitations, with space freed up by storing existing video and image files elsewhere to avoid the iPads becoming unusable.

Q4: <u>Do you feel digital assets are becoming more acceptable as proof, or are you still required to print things out?</u> - Responding that most of his time had been taken up with teaching and assessing numeracy and literacy that year, Mr Andrews again highlighted the secondary status afforded to the teaching of science:

> *...the frontline assessment that has taken all of our time this year is Maths and English, and eventually, you spend weeks doing all that, get to the end of it all and then* 'We need to come up with some assessments for science'*, a bit of an afterthought really, which is a shame, as science is a core subject, but nobody cares about it as much as Maths or English.*

Q5: *If you were looking for markers to help you assess cognitive engagement in learners, what would you be looking for?* As with Mrs Carter, Mr Andrews felt the measures of engagement agreed for the MLAs had been appropriate for this age-group, but highlighted his frustration with the current National Curriculum assessment requirements, using English as an example:

> *In the recent Year 2 assessment, there was very little* 'write an interesting passage to engage the reader'*, so you end up when you're marking stuff not even reading it properly, they might have written a load of rubbish, but it was seeing if an apostrophe was correctly used, if they've spelt that word correctly, honestly, somewhere in the middle would be best.*

Following on from comments made by parent helpers and my own observations, I asked Mr Andrews whether he felt using iPads caused more conflict within his class:

> *It's just dynamics. I just try to group them sensibly - I could easily find the 'destructor' group where you wouldn't get your iPad back!* [laughs] *Sometimes they surprise you with a mix that works, you just try to build in sharing,* 'Now it's time for so and so to have a turn'*, which is quite tricky because you've got to keep your eye on the clock and make sure. Most manage to take their turn in sharing, which is why one* [iPad] *between two would work best.*

Q6: <u>How many iPads are there now in school compared to 2014 and 2015?</u> - Mr Andrews confirmed that each year group in the school had six iPads between them, but that he could borrow other class sets on an *ad hoc* basis, if required for a whole class activity.

Q7: <u>What impact, if any, do you think mobile learning has had on how the children in your class have learned?</u> - Highlighting his focus on the teaching of literacy and numeracy skills, Mr Andrews commented that spelling games were “*more fun*” on the iPad, as he had seen high levels of engagement in the children while they were using these, also noting that “*you'd need to follow up, sit with them for a longer time to get an idea of what's gone in, whether they'd applied the spellings they'd been learning on the iPad in other contexts.”*

While highlighting that it was *“the use of the iPad that's made the difference*” in terms of learning times tables for many of the children in his class, it was interesting to hear Mr Andrews comment that some were happy to use iPads for ‘fun’ but not for learning, reiterating that there were a few that preferred hand-writing and drawing:

> *They're quite a quirky bunch, my class, quite unusual; some of them pick up an iPad for their own fun but they're not fussed about using it in class* [for learning]*; a few of them actually prefer writing, they'd rather hand-write and draw.*

The interview concluded with an agreement to schedule a subsequent meeting to discuss the summative analysis, once it had taken place, with an emphasis on the referral of findings to the teachers as expert witnesses for corroboration or otherwise, using purposively-selected data sources such as photographs, excerpts from observation recordings and learner-generated content to focus discussions.

7.1.4.3 Learner Focus Groups

Focus groups with learners took place a few days after Mr Andrews’s interview and involved informal conversations being audio-recorded with five randomly-selected table groups in Mr Andrews’s class, comprising four groups with 4 members and one with 3 members.

Following Morgan et al. (2002), I worked with each group separately for 10-15 minutes and began by asking them to talk me through their eBook to focus them, and then moved on to ask specific questions related to their views on the activity and mobile learning in general.

Most groups appeared to have collaborated on all pages together rather than having ownership of one, and I noted great variation in the vocabulary used by the children, with some noticeably more proficient at expressing themselves than others.

All groups appeared genuinely proud of the eBooks they had produced, and watched the embedded video clips of themselves and their insects with amusement (see Figure 7.5).

Figure 7.5: Y2 group reviewing their eBook

Three key themes of control, learner creative preferences and group dynamics emerged from analysis of the audio recordings of these focus groups. Where applicable, quotes are attributed to a child using the previous group identification notation.

In response to a question on whether they preferred making eBooks or using paper and pencil, opinion was divided, with the response from one child regarding her preference for using paper and pen implicitly underpinned by concerns around control and group-related issues, (cf. Selwyn, 2002): *"Because you actually make them and draw them and you get to do them your own self - it isn't just have a choice, you can decide for yourself …I like working by myself sometimes, because sometimes you just need to calm down"* (A3_5_G2), whereas another commented: *"eBooks - I vote eBooks because I just love technology*", and another "*I'm not very good at writing because it looks like a robot writes it, so I prefer eBooks"* (A3_2_B1).

All learners appeared to accept that eBooks did enable videos and photographs to be embedded within them: "*I think eBooks because you can just type and put in videos and pictures"*, but it was noteworthy that one learner did highlight the simple fact that: *"You can't put videos into paper books, but you might prefer drawing to making videos"* (A3_5_G2), a view which was echoed by another learner: *"I think paper because I love artwork" (*A3_2_G1).

Following on from control issues, high levels of reflexivity were demonstrated by the children when watching themselves in the clips, with one girl commenting: "*I also noticed that I was a bit bossy, so I regret that*" while another exclaimed: "*You were whistling much too much in that* *one,* [name of child]!" (A3_5_G3). Echoing some of my own observations and the comment from one parent helper, notions of 'hogging' the iPad were a recurrent source of antipathy in several groups, with one group in particular giving strong expression to the fact that one girl had taken over the activity without giving any of them a turn, to which she responded "*The reason I was bossy is because we weren't really collaborating and I just got a bit shouty and none of them were barely listening*." Another group commented that their original intention had been for each member to be responsible for completing two pages in their book, including the recording of video clips and photographs, but that this had not been followed through once in the nature reserve, as the recording role had been allocated to one child with specific learning difficulties.

When asked whether they liked going to the nature reserve, all children that expressed an opinion (12 out of 18) replied that they liked learning outdoors, with comments such as: "*I like nature because it keeps me calm*", and "*Nature's really nice; I like being round grass and flowers*" and "*I like finding stuff outside*"; none expressed any negative feelings.

In terms of being able to concentrate on their learning when outside, three children raised the issue of noise from others hindering their concentration when making their videos, one highlighted problems of spelling and insects moving off while they were filming them: "S*pelling is difficult and insects can fall onto the floor*", and all groups cited issues relating to working within teams, ranging from individual group members not being on-task: "[name of child] *kept shouting and messing about*", to the hogging and control issues mentioned above: "*Working in a group is quite hard, because you've all got different opinions*".

Two groups wanted to edit their eBooks further during the conversation, and asked for help in doing so, highlighting high levels of engagement with what they had produced. Another group, inspired by revisiting their eBook, wanted to share their knowledge of insects, citing the *Bugs Count* app as a source:

A3_2_B1: *Do you know what the difference is between centipedes and millipedes*?

A3_2_G1: *One's yellowy-brown, the other's black.*

A3_2_B1: *And also, it said in that app, 'Bug Count'* [sic]*, that they had different numbers of body segments.*

7.1.5 Summary of DBRC_P3 and Issues Arising for Feed-forward

Evaluation of this DBR cycle and initial findings were derived from analysis of the data sources outlined in section 1.8. Findings directly addressed the research questions CRQ1 *("How might the process of creating eBooks using mobile devices engage 6-7 year old children with science topic work, working in groups across classroom and outdoor settings?"),* and CRQ2 *("How might the process of creating eBooks using mobile devices enhance understanding of science topic work for 6-7 year old children working in groups across classroom and outdoor settings?"),* highlighting that using mobile devices to create eBooks of insects in class and outdoor settings can be highly-motivating and engaging for children aged 6-7 years working in groups, helping to focus and embed learning, deepen understanding and promote learner autonomy.

In addressing CRQ3 *("How might engagement of 6-7 year old children using mobile devices in groups for science topic work in outdoor settings be assessed?"),* the agreed markers for measuring engagement (see Table 7.1) were considered appropriate by the teachers for this MLA, with a final meeting scheduled for further discussion of their fitness-for-purpose once summative analysis of findings had taken place.

Findings resulting from the analysis of this cycle suggested that:

- Exemplar video excerpts can be used to good effect to inspire young learners, for example, by demonstrating presentational skills and language they can adopt to convey their own facts effectively (Kirkorian et al., 2008);
- Producing eBooks with embedded video clips can enable more reluctant writers to showcase their understanding (Cooper, 2016);
- The experience of creating eBooks using a combination of text, drawings, photographs, video clips and audio clips (the three latter learner-generated or

imported from the internet), can provide learners with a valuable foundation on which to build ICT skills (Sefton-Green, Marsh, Erstad & Flewitt, 2016);

- Issues relating to inadequate scaffolding (Nouri et al*.,* 2014) and group dynamics can have a detrimental impact on the learner experience;
- Cross-contextual activities of this nature can support a combination of learner-centred, collaborative, kinaesthetic, experiential, outdoor and exploratory forms of learning.

7.2 DBRC_P4: Film-making with Year 3 using eBooks (June/July 2016)

As part of a suite of activities, this MLA followed on from the Y3 QR-code trail activity (see sub-section 5.5.1) and two staged visits to the reserve focusing on the Y3 '*Lifecycle of Plants*' topic. Alongside discussions with the Y2 teachers on the previous MLA, agreement was also reached with Miss Hope and Miss Brown, the Y3 teachers, to trial the use of eBooks.

7.2.1 Refinement of Mobile Learning Activity and Research Questions

As much of the research into the functionality and usability of *Book Creator* had already taken place during the design phase of DBRC_P3, discussions with the Y3 teachers focused on the practicalities of dovetailing the staged visits to the reserve with the use of the app. One staged visit had already taken place, which included the preparation of a dedicated slot in the nature reserve and the sowing of wildflower seeds. Two further visits to the reserve were planned to check on the progress of the seeds, with the intention that the children would create eBooks to document this. Existing markers for engagement outlined in Table 7.1 were agreed as an appropriate starting point by the teachers.

The cycle-specific research questions for this activity were refined as follows:

CRQ1- "*How might the process of creating eBooks using mobile devices engage 7-8 year old children with science topic work, working in groups across classroom and outdoor settings?*"
CRQ2 - "*How might the process of creating eBooks using mobile devices enhance understanding of science topic work for 7-8 year old children working in groups across classroom and outdoor settings?*"

CRQ3 - “*How might engagement of 7-8 year old children using mobile devices in groups for science topic work in outdoor settings be assessed?”*

The final agreed specification of the activity comprised:

- Classroom sessions to be organised to familiarise the children with using *Book Creator;*
- Children working together in learner groups of no more than 4 to create an eBook showcasing their understanding of the life-cycle of plants, with each child having ownership of at least one page;
- Two outdoor sessions to take place in the local nature reserve prior to the mobile learning session to: (i) view the progress of the wildflower bed; and (ii) further familiarise the children with the topic using a themed scavenger trail; and (iii) enable them to incorporate photographs and video clips into their eBooks while in the outdoor setting;
- Adult helpers to be primed to ‘loosely lead’, providing support where necessary;
- Engagement to be assessed by myself and the teachers, using agreed markers.

7.2.2 Outdoor Film-making with eBooks Sessions

Both classes attended separately on a sunny day in mid-July, with Miss Hope’s class coming in the morning and Miss Brown’s in the afternoon. There were approximately 30 children in each session working in groups of three to four, with each group having access to one school iPad containing their eBook. Each session also had two TAs, two student teachers and two adult helpers in attendance. Each class initially attended a talk led by the reserve Education Co-ordinator relating to the progress of their wild flowers, which was followed by a scavenger hunt and the eBook session. The following section reports on findings relating to both classes.

7.2.2.1 Observation and Initial Analysis of Sessions

On arrival at the reserve, several children, from both classes respectively, were observed running to the flower bed to see whether their seedlings had grown. Both classes appeared to listen attentively to the talk given by the Education Co-ordinator, which took place at the flower bed. The children were then allocated to their ‘eBook groups’ and took part in a scavenger hunt, designed to focus them in on the key aspects of the plant lifecycle process they needed to highlight in their eBooks. High levels of enthusiasm and competitiveness were observed across groups during the hunt.

Following the hunt, the majority of children in both classes appeared calm and on-task as they went around the reserve (see Figure 7.6), either looking for suitable photographs to add to their eBooks, finding an appropriate spot to create a video clip or reviewing their clips. This was perhaps due to having expended physical energy in the scavenger hunt, or may have resulted from their having had prior experience in creating video clips during the QR-code trail (see section 5.5).

Figure 7.6: Y3 creating a video clip for their eBook

I observed three groups through the process of navigating to the correct page in their eBooks, collaborating on what should be said in their clip, deciding where the clip should be taken and then reviewing their clip. In the groups observed, this was accomplished with negotiation and without adult input, exemplifying the high levels of learner autonomy that the design of this MLA had intended to engender, while also evidencing the children's emotional, behavioural and cognitive engagement with the activity. The extract below illustrates one example of a group (see Figure 7.7) discussing whether the clip they have created is factually correct. B2_1_G1 emphasises a possible misunderstanding in the words used by B2_1_G3, but does so in a supportive manner, as evidenced by the tone of her voice and her choice of words:

B2_1_G1: "*You said:* 'Seeds sometimes get spread by <u>sycamores</u>.' *It should be*: 'Seeds sometimes get spread by <u>sticking</u>.'"

B2_1_G2: "*You might have got mixed up."*

B2_1_G3: "*Oh, I know what that is! We've been learning about this! You mean like to animals?"*

B2_1_G1: "*Yep. Let's film it again."*

Figure 7.7: Group B2_1 reviewing their video clip

As with previous MLAs and as highlighted above, there were many examples of children illustrating the points they were trying to bring out in their video clips by pointing to or touching the objects they were speaking about, as shown in Table 7.7. Here, two members of a group are being filmed by a third member showcasing their knowledge of wildflowers, in particular their recollection of the names of the individual plants. Touching the flowers appears to aid recall in the girl shown in the middle column, as she first touches a flower, pauses for a few seconds and then says its name.

		
"This flower's marigold."	*"This is... camomile and... that is ... a poppy..."*	*"And this one is a cornflower."*

Table 7.7: Group H2_1_G1 showcasing their knowledge of wildflowers

This reflects a comment made by a TA during the session, where she suggested that looking at plants in an outdoor setting appears to aid memory in children: "*It's surprising what they remember, once they've found what they need, for example the shape of a leaf. It's because you've gone through that process of what is it, what shape is it, it really sticks in your mind."*

7.2.2.2 Summary and Analysis of Learner-generated eBooks

Responding to the research questions, a selection of screenshots from some of the eBooks created by the Y3 children is included in Table 7.8, along with transcriptions of sample extracts taken from their books, both to illustrate their engagement with the activity, and their understanding of the topic.

Analysis of the eBooks highlighted that children had incorporated photographs they had taken in the reserve, including ones of their wildflower bed, as well as photographs of drawings they had created in class and plants they had grown from seed in the classroom. The eBooks also contained videos taken in the reserve where they were describing what they understood of the plant life cycle, and drawings and audio clips they had created within *Book Creator* while in class.

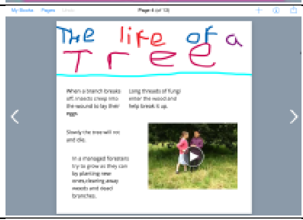
Extract	eBook Screenshot	Research Notes
When an apple tree drops an apple, a bird or a rodent might eat it and they might have swallowed a seed in the apple, and then they might [drop] out the seed once they have gone away and then it starts to germinate and turn into an apple tree.		12 pages: photographs (reserve), descriptive text, audio clips, one video clip. Science facts and understanding shown.
The plant germinates by using the water and the sun. After that the roots come out and they hold the plant. Next the flower comes with seeds in and it drops some and the lifecycle carries on.		6 pages: photographs (reserve), hand-drawings, descriptive text, video and audio clips, song. Science facts and understanding.
Pollination is where pollen gets spread from flower to flower.		9 pages: photographs (classroom and reserve), hand-drawings, descriptive text, one video clip. Science facts and understanding.
When a branch breaks off, insects creep into the wound to lay their eggs. Slowly the tree will rot and die.		13 pages: photographs (reserve), hand-drawings, descriptive text, 4 video clips, glossary. Some science facts.
Bees go into flowers and they get pollen on then go to another flower Pollen makes hayfever.		8 pages: photographs (reserve), one video, descriptive text, audio clip. Some science facts.
Seeds take quite a while to hatch because it has to have enough sunlight and water to survive.		11 pages: hand-drawings, photographs (class and reserve), descriptive text, one video clip. Science facts but some incorrect vocabulary.
And now we will show you some. This is the pollen inside and you can actually see it. It is actually green. It is actually green inside a buttercup.		10 pages: photgraphs (reserve and classroom), video clips, descriptive text. Some science facts and understanding shown.

Table 7.8: Screenshots, transcribed extracts and summary details from Y3 '*Lifecycle of Plants' eBooks*

7.2.3 Evaluation with Year 3 Teachers

Three key themes emerged from analysis of the semi-structured interviews with Miss Brown and Miss Hope, namely learner engagement with the activity, learner autonomy, learners losing focus in the outdoor setting and issues relating to assessment of learning objectives.

7.2.3.1 Learner Engagement and Learner Autonomy

Both teachers highlighted the high levels of engagement the children in their classes had evidenced when creating their eBooks, with Miss Brown mentioning that the only issues that arose in her class were due to problems with collaboration rather than the software itself: *Equally, across the class, everyone really enjoyed doing it. ...It was more the process of being collaborative that was the issue, rather than the eBooks themselves. The majority were absolutely great with that.*

In response to a follow-up query relating to how they thought learner engagement manifested itself in her class, Miss Hope described something she termed the *"learning hum"*, echoing Mr Andrews' term "*learning buzz*", where children were *"Engaged, doing, not necessarily quiet or silent",* highlighting that "s*ometimes they're talking to themselves, talking through what they're doing, often to each other*." She also mentioned the importance of analysing the *"outputs, what they create at the end of it",* to evaluate levels of engagement.

In her response, Miss Brown was effusive in describing the facets of learner engagement she felt her class had shown when working on their eBooks, highlighting focus, planning, team work and learner autonomy in particular:

> *They're not chatting about something else, they're talking amongst themselves, they're planning, they're talking about the task, they're completely engaged, they're focused, they're listening to each other, they're saying "*I'll do this first*", "*I'll do that*", they're working as a team. And then they're going away and you see what they've produced.* "You're doing this page, you're doing that page, we're going to put this in here", *you know, they're working together completely. That learning behaviour, it's massive.*

Having previously described herself as an under-confident user of ICT, Miss Brown highlighted her appreciation of *Book Creator*, particularly its ease of use, and her eagerness to use it the following year. She described the 'drip-feed' process of how knowledge of the software functions was shared within her class, and how ten children in Miss Hope's class had initially come in to *"get us started"*:

> *It was very simple, and other children, as they learnt how to do things, it was like a drip-feed through the class, and someone would say: "*I know how to do this now,*" and we'd all watch them do it*. [laughs] *I didn't know anything about Book Creator before this, and I'll definitely use it next year ...there was no teacher involved really, which was lovely, because then I could concentrate on other stuff.*

7.2.3.2 Losing Focus in the Outdoor Setting

Acknowledging that while there probably *"wouldn't be the buzz"* if the activity had been a piece of hand-writing, Miss Hope again expressed her concern that some of the science facts had been lost when her class were creating videos in the reserve, which she suggested had been there when the children had been practising in school the week before:

> *...they were videoing, preparing these books, all the knowledge was there, the understanding, and all the scientific vocabulary was there, that was lost when we were outside. So I don't think it was the actual ICT tool, it was the location.*

A similar view was echoed by Miss Brown, who also noted that some children were over-focused on performance:

> *They've gone a bit giddy with some of their videos today - some of it's the timing, near the end of the year ...they're sort of juggling with apples, more of a performance, and I think some of the science work has been lost a little.* [laughs]

Interestingly, while Miss Hope considered that this may have been due to it being a sunny day towards the end of term and that the children had perhaps wanted to enjoy being outside: *"to use it as time just to immerse themselves in the outdoors",* she also suggested that it was possible that the children considered the classroom to be the seat of learning: *"maybe they* *sort of segregate the learning into classroom space and outdoor space."* Miss Hope went on to relay a conversation she had recently had with some children who had commented that they were not learning in certain subjects: *"Art was mentioned. What was it? Ah yes ...*'We're not learning, we're doing some drawing.*' I said: '*Do we not learn when we're drawing? We're learning all the time.*' They said: '*Oh, really?*' '*Yeah - it never stops.*'"* [laughs]

This notion was revisited at the end of the interview, where Miss Hope was asked whether she was concerned children might get bored with going to the same setting for outdoor activities:

> *From a learning point of view, that might be a good thing, because then they won't separate learning in the classroom with learning outside. So that there's no differentiation about where you're learning - you're learning full stop.*

7.2.3.3 eBooks as Assessment Pieces

Both teachers confirmed they would be using the eBooks as assessment pieces for the science curriculum, with Miss Brown indicating that she would *"watch them"* in order to assess the children's understanding of the topic:

> *It's very much a tick-list, so that would give me an understanding of who knows what and who doesn't. I've already read little bits of text* [in the eBooks] *and thought "Oh - they understood this or ...there are some other things they've written like seeds hatching* [laughs] *...not the right vocabulary, but the right idea* [laughs]. *So it's both the scientific vocabulary <u>and</u> understanding behind it we're after.*

Having previously raised the concern that some children may not have demonstrated all their science knowledge in the eBooks, Miss Hope suggested that she would be asking the children to present their eBooks in class to confirm their level of understanding: *"they're going to take turns as a group to share what they've done, and as they're sharing, we can look at their techniques, ask questions and I can then do my assessments as they go".* In a follow-up email, Miss Hope confirmed that she had done this, and that questioning each child as they took turns presenting had proved to be a useful method for assessing individual understanding of the topic, as well as being an engaging session for the class as a whole.

7.2.4 Summary of DBRC_P4

The evaluation of this DBR cycle and initial findings were derived from analysis of the data sources detailed in section 1.8. Findings directly addressed the research questions CRQ1 *("How might the process of creating eBooks using mobile devices engage 7-8 year old children with science topic work, working in groups across classroom and outdoor settings?")*, and CRQ2 *("How might the process of creating eBooks using mobile devices enhance understanding of science topic work for 7-8 year old children working in groups across classroom and outdoor settings?"),* highlighting that using mobile devices to create eBooks to demonstrate their understanding of the lifecycle of plants can be highly-motivating and engaging for children aged 7-8 years working in groups, particularly for learners that find hand-writing challenging. Some concerns were expressed by teachers regarding the tendency for certain children to 'forget' their science knowledge while in the outdoor setting, which is explored further in Chapter 8.

In responding to CRQ3 *("How might engagement of 7-8 year old children using mobile devices in groups for science topic work in outdoor settings be assessed?"),* both teachers discussed the markers for engagement detailed in Table 7.1 during the design phase of this activity, responding that they felt these suitably reflected the types of learning engagement they would expect to see for this activity. This was re-iterated during their formal evaluations of the activity, and led to discussions focused on learner engagement and learner autonomy.

7.3 Summary of Chapter 7

This chapter described the final round of two design-based research (DBR) cycles focused on the design, development, implementation and evaluation of mobile learning activities relating to the *production-focused learning* research activity stream. Spanning one academic year, these mobile learning activities involved learners using eBooks in both indoor and outdoor settings to incorporate their own text, photographs, drawings and films, linked to the *'Living* *things and their habitats'* curriculum topic for Y2, and the *'Lifecycle of Plants'* curriculum topic for Y3. Findings derived from the analysis informed the development of a set of mobile learning design principles, which are detailed in Chapter 8.

The following chapter draws together the findings from all activities relating to the *discovery-based learning* and *production-focused learning* research activity streams, discussing implications for mobile learning theory, highlighting aspects relevant to practitioners in primary education, and outlining suggestions for further research.

Chapter 8 Discussion and Conclusion

This study sought to address the primary research question of: *“**How might mobile learning influence learner engagement of primary school children working in groups on science topic work in outdoor settings**?”,* analysing qualitative data resulting from a series of design-based research cycles focused on the design, implementation and evaluation of a range of mobile learning activities (MLAs). The MLAs were developed in close collaboration with 5 primary school teachers and were conducted with around 540 children aged 6-10 years over a period of three years.

8.1 Background and Context

In line with Dewey’s conviction that children learn best when they are engaged in activities that are child-centred and that are linked to their own interests and community (Dewey, 1938), while also acknowledging Bruner’s response that the “*Interests* [of a child] *can be created and stimulated*” (Bruner, 1979, p.117), the design of these MLAs sought to provide children with enough freedom to explore their local environment, while harnessing the affordances of mobile devices to guide and exploit the rich learning potential offered by the authentic setting of a local nature reserve.

During the study, data were collected from a variety of sources comprising video-recorded observations, audio-recorded interviews and focus groups, field notes and learner-generated digital and non-digital artefacts. Using grounded theory, an inductive and iterative process of coding and categorising this data within *ATLAS.ti* led to the identification of emergent patterns, with axial coding employed to explore and draw out key themes and relationships between the various entities to help generate theory (see sub-section 4.3.1).

Following each design-based research (DBR) cycle, the new batch of data source files was imported into *ATLAS.ti*, and constant comparison used during the coding process to ensure consistency and fitness-for-purpose of existing categories and codes. The functionality of *ATLAS.ti*, whereby one can select a category or code to view or play (in the case of video and audio clips) all data source extracts associated with it, enabled easy comparison, re-assignment or editing of particular categories and codes and associated extracts, to ensure the coding system was true to the data. The coding and categorisation process led to the development of a framework to aid conceptualisation of the influence of mobile learning on learner engagement, with an emphasis on the interplay of its various behavioural, emotional and cognitive elements and their relationship to the learning theories underpinning the MLAs. A listing of the various categories and codes used in the analysis is provided in Appendix One.

Any issues, either relating to coding or emergent findings, were referred to participant-teachers in their role as expert witnesses for corroboration or otherwise (Yin, 1989), with their member-checking used in order to strengthen credibility and verifiability. Alongside efforts to maintain theoretical sensitivity (Glaser & Holton, 2004), rich descriptions of the research context were also included to promote dependability and transferability of the findings (Guba & Lincoln, 1985).

Findings indicated that MLAs taking place in natural outdoor settings can support a complex web of learner-centred, collaborative, experiential, contextualised, place-based and kinaesthetic forms of learning, and can foster a sense of ownership of their learning in primary-aged children, increasing their motivation and engagement with activities as a corollary. Where a correlation between ‘malleable’ negative markers for engagement (Fredericks et al., 2004) and a particular MLA were uncovered, namely negative markers that could realistically be mitigated through the design of an activity, these informed a set of mobile learning design principles, which are detailed in sub-section 8.4.2.

8.2 Learner Engagement

Addressing the primary research question, sub-sections 8.2.1 to 8.2.4 summarise findings that emerged during the analysis of data collected during the DBR cycles, with a particular focus on the three elements of learner engagement, namely emotional, behavioural and cognitive engagement, and the emergence of flow (Csikszentmihalyi, 1997). Instances of positive and negative markers for engagement were coded in *ATLAS.ti* within a grounded theory process (see sub-section 4.3.1), using constant comparison to refine categories and codes until saturation was reached (Glaser & Strauss, 1967). Data were subsequently interrogated using analysis tools provided within *ATLAS.ti* to highlight relationships between codes and categories (see sub-section 4.7.1), and a relative *Measure of Engagement* derived for each element, thereby responding to the secondary research question: *"How might engagement of primary school children be assessed in outdoor settings?"*

With reference to the summative analysis, it should be noted that:

(i) Data relating to the Y5 QR-code Museum Trails were not included due to the indoor setting of those activities;

(ii) Codes for negative and positive markers were intended to balance each other, i.e. a positive marker had its equivalent negative marker;

(iii) Correlations between codes were assessed using the *ATLAS.ti* 'Query Tool', applying expressions built using Boolean operators on operands (such as particular codes or code families), to determine the frequency of co-occurrences of particular codes and the nature of the relationship between them;

(iv) Given the 'messy' conditions for data collection across the MLAs, disparities between the activities did exist, such as their duration; where codings for activities were directly compared, any incommensurability was identified;

(v) Some codes were included as they were of interest to the study but were not used in any comparative analysis; these codes are marked with an asterisk to differentiate them (see Table 8.3);

(vi) The relative *Measure of Engagement* for each element was derived by dividing the sum of instances of positive markers for that element by the sum of instances of negative markers for that element, mapped to a particular MLA.

8.2.1 Emotional Engagement

Acknowledged by many as the most complex element of learner engagement to define (e.g. Fredericks et al., 2004; Appleton, Christenson & Furlong, 2008), emotional engagement (EE) interweaves internal cognitive processes with personality traits and mood, leading to particular difficulties around categorisation and measurement. This ambiguity is revealed in the literature, with definitions of EE ranging from the "*interest ...happiness ...anxiety ...and ange*r" (p.575) children feel when taking part in school activities (Skinner & Belmont, 1993), to "*the degree to which they* [the children] *care about their school*" (Sciarra & Seirup, 2008, p.218).

This study took the broader view and worked with teachers to define a set of markers which encompassed the range of emotions that might impact on the engagement of children with an MLA, including EE:*NotEnjoyingCompany* (which might impact on collaborative work), EE:*Bored/Apathetic* (which might arise from a lack of cognitive engagement), and more positive markers such as EE:*Enthusiastic* (incorporating excitement and eagerness), and EE:*Happy* (contrasted with its corresponding negative marker of EE:*Angry*).

Emotional Engagement (EE)	**2014** (Y5) Staged Activity	**2014** (Y5) iMovie Trailers	**2014** (Y2) Video Clips	**2015** (Y2) Video Clips	**2016** (Y2) eBooks	**2016** (Y3) eBooks	**2016** (Y2) QR-code Trail	**2016** (Y3) QR-code Trail
Duration (minutes/ no. of sessions)	*120(/2)*	*60*	*120(/2)*	*45*	*60 (/3)*	*90 (/2)*	*60 (/3)*	*90 (/2)*
+ Markers								
Enthusiastic	13	49	54	24	34	43	38	32
EnjoyingCompany	22	30	39	26	23	38	15	27
EnjoyingNature	10	15	37	19	18	22	20	23
Happy	25	34	45	15	16	31	13	18
- Markers								
Bored/Apathetic	3	0	3	4	0	2	0	2
NotEnjoyingCompany	2	1	8	4	4	2	4	4
NotEnjoyingNature	0	0	0	3	1	0	0	1
Angry	1	1	3	0	6	1	1	3
Rel. Measure of Engagement	**11.7**	**64.0**	**12.5**	**7.6**	**8.3**	**26.8**	**17.2**	**10.0**

Table 8.1: Instances of markers for Emotional Engagement mapped to MLA

EE*:Enthusiastic* was the most frequently-coded EE marker across activities (n=287), as illustrated in Table 8.1, particularly in the Y2 classes, where a strong correlation (see section 8.2) with instances of LT:*Learner-centred*, LT:*Exploratory* and LT:*Kinaesthetic* was noted. The Y5 iMovie Trailers activity scored highest in terms of its overall measure of engagement, with the vast majority of children noted as EE:*Happy*, EE:*Enthusiastic* and EE:*EnjoyingCompany* for the duration of the session. The less impressive overall score for the Y2 eBooks activity was due to children being coded as EE:*Angry* when they were unable to find or film a particular insect, or EE:*NotEnjoyingCompany* due to issues relating to group dynamics. Corroborated by their teachers as being typical for their age, Y2 (and some Y3) children were more likely to overtly display or give expression to negative emotions. The instances of negative EE noted in the Y3 QR-code Trail activity were primarily due to ongoing animosity between two members of one of the Y3 classes. Despite an increase in time available for observation, fewer instances of negative EE relating to group dynamics were coded in the Y5 activities, suggesting that children may become more adept at handling their emotions as they progress up the school, and require less emotional support from an adult as a corollary.

Of the few instances of EE*:Bored/Apathetic* that were noted during the study, these occurred in: (i) Y2 2014, where a correlation with code BE*:NotSharing* was found (see sub-section 6.2.6.1.3) or where a group was being strongly-led by an adult; (ii) Y2 2015, where a correlation with EE:*NotEnjoyingNature* may have been related to inclement weather (see sub-section 6.4.4.1); and (iii) Y5 2014, where correlations with BE*:Distracting* and BE*:OffTask* suggested that certain boys failed to cognitively engage with the staged activity (see sub-section 5.3.3).

Using the *ATLAS.ti* 'Query Tool' in conjunction with the 'time-stamp' property of video clip extracts defined during analysis, I noted that negative emotional markers in certain children often preceded negative behavioural markers during outdoor sessions, which appeared to impact on their engagement with an activity; for example, where a child appeared to be ill-disposed towards a particular class-mate early on in a session, this was often followed by BE:*Arguing* and/or BE:*OffTask*, and later correlations with instances of EE:*Bored/Apathetic* or BE:*NotCollaborating* (see sub-section 5.5.3.2). While some of these issues may have been alleviated by selecting alternative learner groups (Blatchford et al., 2003), this was also occasionally observed in groups made up of children whom teachers had indicated worked well together (e.g. sub-section 6.2.6.1.3). This suggests a need for more direct adult support with the younger year groups, to enable all learners to get the most out of the learning experience.

Acknowledging that children are more likely to respond positively to: (i) activities set in natural outdoor settings (Dillon et al., 2016); (ii) using devices they consider to be of high cultural value (Selwyn et al., 2010); and (iii) away from normal class routine (Law & So, 2010), positive markers for EE were found to have outweighed negative markers during these activities by a factor of 13.6. The children's positive EE when using mobile devices in the outdoor setting was further corroborated by teachers' comments, both while in the reserve and during follow-up interviews, as evidenced by Mr Andrews's comment on the QR-code MLA: *"Probably the most enthused I've seen them - they were excited about what they were doing"*, Miss Hope's on the Y3 MLA: *"They've thoroughly enjoyed it!"* and Mrs Carter's on insect documentary-making: "*We've been down that way* [the nature reserve] *for various things, and that's been the best session. They loved it …they were buzzing!*"

8.2.1.1 Summary of Key Findings for Emotional Engagement

For the majority of classes taking part in the MLAs, enthusiasm (EE:*Enthusiastic*) emerged as the primary positive marker for EE, while secondary or supporting markers included enjoying the company of friends (EE:*EnjoyingCompany*) and enjoying the natural environment (EE:*EnjoyingNature*).

Very few instances of negative markers for EE were observed during the study; however, where these were noted, a correlation with collaboration issues or a diminished sense of learner autonomy was identified. This highlights the importance of underpinning MLAs with tenets of child-centred learning, while also providing adequate adult support to mediate on collaboration issues for younger learners.

8.2.2 Behavioural Engagement

This study followed Fredricks et al.'s (2004) view of behavioural engagement (BE) as participation in school activities, and adopted Appleton et al.'s (2008) definition of it as: "*positive conduct, effort, participation*" (p.370). BE was the most straightforward element of learner engagement to categorise during analysis, with positive markers for BE:*OnTask* the most frequently-coded (342 instances), followed by BE:*Collaborating* (288 instances), as illustrated in Table 8.2.

Behavioural Engagement (BE)	**2014** (Y5) Staged Activity	**2014** (Y5) iMovie Trailers	**2014** (Y2) Video Clips	**2015** (Y2) Video Clips	**2016** (Y2) eBooks	**2016** (Y3) eBooks	**2016** (Y2) QR-code Trail	**2016** (Y3) QR-code Trail
Duration (minutes/ no. of sessions)	*120(/2)*	*60*	*120(/2)*	*45*	*60 (/3)*	*90 (/2)*	*60 (/3)*	*90 (/2)*
+ Markers								
Collaborating	33	47	41	27	29	34	31	46
Encouraging	3	2	4	2	1	1	5	2
EnergeticPos	10	21	28	17	11	24	16	18
LeadingWell	1	2	2	1	2	2	0	3
Negotiating	3	4	9	4	9	5	2	3
OnTask	45	47	46	30	42	51	34	47
Respectful	7	12	3	2	4	4	3	3
Sharing	10	12	13	9	4	15	7	6
- Markers								
NotCollaborating	15	2	3	3	2	2	0	1
Complaining	2	0	1	3	3	1	0	2
Distracting	3	0	2	3	1	0	0	0
Overbearing	0	2	3	1	4	1	1	2
Arguing	3	4	6	4	7	3	2	5
OffTask	10	2	4	3	0	0	1	1
Disrespectful	5	2	11	5	5	2	0	1
NotSharing	0	0	3	4	8	2	4	1
Rel. Measure of Engagement	**2.9**	**12.1**	**4.4**	**3.5**	**3.3**	**12.2**	**12.3**	**9.6**

Table 8.2: Instances of markers for Behavioural Engagement mapped to MLA

Across all activities, positive markers for BE outweighed negative markers by a factor of 5.6, with children observed as collaborating and being on-task for the majority of the time in each session, something noted as unusual during conversations held with three of the five participant teachers during the activities. Where groups were observed working well, this appeared to be related to their acceptance of the role they held within the group (for example, where a group had allocated one member to do the filming, as highlighted in sub-section 6.2.6.1.2), or where access to the mobile device was equitable.

In follow-up semi-structured interviews, four teachers echoed Gray et al. (2017) in suggesting that mobile devices had acted as a focal point for group collaboration, highlighting their capacity to: (i) guide group exploration, as with the QR-code trails; (ii) scaffold learning, as with the eBooks developed to support the Y5 '*Lifecycle of Plants'* topic and the *Bugs Count* app; and (iii) intrinsically support learning activities, as with the provision of the camera app and *Book Creator* app.

As mentioned in sub-section 8.2.1 above, negative *behavioural* markers were sometimes noted after (or alongside) negative *emotional* markers for certain children, with a correlation between instances of children being coded as BE:*OffTask* and instances of the PIE:*SupportLacking* code. This suggests an opportunity for greater adult involvement to provide arbitration or encouragement, where a child-led solution to an issue looked unlikely, and where disengagement of one or more children from the activity might ensue.

While BE:*EnergeticPos* was considered a positive marker for BE (i.e. where children were expending physical energy in a positive way), this was only coded when children were also BE:*OnTask*, for example running to find the next QR-code or insect. There were not as many instances coded of children BE:*NotSharing* the mobile devices as had been anticipated, given the relatively low ratio of mobile devices to children (generally 1:4); alongside the point made above regarding allocation of roles, this may also have been offset by a possible correlation found with social learning (LT:*Social*), where children appeared content to 'take a back seat' and learn from others (see sub-section 6.3.4.1.1), rather than compete for control of a device. This situation was identified by three teachers as less than ideal, as illustrated by Miss Hope's comment: "*Some don't get the chance to use ICT on their own, so that's a shame really, and obviously the dominant one, or the one with more ICT experience, they're in control."* This comment also highlights the possibility for conflict between the dominant personality and the child who knows how to use the device.

In his 2016 interview, Mr Andrews went on to comment that certain children in his class would "*squabble about anything"* and, echoing Blatchford et al. (2003), that it was how he grouped them that made the difference: *"It's just dynamics. I just try to group them sensibly - I could easily find the 'destructor' group where you wouldn't get your iPad back!"* These comments corroborated my observations that the majority of instances of negative markers noted for BE were related to group dynamics, especially with the younger age-groups.

Where instances of BE:*Disrespectful* or some other negative behaviour were displayed by one member of a group to another, these were generally short-lived. Analysis of 31 illustrative video extracts where this had occurred suggested the LT:*Contextualised* and LT:*Child-centred* nature of the activity, where activities were authentic and children had autonomy over their learning experience, coupled with sheer enthusiasm for using the mobile devices (as evidenced by the excitement in the children's voices and their requests or moves to take ownership of one) generally acted as a steer to re-focus energy in a more positive way.

8.2.2.1 Summary of Key Findings for Behavioural Engagement

As illustrated in Table 8.2, the primary positive markers for BE noted during the MLAs were of children collaborating well in groups (BE:*Collaborating*) and their being on-task (BE:*OnTask*), while secondary markers included sharing the device appropriately (BE:*Sharing*), or more active, task-focused behaviour (BE:*EnergeticPos*), such as running to find a QR-code.
On the occasions where children were noted as being off-task, there was a strong correlation with one or more of: (i) a perceived lack of autonomy over the learning experience; (ii) a lack of cognitive engagement with the task; (iii) collaborative issues such as sharing a mobile device; or (iv) simply enjoying the freedom of being outside. This again underlines the importance of fostering learner autonomy through the design of MLAs that are underpinned by age-appropriate exploratory and child-centred learning approaches, while also ensuring equitable access to mobile devices.

8.2.3 Cognitive Engagement

Taking Fredricks et al.'s (2004) definition of cognitive engagement as the element of engagement which "*incorporates thoughtfulness and willingness to exert the effort necessary to comprehend complex ideas and master difficult skills*" (p.60), positive markers for CE included markers for CE:*ShowingAutonomy*, CE*:AskingGoodQuestions*, CE*:UsingApp* (to support learning) or demonstrating a CE*:GrowingUnderstanding* of a topic, with equivalent negative markers such as CE:*LackingAutonomy*, CE:*LettingOthersDoThinking* or CE:*Misunderstanding*, where children displayed passivity or uncertainty over an aspect of the topic but did not seek clarification or support.

Cognitive Engagement (CE)	2014 (Y5) Staged Activity	2014 (Y5) iMovie Trailers	2014 (Y2) Video Clips	2015 (Y2) Video Clips	2016 (Y2) eBooks	2016 (Y3) eBooks	2016 (Y2) QR-code Trail	2016 (Y3) QR-code Trail
Duration (minutes/ no. of sessions)	*120(/2)*	*60*	*120(/2)*	*45*	*60 (/3)*	*90 (/2)*	*60 (/3)*	*90 (/2)*
+ Markers								
AskingGoodQuestions	2	1	3	1	2	2	4	3
FocusingIn	20	28	43	20	27	33	27	39
GrowingUnderstanding	5	13	16	11	9	13	13	7
ShowcasingGood	8	21	42	27	38	21	8	9
ShowingAutonomy	17	31	41	19	28	33	22	36
- Markers								
LettingOthersDoThinking	10	0	4	3	3	1	3	9
NotFocusingIn	16	5	3	3	1	2	2	3
Misunderstanding	2	4	8	4	7	9	1	15
ShowcasingSuperficial	3	9	3	1	1	4	1	3
LackingAutonomy	1	0	5	4	1	0	1	1
Rel. Measure of Engagement	**1.6**	**5.2**	**6.3**	**5.2**	**8.0**	**6.4**	**9.3**	**3.1**
*UsingApp**	n/a	n/a	15	13	3	n/a	n/a	n/a
*UsingMap**	n/a	n/a	n/a	n/a	n/a	n/a	15	10
*Wonder**	*2*	*0*	*12*	*4*	*14*	*5*	*9*	*7*

Table 8.3: Instances of markers for Cognitive Engagement mapped to MLA

** These markers were not used in any comparative analysis. Activities that did not use the* Bugs Count *app or the map are marked as 'n/a'.*

Instances of positive markers for CE outweighed instances of negative by a factor of 4.8, with CE:*FocusingIn* (n=237) and CE:*ShowingAutonomy* (n=227) the most frequently coded (see Table 8.3). As also highlighted in sub-section 8.2.2, there was a greater proportion of children willing to let others take control than I had anticipated, and this often coincided with instances of negative CE, particularly CE:*LackingAutonomy* and CE:*LettingOthersDoThinking*. While this 'free-riding' behaviour is not unusual in collaborative learning activities (cf. Slavin, Hurley & Chamberlain, 2003; Baines, Rubie-Davies & Blatchford, 2009), one stated aim of these MLAs had been to engage group members equally, suggesting a need for future work focusing on how this might be achieved using shared mobile devices.

Instances of positive CE in the Y5 Staged '*Lifecycle of Plants*' sessions were offset by negative instances, primarily due to incidences of CE:*LettingOthersDoThinking* and CE:*NotFocusingIn* amongst two groups of boys participating in the activity, matched by related negative BE markers, namely BE:*OffTask* and BE:*Distracting*. While the majority of the children appeared behaviourally-engaged, only two instances of *Wonder* were noted, and analysis indicated that most instances of CE:*FocusingIn* were related to taking photographs and measurements rather than any correlations with CE:*GrowingUnderstanding*, EE*:Enthusiasm* or EE*:EnjoyingNature*. This suggests the design of the activity, while aiming to foster child-centred learning, may have been overly-prescriptive; as mentioned in sub-section 5.3.6, teachers also did not make use of the blog intended to act as a focal point for the activity, which may have compounded a feeling of task inauthenticity for the children, and a subsequent lack of focus on outcomes.

This was in direct contrast to the Y5 iMovie Trailers summative activity for this topic, where children had been given sole responsibility for creating storyboards and movie trailers to summarise and showcase their understanding. This session resulted in a high number of instances of CE*:ShowingAutonomy* (31) and CE:*FocusingIn* (28)*,* matched by positive markers for EE and BE, but did not score as highly in CE:*ShowcasingGood* or CE*:GrowingUnderstanding,* with some 9 instances of CE:*ShowcasingSuperficial* and 4 of CE*:Misunderstanding* being coded. Following up on this in interview, Miss Hope commented that she felt some children had focused overmuch on the ‘showy’ aspects of their trailers when in the reserve rather than on conveying the science facts: “*They did have the science knowledge, they were more than capable of applying that, because it was in their storyboard, but they got a bit excited about being on film.*”

My own analysis of the video-recorded observations and the learner-generated movies for these activities highlighted that the children had been given a very broad remit to demonstrate their learning, including the creation of an imaginary flower. Several bizarre interpretations of this remit emerged (see sub-section 6.3.1), and it is possible that the unusual nature of these, while demonstrating understanding of the seed dispersal and germination process, may have impacted on Miss Hope’s appreciation of the work.

Despite similarly high levels of positive EE and BE noted in the Y3 2016 QR-code Trail (where children recorded video responses to questions posed by QR-codes), the child-centred, socio-constructivist learning approach underpinning these activities resulted in 15 instances of CE:*Misunderstanding* of scientific concepts being coded, and a high correlation with PIE*:ScaffoldingLacking*, indicating that these misconceptions were not corrected at the time. In keeping with the tenets of authentic (Kearney & Schuck, 2005) and contextualised learning (Rikala & Kankaanranta, 2012), the intention for this MLA had been for children to explore the natural setting themselves for evidence to help formulate their understanding and feed into their video responses; it is acknowledged, however, that there are inherent dangers in this form of unguided discovery, as highlighted by Brown (1992): *"Children 'discovering' in our biology classrooms are quite adept at inventing scientific misconceptions"* (p.169), who recognised that determining when to hold back and when to step in can be a difficult balancing act for educators. Dependent on the learning objectives set for a particular activity, this underlines a need for a suitable scaffolding strategy to be in place to head off key misconceptions as they arise, using adult helpers, digital apps or other supports as appropriate.

While scientific misconceptions were noted in some clips, there were also 10 instances of CE:*GrowingUnderstanding* observed, all with correlations to LT:*Kinaesthetic* and LT:*Contextualised,* for example where children were observed picking up natural objects or looking around their surroundings for inspiration to help them answer a question. Two children also highlighted an initial misconception in their clips (for example, stating that woodlice have no important part to play in decomposition), and then went on to correct their understanding while they were speaking (sub-section 5.5.3.2). This may support Vygotsky's (1987) and Bruner's (1961) views that children develop their understanding through language and the articulation of ideas, suggesting that the process of narrating a video response could, in itself, be a useful mechanism for supporting knowledge-building.

When Miss Hope used the *Prezi* with their embedded clips in a follow-up session to discuss these misconceptions (sub-section 5.5.4), she noted that some children *"did comment on how their answers did not reflect what they actually know".* This raises an issue of potential significance, which Miss Hope underlined following the later Y3 eBooks activity, where she suggested that children had evidenced scientific knowledge in video clips they had made as practice in school, but that they had appeared to forget this once they were in the nature reserve (sub-section 7.2.3.2).

This echoes Nouri et al.'s (2014) and Sharples and Pea's (2014) findings that the numerous inputs occurring in the messy conditions of an outdoor setting, coupled with inadequate scaffolding provision, may be unconducive to conceptual thinking in primary-aged children. In line with Nouri et al.'s (2014) recommendation that outdoor activities should be followed up with indoor sessions where teachers can scaffold their students' conceptual thought processes, the agreed design for all MLAs in this study had specified follow-up sessions to embed the outdoor learning.

Instances of CE:*ShowcasingGood* in the Y2 insect-documentary sessions were spread relatively evenly across all three iterations of the MLA, taking into account the discrepancies between the duration of the sessions. This contrasts with CE:*FocusingIn*, where some 43 instances were noted in the 2014 session, with the majority occurring in the class which was more loosely-controlled, compared to the 2015 and 2016 sessions, where 20 and 27 instances were coded respectively. As corroborated by comments made by adult helpers, teachers and the children themselves during the 2015 and 2016 sessions, this disparity may underline a need for adequate time to be allocated to outdoor sessions of this type, to enable children to fully immerse themselves and gain the benefits offered by contextualised and kinaesthetic learning approaches.

Instances of CE:*ShowcasingSuperficial* were far fewer with the Y2 age-group, with the majority appearing to take their role as authentic producers of knowledge seriously (for example, in Table 7.2, where one group member uses the film-making phrases "*Action*" and "*Cut*"). Five examples were noted of children accurately imitating the style and delivery of the BBC presenter they had watched as preparation for their outing (see sub-section 7.1.3.1), with CE:*ShowcasingGood* correlating highly with instances of CE*:FocusingIn,* EE:*Enthusiasm*, EE:*EnjoyingNature* and BE:*OnTask*. This signalled that using pre-selected video clips as inspiration prior to participation in an MLA of this type can be a successful strategy to engage children of this age, enabling them to employ social learning to give them a starting point from which to build their presentation skills, while familiarising them with scientific language set at an appropriate level.

8.2.3.1 Summary of Key Findings for Cognitive Engagement

The primary positive markers for CE noted during the MLAs were of children showing autonomy (CE:*ShowingAutonomy*) in the way they approached the task, and a ‘focusing in’ on the topic under investigation (CE:*FocusingIn*). Secondary markers included the effective use of technology to demonstrate understanding (CE:*ShowcasingGood*), and examples of children articulating their thinking and growing understanding (CE:*GrowingUnderstanding*). This suggests that MLAs underpinned by a child-centred, exploratory learning approach can effectively promote cognitive engagement in children working together on outdoor science topic work.

The primary negative marker for CE was a tendency for some children to create video clips that focused on superficial presentation rather than scientific depth, as evidenced in the Y3 (QR-code Trail) and Y5 (iMovie Trailers) activities. This issue may have been attributable to difficulties in articulating conceptual thinking in complex outdoor settings, and suggests a need for the provision of suitable scaffolding and follow-up activities to clear up misconceptions and embed learning (Nouri et al., 2014).

With particular reference to the *production-focused* activity stream, findings indicated that watching exemplar video excerpts prior to creating their own video clips inspired certain Y2 children, providing them both with the presentational skills and appropriate language to enable them to effectively showcase their learning (Kirkorian et al., 2008). Findings from the *discovery-based learning* activity stream suggested that harnessing the motivational ‘scavenger hunt’ aspects of an outdoor QR-code trail, in conjunction with the use of an annotated map, can be a powerful technique to cognitively engage young children with science topic work, while also building their map-reading skills.

8.2.4 Learner Engagement and Flow

Csikszentmihalyi's flow theory (1997) was described in sub-section 2.1.1 as the 'gold standard' for educational activities, where learners are deeply engaged and absorbed in a task that is "*intrinsically enjoyable*" (Shernoff et al., 2003, p.160). To experience flow, learners must exhibit *concentration*, *interest* and *enjoyment* contemporaneously when participating in an activity (Csikszentmihalyi, 1997), with both cognitive and sensory curiosity playing an important motivational role in promoting ongoing learner engagement.

The design of the MLAs in this study acknowledged Csikszentmihalyi's (1997) recommendation that to maintain flow, the aim should be to balance the difficulty of learning activities with the level of new skills required, corresponding to Vygotsky's notion of a ZPD (1980), to avoid learners either becoming anxious (when challenges set are too high) or complacent (when challenges set are too low). All MLAs consequently involved collaboration with teachers to: (i) develop suitable preparatory classroom sessions to familiarise learners with both the technology and the skills needed to successfully complete the activity; and (ii) design MLAs with an appropriate balance of challenge and skills.

8.2.4.1 The Use of Flow in this Study

It is acknowledged that certain elements of flow may seem incompatible with the stated aims of this study; in particular, three of Csikszentmihalyi's nine indicators for flow suggest a reliance on learners entering a state where time becomes distorted, where distractions are excluded and where activity becomes autotelic (1997). This may at first appear difficult to reconcile with: (i) activities which involve children working in groups on time-limited, teacher-initiated topic work; and (ii) the recommendation that outdoor learning should be punctuated with opportunities for discussion and reflection (Sharples & Pea, 2014; Nouri et al., 2014).

There were, however, several examples noted of individual children appearing to experience flow during the study (e.g. sub-sections 3.2.3 and 6.2.6.1.1), suggesting that young children may more easily be able to enter a state of deep absorption, as propounded by Montessori (1959). In addition, further examples of children appearing to undergo a state of 'group flow' were noted, where they were so deeply immersed in the group creation of a video, for example, that they were wholly focused on what they were doing, losing both track of time and awareness of external distractions as if in their own ‘bubble’ (e.g. sub-sections 6.2.6.3.2 and 6.2.6.3.3).

Following collaboration with Csikszentmihalyi, who had previously referred to the concept of group flow in his work (e.g. 1990, 2014), Sawyer expanded the term to develop a model when studying jazz ensembles, where he described group flow as “*a collective state that occurs when a group is performing at the peak of its abilities*” (Sawyer, 2003, p. 167). While Sawyer’s particular focus was on the cognitive processes that occur in jazz improvisations, the concept has since been adapted both by business and, more pertinently, in classrooms. Armstrong (2008), for example, used Sawyer’s model to investigate children learning mathematics in groups, concluding that group flow was fragile and highly-dependent on the personalities of individual group members.

The underlying aim for the activities associated with this study, however, was to engage learners in enjoyable and meaningful experiential learning activities, where they collaborated together to create digital artefacts that could be shared as part of class-based follow-up sessions. The use of the term ‘flow’ in this investigation can therefore be taken to indicate a state of deep engagement and absorption in the activities.

8.2.4.2 Identification of Flow

During analysis, the contemporaneous co-occurrence of three specific EE, BE and CE markers was determined as signalling flow, namely EE:*Enthusiastic*, BE:*OnTask* and CE:*FocusingIn* (which incorporated both concentration and interest). This cluster was sometimes extended by secondary or supporting markers, which included EE:*EnjoyingNature*, EE:*EnjoyingCompany*, BE:*EnergeticPos*, CE:*GrowingUnderstanding,* CE*:ShowingAutonomy,* CE*:ShowcasingGood* and CE:*Wonder*, as illustrated in Figure 8.1.

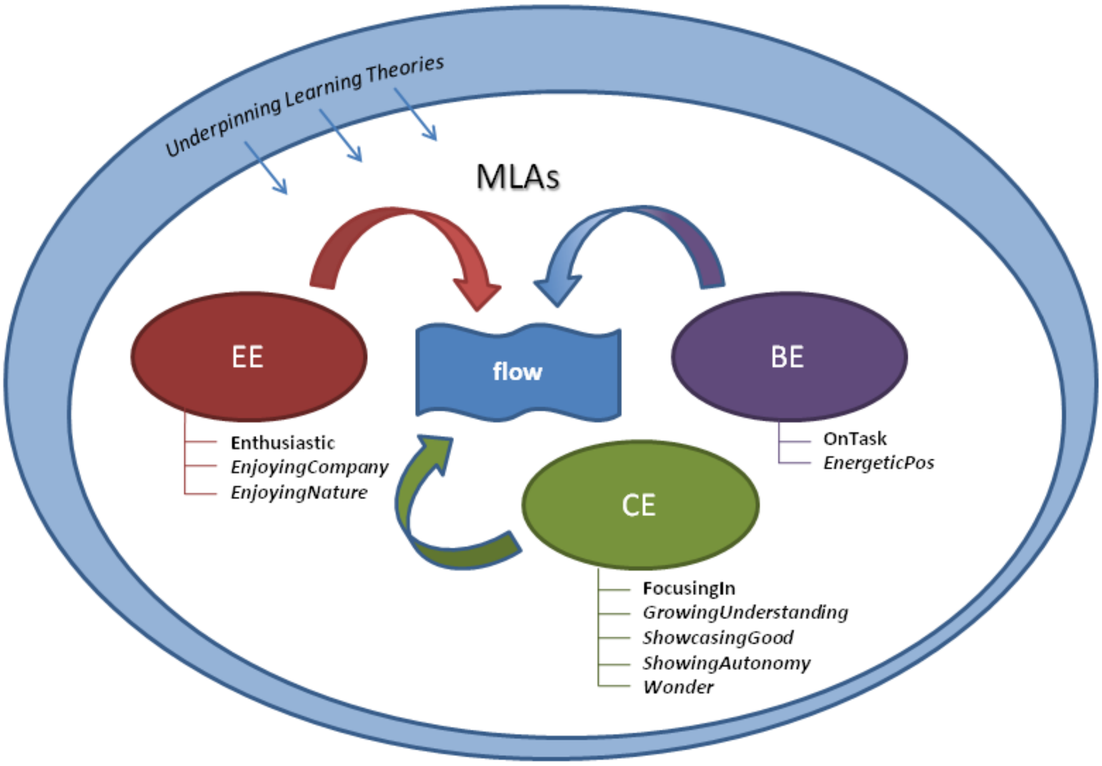


Figure 8.1: Relationship between Emotional, Behavioural and Cognitive Engagement, and Flow

In all, 159 instances of flow were identified during the study (see Table 8.4), with the majority noted where children had time to immerse themselves in the activity, and where child-centred learning underpinned the activity.

Flow	**2014** (Y5)	**2014** (Y5)	**2014** (Y2)	**2015** (Y2)	**2016** (Y2)	**2016** (Y3)	**2016** (Y2)	**2016** (Y3)
	Staged Activity	iMovie Trailers	Video Clips	Video Clips	eBooks	eBooks	QR-code Trail	QR-code Trail
Duration (minutes/ no. of sessions)	*120 (/2)*	*60*	*120 (/2)*	*45*	*60 (/3)*	*90 (/2)*	*60 (/3)*	*90 (/2)*
Flow Cluster	***4***	***22***	***35***	***18***	***25***	***21***	***19***	***15***
EE:EnjoyingCompany	*3*	*19*	*14*	*9*	*14*	*16*	*11*	*9*
EE:EnjoyingNature	*1*	*0*	*19*	*15*	*10*	*18*	*15*	*12*
BE:EnergeticPos	*0*	*15*	*20*	*9*	*7*	*15*	*14*	*11*
CE:GrowingUnderstanding	*0*	*1*	*9*	*8*	*6*	*10*	*12*	*5*
CE:ShowingAutonomy	*2*	*22*	*30*	*13*	*21*	*19*	*18*	*12*
CE:ShowcasingGood	*1*	*16*	*20*	*14*	*22*	*18*	*5*	*6*
CE:Wonder	*1*	*0*	*6*	*2*	*5*	*2*	*7*	*3*

Table 8.4: Instances of markers for Flow and related codes mapped to MLA

The Y5 iMovie Trailers session, in particular, was notable for the lack of adult input sought by the children, with all appearing highly-engaged and motivated in creating their trailers for the entirety of the session. Three groups in the second Y2 2014 session, all made up of boys, displayed the same high levels of motivation and engagement as seen in the iMovie Trailers session, demonstrating deep immersion in the activity, with the markers for flow noted alongside EE:*EnjoyingNature* and CE:*Wonder*. A high correlation between learners exhibiting flow and CE:*ShowingAutonomy* was also noted across all activities, suggesting that an emphasis on child-centred learning is key in fostering motivation and engagement (Wang & Eccles, 2013).

Correlations between flow and CE:*GrowingUnderstanding* were most often noted in the Y2 and Y3 QR-Code Trails, where the motivational aspects of a scavenger hunt (Wyeth et al., 2008), used alongside the contextualised placement of questions posed by the QR-codes, appeared to support learners' map-reading skills and scientific conceptualisations, as exemplified in this comment from a Y3 participant: *"They are QR-codes, which are where we get our ideas from*" (see Table.5.7). This suggests that contextualised QR-code trails of this nature can be useful both in engendering flow, and also in supporting conceptualisation and theory-building in primary-aged children aged 6-8 years.

It is acknowledged that while children may experience flow, this in itself does not necessarily equate to an increase in understanding, as evidenced by some correlation with CE:*Misunderstanding* noted across all MLAs. This again underlines the need for a balance between designing activities that foster learner autonomy, while also providing suitable scaffolds to enable children to progress their understanding, as discussed in sub-section 8.2.3. This aligns with Csikszentmihalyi's (2014) view that experiencing flow naturally encourages further exploration, leading to a *symbiotic relationship* between looking for further challenge and building up skills in the process.

8.2.5 Learner Engagement and Engaged Learning

While the overarching research question guiding this study related to the influence of the use of mobile devices on *learner engagement*, subsidiary cycle-specific research questions also led to the collection of data relating to *engaged learning*, namely, evidence of learning (or lack of learning) uncovered during the analysis of the mobile learning activities themselves. Here, the term 'engaged learning' draws on Jones et al.'s (1994) discussion of learner engagement, where the aim of activities should be to fire learners' enthusiasm and inspire them to take '*the next step in their thinking, research, or creative production*" (p.13).

Sub-sections 8.2.1.1 to 8.2.1.3 summarise evidence of engaged learning uncovered within the cycles, aspects of which were also drawn on in sub-sections 8.2.2, 8.2.3, 8.2.4 and 8.2.5, where the discussion was focused on the three key elements of learner engagement and flow.

8.2.5.1 Evidence of Scientific Language and Concepts

Ample evidence of children demonstrating newly-acquired scientific terminology was collected during the study, for example:

(i) Y3 children using words such as "*habitat*" (e.g Table 5.4), "*decaying*" (e.g. Table 5.6) and "*decompose*" (e.g. Table 5.5) within their video responses on the QR-code trail;

(ii) Y2 children referring to "*pincers*" and "*body segments"* to describe insects in their collecting jars (e.g. sub-section 6.4.4.1), or the use of "*species*", "*larva*" and other insect-specific vocabulary gleaned from external sources such as the *Bugs Count* app (e.g. sub-sections 6.2.6.1.1, 6.2.6.3.2, 7.1.3.2 and 7.1.4.3), teachers and other adults (e.g. sub-sections 6.4.4.1.1, 7.1.2 and Table 7.4), their classmates (e.g. sub-section 6.4.4.1.1 and Table 6.4) or websites (e.g. Table 7.3, Figure 7.4 and Table 7.6);

(iii) Y5 children, using terminology such as "*buds*", "*root systems*", *seed dispersal*" and "*germination*" in their lifecycle of plants topic (e.g. sub-sections 5.3.3 and 6.3.1).

As well as providing a useful means of demonstrating their scientific vocabulary, learner-generated video clips and eBooks were also considered a valuable resource by teachers for assessing their class's understanding of scientific concepts relating to that vocabulary. In addition to the formal evaluation of the interventions with teachers, plentiful evidence of this was collected from both observational and learner-generated video clips, for example, where learners are describing the life-cycle of an apple tree (e.g. Table 7.8), the damage insects can do to plant structures (e.g. Table 5.8), the dispersal of pollen and the pollination process (e.g. Table 7.8), the function of seed pods (Table 5.9), the notion of dormancy (e.g. Table 5.6), the role of decomposition (e.g. Tables 5.4 and 5.5), the characteristics of particular insects and plants (e.g. sub-sections 5.4.3.2 and 6.2.6.3.3), the role of antennae (sub-section 6.4.4.1.1) and the conditions required for plant growth (Table 5.7).

8.2.5.2 Evidence of Conceptual Change and Learning Breakthroughs

It is acknowledged that any claims of enduring conceptual change in the children's understanding of topic-work during these mobile interventions can only be made on a tentative basis without recourse to a further longitudinal study with those children. A number of learning 'breakthroughs' (Sharples, 2009), however, were observed, both in the field and within learners' video clips, which were subsequently corroborated by teachers as evidence of new learning having been initiated. Examples included: Y2 learners' observable excitement at overcoming thresholds relating to understanding of map-reading, perspective, decomposition and dormancy during their seasonally-focused QR-code trail (sub-section 5.4.3.2); Y2 groups learning that insects can be "*vegetarian*" or "*meat-eaters"* (sub-section 6.2.6.1.1), that beetles can have wings (sub-section 6.4.4.1.1), that newts can be considered minibeasts, that some minibeasts eat each other (sub-section 7.1.2) and that snails have a 'face' (Table 7.2); Y3 groups recognising the ecological benefits of woodlice (Table 5.4), the role of decomposition (Table 5.5), that certain insects can be beneficial or harmful to plants (Tables 5.8 and 5.10) and that plant seeds get spread by sticking to animals (sub-section 7.2.2.1).

8.2.5.3 Evidence of Misconceptions

Alongside examples of learning breakthroughs as noted above, the children also revealed evidence of science misconceptions, where, in the absence of scaffolding, they were 'inventing' rationales for what they were seeing (Brown, 1992). These ranged from children claiming that a butterfly with 2 wings is a moth (Table 6.4); that woodlice play no role in decomposition (5.5.3.2); that ladybirds bring no benefit to plants (Table 5.8); that plants are dead in spring through lack of water (Table 5.5) or because people have stepped on them

(Table 5.6) rather than through the natural process of decay; and that snails are slugs that live in a shell (Table 7.5).

8.2.6 Summary of Learner Engagement

This section addressed the primary research question relating to the influence of mobile learning on learner engagement of primary school children in outdoor settings, and also provided examples of *engaged learning* evidenced during the study.

Analysis of findings highlighted enthusiasm as the primary positive marker for emotional engagement across the MLAs, while secondary markers included enjoying the company of friends and/or nature. The primary positive markers for behavioural engagement were of children being on-task and collaborating well in groups, while secondary markers included active, task-focused behaviour. Children showing autonomy and 'focusing in' on the task were the primary markers for cognitive engagement, while secondary markers included effective use of technology to showcase their understanding. The co-occurrence of three specific markers were identified as signalling flow (Csikszentmihalyi, 1997), namely EE*:Enthusiastic*, being BE*:OnTask* and CE*:FocusingIn*, and that promoting flow involves the balancing of skills and challenge (Csikszentmihalyi, 2014).

Markers for negative engagement generally correlated to: (i) a perceived lack of autonomy; (ii) a perceived lack of cognitive engagement; or (iii) collaboration issues, and highlighted the importance of underpinning mobile learning activities with a child-centred approach alongside the provision of suitable scaffolding and follow-up activities (Nouri et al., 2014).

8.3 Implications for Theory

This section revisits the learning theories discussed in Chapter 2, contextualising the findings of the research against literature which informed the design of the mobile learning activities (MLAs), and explores the notion of a *digital disconnect* between teachers and technology, examining the relationship between teachers, children and technology through the lens of capital (Bourdieu, 1997; Park, 2017).

8.3.1 Implications for Learning Theory

This sub-section aims to address the secondary research question: *"How might the affordances of mobile technologies be leveraged to develop effective pedagogic interventions to engage primary-aged learners in outdoor settings?"*, by discussing the influence mobile technologies appear to have had on learner engagement with particular reference to the various learning approaches underpinning the design of the MLAs. Where implications for practice or policy were noted, these are covered in section 8.5 below.

8.3.1.1 On Contextualised, Place-based and Kinaesthetic Learning

In keeping with Zimmerman and Land's mobile learning guidelines for place-based learning, namely that the design of activities should aim to: *"facilitate participation in disciplinary conversations and practices within personally-relevant places* ...*through exploring new perspectives, representations, conversations, or knowledge artifacts"* (2014, p.77), many children evidenced experiential learning in disciplinary conversations held with their peers as part of creating their video clips, linking past experiences to current as they attempted to share their understanding of a particular scientific concept (e.g. sub-section 5.5.3.2). <u>This study therefore extends Zimmerman and Land's work on place-based learning by reporting findings on learner engagement with MLAs that incorporated learner-generated video created in personally-relevant outdoor settings.</u>

The contextualised nature of those MLAs that focused on the creation of video clips of insects or the natural environment, as well as providing a rich learning environment to explore the topic under investigation (Lai et al., 2007), also entailed a useful pause for reflection for some children (Sharples & Pea, 2014), where they appeared to articulate their growing understanding as part of formulating their response, i.e. 'thinking out loud' (e.g. sub-section 5.5.3.2). In the Y2 QR-code Trail, the requirement to scan QR-codes and take photographs as evidence appeared to fulfil the same function, resulting in high levels of CE, with more children coded as CE:*AskingGoodQuestions* than in other MLAs, and the highest relative *Measure of Engagement* for CE found across all activities (see Table 8.3).

This study therefore produced evidence to support Vygotsky (1987) and Bruner's (1961) theorisations on the importance of language in knowledge-building in children.

All video-related MLAs conducted with the Y2 and Y3 children provided plentiful evidence of children using sight and touch to support the points they were making in their video clips, for example bringing a buttercup to the camera for a close-up to highlight its pollen (sub-section 7.2.2.2), picking up insects or leaves (sub-section 6.2.6.3.3*)* or looking around for signs of things decaying to give themselves inspiration (sub-section 5.5.3.2), clearly demonstrating an affinity for contextualised kinaesthetic learning, with some 231 separately-coded instances reported in *ATLAS.ti*. While the lower levels of EE, BE and CE noted in some children in the Y5 Staged Activity may suggest that older children are less motivated by contextualised kinaesthetic learning, echoing findings from Lai et al.'s (2007) study, the lack of use of the blog by the Y5 teachers as a focal point for this MLA is likely to have impacted on learner engagement with this activity.

This study therefore found that mobile learning activities in natural outdoor settings that are underpinned by contextualised (Rikala & Kankaanranta , 2014), place-based (Zimmerman & Land, 2014) and kinaesthetic learning (Pruet et al., 2016) approaches can foster high levels of emotional, behavioural and cognitive engagement in primary-aged children, particularly those aged 6-8 years, encouraging children to focus in on science topic work and promoting disciplinary conversations.

8.3.1.2 On Cross-contextual and Constructionist Learning

Agreeing with Vavoula et al. (2009) and Nouri et al. (2014) that learning supported by the use of mobile devices in outdoor settings can be deepened through follow-up classroom activities, the design of all MLAs in 2014 and 2015 included a follow-up class activity which was intended to incorporate digital artefacts created by learners out in the field to: (i) enhance the children's sense of ownership of the activity; (ii) heighten its perceived authenticity; and (iii) link the children's 'inside learning' with their 'outside learning' (van't Hooft, 2013), to embed understanding and clear up any misconceptions.

Feeding into cross-contextual learning, constructionist learning also underpinned the design of the MLAs, following Papert's (1980) and Zimmerman and Land's (2014) assertions that children can deepen understanding by creating their own digital artefacts. In addition to constructionism providing a focus for activities while in the outdoor setting, there were many examples of nature providing unforeseen and exciting exploratory learning opportunities for the children, such as discovering beetles can fly or finding their first newt (as evidenced by over 50 instances of CE:*Wonder* noted across the study), which they were able to capture digitally for sharing or incorporation in follow-up activities once back in class. This affordance of the mobile devices to both record and present what the children had discovered appeared to add an extra layer of motivation and enthusiasm to the outdoor sessions, encouraging them to focus in on what they were observing more than they might have otherwise (Rikala & Kankaanranta, 2012), as corroborated by the Y2 teachers (e.g. sub-section 7.1.4.2). Comments from three teachers during their interviews (one Y2, and two Y3) also echoed Kearney and Schuck's (2005) view that watching each other's video clips when back in class had motivated the children more than traditional methods, serving to promote cognitive engagement with the science topic, particularly where misconceptions were revealed in their own clips.

While teachers acknowledged the pedagogic benefit of running follow-up sessions, this was not always carried through in practice in the first round of DBR cycles. The use of learner-generated eBooks to showcase topic work in the final round of data collection was intended to put the locus of control back into the hands of learners, enabling them to incorporate and edit whatever topic-related textual content, photographs, audio or video clips they chose to include in their eBooks. The process of creating the eBooks took place over a number of weeks, with the intention that learners would have agreed on the type of photographs or video clips they wished to incorporate into their book before visiting the reserve, thereby alleviating issues relating to too many inputs (cf. Nouri et al., 2014).

In practice, while the sense of ownership of the eBooks in both Y2 and Y3 classes was highlighted as very strong by all four teachers taking part, one Y3 teacher corroborated Nouri et al.’s (2014) and Sharples and Pea’s (2014) concerns relating to issues with conceptual thinking in outdoor settings (see sub-section 7.2.3.2), citing the difference between the clips her class had created in school (where they demonstrated a higher level of scientific understanding) to those they created in the nature reserve. This discrepancy was not obvious in the eBooks created by the Y2 children, however, the majority of whom used scientific language and relayed key insect-related facts in their embedded video clips (see sub-section 7.1.3.2). Although this may have been related to their having watched episodes of the BBC ‘Jess’ character in class, which helped give them a style of delivery suitable for insect documentaries, one might also conjecture that talking about and filming insects that were obviously ‘alive’ may have engaged children more than plants, which may appear inert to younger children (Carey, 1985). This may have led to Piaget’s concept of ‘*play’* manifesting itself in some of the Y3 children, in that they had difficulty linking the scientific knowledge gained in the classroom with their experiences in the outdoor setting, resulting in an overload of assimilation processes (1952).

Against this background, <u>this study builds on Papert’s (1980) and Zimmerman and Land’s (2014) work on the value of constructionist learning in deepening children’s understanding, while also extending Nouri et al.’s (2014) and Sharples and Pea’s (2014) theorisations on issues relating to cross-contextual learning and conceptual thinking in complex outdoor settings.</u>

8.3.1.3 On Experiential, Child-centred and Exploratory Learning

As highlighted in sub-section 8.4.1, findings suggest that contextualised mobile learning fosters experiential learning in children, who instinctively strive to link current experiences to previous ones when building their understanding (Dewey, 1938; Kolb, 1984). Experiential learning was particularly evident in learner-generated clips where children were unsure of the answer to a question posed by a peer or a QR-code, for example, or when faced with the unexpected, such as an opportunity to compare and contrast live millipedes and centipedes. Such clips epitomised tenets of Kolb’s experiential learning theory: “*it is in this interplay between expectation and experience that learning occurs*” (1984, p.28), and it is acknowledged that the complex natural setting of the nature reserve afforded a rich and varied learning environment for supporting this form of learning, highlighting the importance of context in grounding experiences (Lai et al., 2007; Zimmerman & Land, 2014).

Analysis carried out within *ATLAS.ti* highlighted 58 separately-coded instances of children demonstrating experiential learning, with the majority occurring in activities where children were working together to create video responses. A few learners were observed sharing information across groups, particularly in the Y2 insect-focused activities, where three children demonstrated a greater depth of knowledge than their peers, and were observed as being eager to share it (evidenced by a co-occurrence of EE:*Enthusiastic*, EE:*EnjoyingNature*, BE:*Collaborating*, CE:*ShowcasingGood* and LT:*Socio-constructivist*).

Interrogating the data within *ATLAS.ti* to explore possible causal relationships between learner engagement and the pedagogical approaches underpinning the MLAs highlighted that instances of LT:*Child-centred*, in particular, most often correlated with positive EE. This was particularly evident in the Y5 iMovie Trailers activity, which also scored highly for BE, and suggests MLAs should aim to harness the motivational aspects of child-centred learning to promote positive EE and BE.

An LT:*Exploratory* learning approach, in conjunction with tenets of LT:*Contextualised,* LT:*Place-based* and LT:*Kinaesthetic* learning, appeared to encourage positive EE, BE and CE in children participating in the activities, with the surroundings of the nature reserve providing a setting that appeared to promote happiness (EE:*Happy*), enthusiasm and excitement (EE:*Enthusiastic*), high levels of BE:*OnTask* and many instances of CE:*FocusingIn* in Y2 and Y3 children. This was evidenced in sub-section 6.2.6.3.3, where B1_3_B2 created his own documentary about the reserve, and was also noted in observations and informal conversations with other children, where the wide-open spaces and natural features of the reserve appeared to encourage LT:*Exploratory* and LT:*Kinaesthetic* learning; for example, in sub-section 5.5.3.2, where H1_B1 was filmed by one of his group immersed in grabbing handfuls of fallen leaves, eventually exclaiming: "*Awesome leaves decaying!*" Giving the children autonomy over the content of their video clips, while also placing the mobile devices in their hands (rather than those of adult helpers), appeared to provide H1_B1 and B1_3_B2 (and others) the freedom to express themselves without inhibition, as was evidenced in the timbre of their voices, the style of their delivery and correlations found with flow (see sub-section 8.2.4).

All MLAs in the study had been designed to promote child-centred learning, with the allocation of a mobile device to each learner group combined with the open nature of the outdoor setting expected to provide the children with a high degree of autonomy over their learning. Despite prior agreement that adult helpers would be primed to this effect, there was great variation in the levels of adult input learner groups had throughout the life-cycle of this study, with some groups left free to explore and complete activities on their own for an entire session, and others being strongly-led from start to finish. This had implications for learner engagement, with those groups that were more strongly-led often exhibiting less enthusiasm for a task (evidenced by a direct correlation between EE:*Bored*, BE:*OffTask*, and an inverse correlation between these codes and LT:*Child-centred,* as illustrated in Table 6.2), and those with little or no supervision displaying and perpetuating science misconceptions in their video clips, either because no MKO was near, or because the adult helper held back (evidenced by a direct correlation between CE:*Misunderstanding* and PIEA:*ScaffoldingLacking*, as illustrated in Table 5.4).

<u>This study, while recognising the benefits of fostering experiential learning and learner autonomy within contextualised MLAs, also supports Nouri et al.'s (2014) and Zimmerman and Land's (2014) findings on the difficulties associated with balancing the positives of child-centred approaches in complex outdoor settings with the negative impact of inadequate scaffolding in MLAs.</u>

8.3.1.4 On the Place of 'Wonder' in Child Learning

A sense of wonder has long been recognised as a key element in engaging young learners with education (e.g. Wilson, 1993; L'Ecuyer, 2014), and with science education in particular, with authors suggesting that a sense of wonder naturally engenders curiosity to find out more (e.g. Goodwin, 2001; Ritz, 2007; Milne, 2010). In his study describing the challenges of teaching primary science in New Zealand, Milne (2010) highlights the importance of conducting exploratory learning activities that: "*with teacher direction and input, provide aesthetic experiences of natural phenomena that will promote a sense of wonder leading to a desire for understanding and explanation of the phenomena for the learners involved"* (p.104), referencing the work of Carson (1988), who suggests that children are born with an innate sense of wonder that should be nurtured rather than neglected.

During this study, many examples were observed of children expressing wonder in the Greendale reserve, and these instances were invariably followed up by a child either asking further questions about the subject of interest (e.g. sub-section 5.4.3.2), pointing the phenomenon out to class mates (e.g. sub-section 6.2.6.3.2) or a further focusing-in on it (e.g. sub-section 7.1.2).

<u>This supports Milne (2010) and McCrory's (2011) theories on primary science learning, that promoting a sense of wonder can be a valuable component in encouraging learner engagement, both with topic work and the natural world itself.</u>

8.3.2 Modelling the Digital Disconnect

Confirming the findings of Perry (2003), Harris et al. (2009) and Gray et al. (2017) outlined in section 2.5, this research has identified that a lack of skills and confidence can act as a barrier to teachers using digital tools to innovate in their professional practice, as illustrated by the account of the Y3 teacher in sub-section 5.5.4. Teachers have also suggested that the children in their classes are more adept at using digital technologies than they are, as illustrated by the account of the Y5 teacher in sub-section 8.4.1.2, highlighting a digital disconnect between teachers and technology (Johnson, 2009; Erstad & Sefton-Green, 2013).

Section 2.5 established a potential connection in the literature between the digital disconnect and digital capital, opening up consideration of a mobile form of capital. While this investigation focused on exploring the influence of mobile learning interventions on learner engagement, it is important to recognise that the concept of mobile capital emerged in the later stages of the study, and to acknowledge that the research was not originally designed to collect data specifically relating to notions of capital. Despite this, in seeking to address the issue of barriers and challenges to teachers' uptake of mobile technologies which arises through SRQ3, the study did collect data related to the digital disconnect, and it was through the analysis of this data that support for the notion of mobile capital began to emerge. To this end, while there are instances of empirical evidence from the study which might support the development of the notion of mobile capital, it should be noted that extrapolation from this data can only be undertaken on a theoretical basis without conducting further research aiming to address mobile capital directly.

In order to both address SRQ3 and respond to those gaps in the literature identified in section 2.5, this section goes on to explore the link to capital (Bourdieu, 1997; Park, 2017) by examining the relationship between the digital disconnect, teachers and children, and taking initial steps towards the development of a model of *Mobile Capital*.

8.3.2.1 Digital Capital and Mobile Capital

In exploring the potential link to capital, it is first proposed that a child's life can be broadly defined as taking place within three distinct, but inter-related and overlapping spheres of influence, specifically home, school and peer groups. Following Bourdieu's (1997) conceptualisations wherein economic, social and cultural capital are developed in adults, the child might be said to develop capital in each of the three domains which is subsequently carried through into their interactions within each of the others.

While Park (2017) puts a case for the concept of 'digital capital' in relation to the notion of digital engagement (Park, 2012), this study has focused on the influence of mobile learning activities on learner engagement in primary-aged children. Developing Park's model of digital capital to: (i) enable consideration of child actors engaged in the pre-economic activity of education; and (ii) acknowledge the technological backdrop against which those child actors are developing into economically-active adult actors, it is proposed that the Mobile Capital (M-Cap) seen at the centre of the model in Figure 8.2 emerges through the interplay of social, technological and educational capital for the participants of this study.

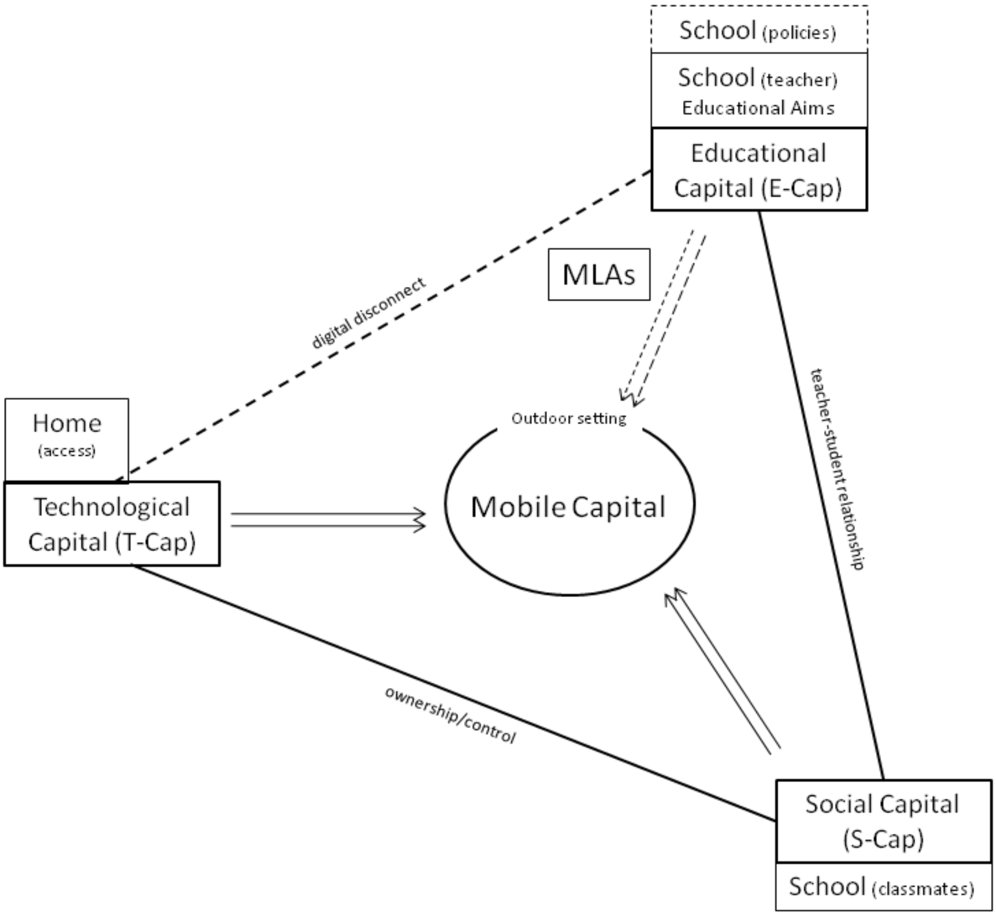


Figure 8.2: A model of Mobile Capital

8.3.2.2 Reconstructing Digital Capital for Non-adult Actors

As highlighted in section 2.5, Park's (2017) focus on economic capital renders her model of *digital capital* ineffective for exploring how mobile learning activities might influence the learning experience of primary-aged children, or impact upon the digital disconnect. Despite this, Park's (2017) conceptualisation of digital capital can be developed to provide a powerful lens through which to encapsulate the three domains of influence in a primary-aged child's life outlined above, wherein social capital is derived through a child's interactions within their peer group, and economic and cultural capital are replaced by educational and technological capital respectively.

In support of the first substitution, while the primary-aged child cannot be said to be actively developing economic capital during their time at school, it is evident from much of the rhetoric surrounding the recent switch in focus from ICT to computer science in schools that changes to the National Curriculum are, in part, driven by an expectation that schools should play a role not only in educating children, but also in preparing them to become economically active actors within the workplace later in their lives (e.g. Quinlan, 2015; Sefton-Green et al., 2016).

In relation to the second substitution, while the notion of cultural capital has previously been identified with the knowledge and abilities inherited through exposure to cultural values inculcated within an individual's family or home life (cf. Bourdieu, 1997), there is evidence both: (i) that children gain experience in the use of a variety of technologies at home (including through the extended network of family and friends), highlighted by the number of children who already had experience of using touchscreen devices (see sections 5.2, 6.2 and 6.4)**;** and (ii) that the mobile telephones of parents and carers are recognised by children as devices imbued with high cultural value (e.g. Selwyn et al., 2010).

8.3.2.2.1 Social Capital

While the foundations on which the development of M-Cap is based form a relationship consisting of Social Capital (S-Cap), Technological Capital (T-Cap) and Educational Capital (E-Cap), in the context of this study each of these is associated with an investigation-specific domain, namely *Classmates*, *Home* and *School* respectively. Since first mentioned by Bourdieu in connection with the development of cultural capital (1997), the notion of S-Cap has appeared in numerous scholarly works (e.g. Coleman, 2000; Lin, 2017). While various definitions can be found in the literature, S-Cap as it is used here remains closely aligned to the conceptualisation outlined by Park (2017), where she refers to the "*resources taken from relationships, networks and social support*" (p.69). For the primary-aged participants in this study, S-Cap might be said to emerge through social interaction within the domain of *Classmates*, that is, other child participants in the study, as illustrated by children sharing their technological expertise (for example, when a member of one Y2 group showed another how to use the *Bugs Count* app in sub-section 6.2.6.1.1) and their knowledge of the topic under investigation (for example, when a child shared knowledge about lily beetles in sub-section 6.4.4.1.1).

Despite this focus on the immediate peer group, it is acknowledged that children also participate in interactions with their class teacher through the teacher-student relationship, forming a link with E-Cap and the domain of *School*, and with the extended network of family and friends within the domain of *Home*, establishing a link to T-Cap.

8.3.2.2.2 Technological Capital

As mentioned above, for Bourdieu, cultural capital represented the knowledge, skills and values associated with the transmission of cultural values through the family (1997), while in this case T-Cap relates to the knowledge, skills and abilities associated with the successful manipulation of mobile technologies to achieve desired outcomes.

In the UK, a proliferation of internet-connected devices over the last decade is seeing the smartphone become ubiquitous, with some 76% of adults said to be owning one in 2017 (Ofcom, 2017), while larger tablet devices have gained significantly in popularity, with 58% of UK homes reported as owning a tablet device in August 2017 (Ofcom, 2017). Concurrently, the financial crisis which hit national economies across the world in 2008 has been followed by an age of austerity (Traxler, 2016), and the well-documented pattern of spending cuts which has taken place across the UK public services sector has impacted on schools' ability to sustain investment in technologies and hardware (BESA, 2015).

As highlighted in sub-sections 5.2.2.1 and 6.2.5.1, the majority of child-participants in this study gained their initial access to mobile devices not within the educational context of the domain of *School*, but within the more entertainment-focused domain of *Home*, and anecdotal evidence suggests that with parents, older siblings and extended family frequently taking up opportunities to upgrade their telephony services, ownership of older devices has naturally cascaded down to the younger actors within this domain. To this end, while this study confirmed that the vast majority of child-participants had developed some experience in operating mobile devices prior to the introduction of the MLAs in the nature reserve, anecdotal evidence suggested that the patterns of prior usage could be characterised as child-centred, self-directed and personalised (cf. Flewitt et al., 2015).

From a theoretical perspective, inevitable overlaps between the domains of *Home* and *Classmates* outside school hours are likely to have facilitated the emergence of a relationship between T-Cap and S-Cap, wherein the skills, knowledge and expertise gained in one household has been transferred through interactions within peer groups. In practice, with the growth of this relationship unhindered by the rules and regulations embodied within school policies, and despite numerous safeguarding initiatives aimed at parents, anecdotal evidence suggests children have experienced substantial freedom in how these devices have been used outside of the domain of *School* (Selwyn, Potter & Cranmer, 2008; Burnett, 2016).

8.3.2.2.3 Educational Capital

Emerging against the backdrop which begins with the teacher-student relationship, E-Cap extends through to governmental educational policy and the educational aims of the National Curriculum, while encompassing policies and practices determined by both the Local Authority and by the school itself. E-Cap can be said to embody the realisation of the educational aims associated with the National Curriculum through the delivery of a combination of scaffolding, embedding and reinforcing children's learning in the unique circumstances of teacher-led groups in a ratio of around 1:30.

As such, it is through the interactions between the individual class teacher and each of those children comprising the group of classmates that the teacher-student relationship which forms the connection between E-Cap and S-Cap emerges. While class-teachers provide the familiar face for much of a child's interactions which lead to their development of E-Cap within the domain of *School*, as highlighted in sub-section 8.3.2.2, there has been an increasing emphasis on schooling as preparation for children to become economically-active actors later in their lives (Department of Education, 2016).

Combined with both the pressures associated with the administrative burden of the role, and the financial cuts referred to in the discussion of T-Cap above, opportunities for teachers to explore novel and innovative uses of mobile technologies to enhance their delivery of the curriculum have been limited, and market penetration of mobile devices within the domain of *School* has lagged behind that seen in the domain of *Home* (cf. Selwyn, 2012; Burnett, 2016). Consequently, patterns of device usage in schools have been shaped by the development of national, regional and institutional policies and practices, and, in contrast to children's experience outside *School*, have become characterised as time-restricted, offering only limited access, often for "drill and practice" activities or in a reward-based context (cf. Gray et al., 2017).

Against this background, the relationship between T-Cap and E-Cap is weakened by perceived and actual conflicts around the aims and objectives associated with the use of mobile devices, and can be characterised as exemplifying the digital disconnect (Johnson, 2009; Erstad & Sefton-Green, 2013).

8.3.2.3 MLAs and Mobile Capital

To this end, the introduction of the MLAs developed in collaboration with teachers as part of this study served to strengthen the E-Cap within the domain of *School*, while assisting in the delivery of the National Curriculum and enhancing the school's reputation through the recognition gained on receiving a national award. Addressing the digital disconnect strengthened the relationship between E-Cap and T-Cap, while the teacher's engagement in the process of designing, implementing and evaluating the MLAs in turn served to engender stronger T-Cap in those teachers, for example, where the Y3 teacher with little ICT confidence came up with her own ideas for using QR-code trails: "*It's just not knowing about them. I didn't know anything - to me it's like, how has she done all this? It's really very simple, well there you go!"* This added a new dimension to the teacher-student relationship which strengthened their S-Cap, with the emergence of M-Cap for the children (and their teachers), and for the school at an organisational level.

8.3.2.4 The Relationship between Flow and Mobile Capital

Having found that: (i) flow can be experienced where a convergence of EE, BE and CE is realised; (ii) M-Cap can emerge through interactions which take place between the domains of *Home*, *School* and *Classmates*; and acknowledging that: (iii) flow "*is based on*" a symbiotic relationship between challenges and skills (Csikszentmihalyi , 2014, p.477), this study posits that, providing the educational challenges set are appropriate, increasing children's mobile capital (which includes their technological skills) feeds into this symbiotic process, thereby heightening opportunities for flow, and increasing their motivation and engagement with an activity as a corollary. This relationship is illustrated in Figure 8.3 below.

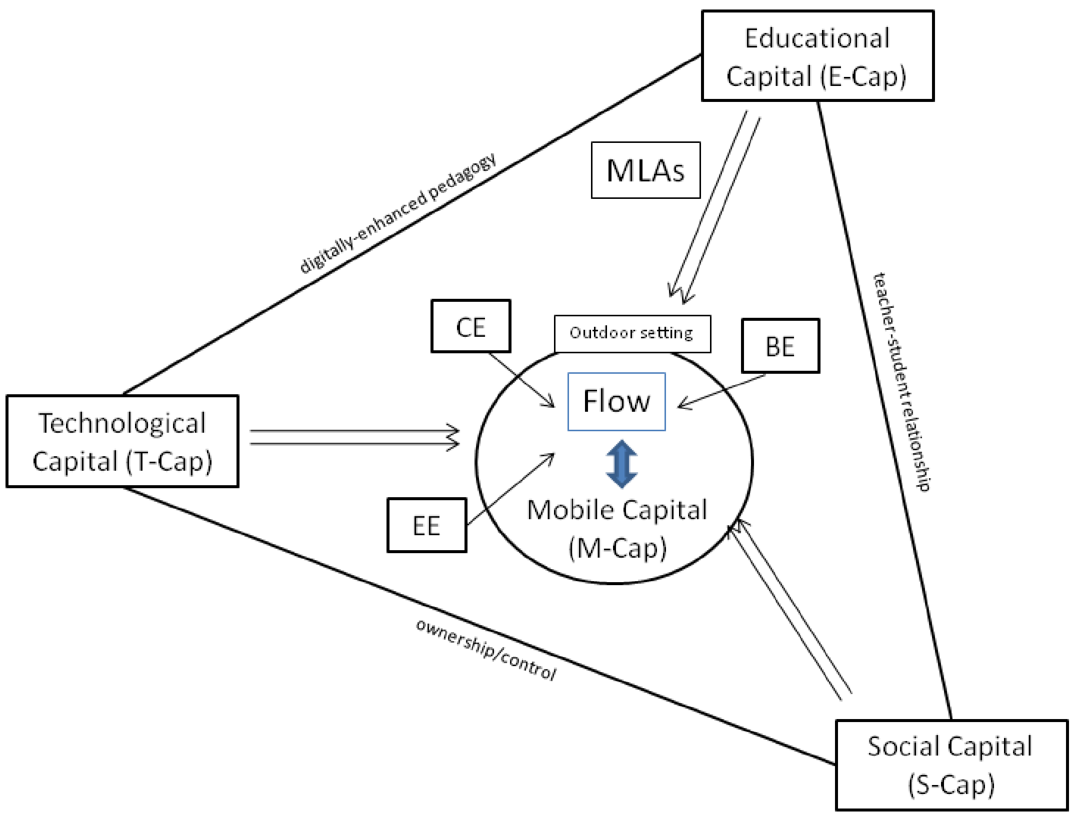


Figure 8.3: The Relationship between Mobile Capital and Flow

8.3.3 Summary of Implications for Theory

This section began by addressing the secondary research question: *How might the affordances of mobile technologies be leveraged to develop effective pedagogic interventions to engage primary-aged learners in outdoor settings?"* Findings extended Rikala and Kankaanranta's (2014) and Zimmerman and Land's (2014) theorisations on the effectiveness of underpinning exploratory mobile learning activities in outdoor settings with contextualised and “place-based” forms of learning, while also building on Papert’s (1980) and Zimmerman and Land’s (2014) work on the value of constructionist learning in deepening children’s understanding. Highlighting the benefits of child-centred approaches for fostering learner autonomy and experiential learning, findings also support Nouri et al.’s (2014) and Sharples and Pea’s (2014) theorisations on issues relating to cross-contextual learning and conceptual learning in complex outdoor settings.

Exploring the notion of a digital disconnect between teachers and technology (cf. Johnson, 2009; Erstad & Sefton-Green, 2013), this section went on to discuss the relationship between teachers, children and technology through the lens of capital (Bourdieu, 1997) and, building on Park’s theorisations around Digital Capital (2017), to model an emerging concept of *Mobile Capital*.

8.4 Implications for Practice

This section addresses the secondary research question relating to the barriers and challenges that are associated with the integration of mobile learning within teachers’ professional practice.

A key motive for selecting design-based research as the underlying methodological approach to guide this study was its emphasis on: (i) working with practitioners; and (ii) the generation of theory and design principles that are “*derived empirically and richly described*” (Amiel & Reeves, 2008, p.35) in order to be “*of use*” to practitioners (Barab & Squire, 2004, p.8). As such, collaborating closely with teachers on the design, implementation and evaluation of the various MLAs not only gave teachers a sense of ownership over the activities that were developed, but also provided valuable insights into their day-to-day working practices and concomitant pressures, and how these might be impacting on the MLAs themselves (Brown, 1992).

8.4.1 Exploring the Digital Disconnect within Teachers' Practice

Analysis of data collected throughout the study highlighted high levels of enthusiasm and excitement whenever children used mobile devices for learning, both in school and in outdoor settings. As noted by Selwyn as far back as 2002, however, there is a continuing disparity between the frequency of access and how mobile devices are used by UK children in what this study has identified as the domain of *Home* (see sub-section 8.3.2.2), and how they are used in the majority of primary schools in the UK.

While UK schools' spending on ICT peaked immediately prior to the financial crisis in 2008, this pre-dated the growth in internet-connected mobile telephones following the unveiling of the first iPhone in 2007 (Macworld, 2007), and the period since the launch of the first iPad in 2010 (Apple, 2010) has been characterised by a pattern of cuts in public spending. The upshot is that the proliferation of mobile devices that has taken place in the last decade has taken place at a time when UK schools' investment in computing hardware has been declining in real terms, and although it is recognised that schools have begun to invest in tablet devices in recent years, by 2015 only 721,000 tablets were reportedly in use by the 8.4 million pupils attending UK schools. While the number of tablet devices in schools was expected to have risen to 846,000 by 2016 (BESA, 2015), year-on-year expansion of the school-age population by 110,000-120,000 pupils meant that the tablet-to-pupil ratio remained around 1:10 (as was reflected at the participant school); however, schools' investment in ICT has since fallen further (BESA, 2017), placing this 10% penetration of mobile devices in the UK's primary and secondary educational institutions in sharp contrast to the 90%+ saturation seen in UK homes (Ofcom, 2017).

Despite both this level of penetration in the domestic market and the (relatively modest) investment in mobile technologies by schools, many teachers still report being relatively inexperienced or under-confident in using tablets within their professional practice (Young, 2016), particularly in outdoor settings where concerns over breakages or ceding control deter many teachers from exploring the learning potential these devices offer. This has led to a situation where banks of tablets may be wheeled out to learners 'as a reward', used as an add-on to existing teaching without any significant consideration of the underlying pedagogy, or simply used as electronic dictionaries (Twining, 2016; Gray, 2017).

With growing concerns regarding a serious computer-skills shortfall in school-leavers, many questions exist regarding current educational policy in the UK, with a particular focus on schools' ICT strategies, and how mobile technologies are being used to support learning. Clusters of excellent practice in embedding the use of tablet devices within teaching do exist in the UK primary sector (e.g. Burden et al., 2012; Dredge, 2014; Gray et al., 2017); however, recent moves to prioritise literacy and numeracy at the expense of other areas of the curriculum, including computing, have compounded existing concerns of teachers in taking on new challenges. The upshot is that many teachers simply retreat to the status quo in their approach to teaching, and, as a consequence, both children and the teachers themselves risk missing out on opportunities for the deep learning opportunities afforded by these devices, as noted by Flewitt et al. (2015): *"if innovative uses of new technologies are absent from the classroom, then we risk failing to turn on a powerful switch that can light up this generation's learning*" (p.17).

8.4.1.1 Lack of Time

The pressure on primary teachers is well-reported in the UK press (e.g. BBC, 2014; BBC, 2016; BBC, 2017a; The Guardian, 2018; BBC, 2018), and has led to repeated calls from teachers' unions for a series of national strikes since the beginning of this study, primarily focused on pay and conditions. Teachers complain of too little time to deal with an ever-increasing administrative burden placed on them to meet the latest governmental initiatives and targets, and this view was corroborated by all participant-teachers in their interviews.

Highlighting a lack of 'time to explore' as the key barrier to using technology in her teaching (cf. Ertmer et al., 2014), one Y2 teacher commented: *"It's just being given the time to learn and finding a way that makes it useful*", with two others also citing the pressures of an overfull curriculum: "*Trying to fit everything in is really hard"* (Y2 Teacher) and *"the literacy and numeracy sort of takes over. The curriculum's squeezed, massively"* (Y3 Teacher).

Echoing Harris et al. (2009) and Burden et al. (2012), one Y5 teacher went on to comment that ICT was viewed as an "*add-on*" by teachers, that gets pushed to the bottom of a long list of things to get done, suggesting that this was partially due to digital assets not being considered as evidence by school inspectors: "*It shouldn't be* [an add-on]*, it should be integral, but the way we have to present all our information, data etc., it's unfortunate"* (Y5 Teacher).

These comments serve to illustrate how many of today's primary-aged children experience the learning landscape (Passey, 2013), where conflicting curriculum pressures, with an increasingly tight focus on attainment targets for literacy and numeracy, often result in teachers turning to tried and tested class-based methods to achieve their objectives (Young, 2016).

8.4.1.2 Technical and Access Issues

Technical issues were also brought up by several teachers as impacting on their uptake of technology*: "The technical side when it doesn't work ...to be honest, I end up thinking why have I bothered sorting out a lesson and doing it that way, when they probably would have been learning just as much doing it a different way?"* (Y5 Teacher), with another mentioning that iPads were not kept in a state ready for use: "*Every time we go to use the iPads, they're not charged.*" (Y2 Teacher)

Lack of access to the iPads was raised as an issue by one Y2 teacher: "*We've only got 6 for the whole of Key Stage 1 and Reception, so you have to book them out* [from other year groups]*, and it doesn't always work*" (Y2 Teacher), with the inconsistent configuration of iPads highlighted by a Y5 teacher as one of her reasons for preferring to use traditional methods: "*They didn't all have the app on, so we could have gone back to 'Old School' ...and put our writing into a nice home-made picture option. I wish I had just chosen that option."*

Some of these practical issues were dealt with during the course of this study, for example a charging trolley was purchased for the banks of iPads, and the number of iPads was increased to 6 per year group. The maintenance of iPads, however, consistently came up as an issue, with no one individual appearing to have overall responsibility for ensuring the devices had sufficient storage capacity or the apps required for a particular activity.

8.4.1.3 Confidence and Attitude

There was a marked disparity between participant-teachers in terms of their attitudes towards mobile devices, and ICT in general, that appeared unrelated to age (cf. Park, 2017). While the majority appeared open to the potentials of new technologies for teaching, one appeared to place the use of them in direct opposition to traditional teaching methods, querying whether money would be better spent on other things as: "*they* [the children] *already know how to use them better than us,*" focusing only on what she saw as negative attributes, such as the potential for disruption and a perceived lack of utility for learning. Other teachers initially lacked confidence, but towards the end of the study were increasingly offering their own ideas for MLAs, suggesting that their level of *Technological Pedagogical Content Knowledge* (Mishra & Koehler, 2006) had increased as a result of participating in the study.

It is notable that, in response to some follow-up activities not being run in the first round, edited learner video clips, print-outs of photographs and *Prezi* presentations with embedded learner video clips were provided to teachers in subsequent rounds, all of which were used in class activities. This suggests that lack of preparation time and/or ICT experience were barriers to the integration of these follow-up activities.

8.4.2 Design Principles for Mobile Learning Activities in Outdoor Settings

A set of theory- and practice-informed design principles emerged from the evaluation of nine mobile learning activities, eight of which were developed in collaboration with five primary school teachers, conducted with around 540 children aged 6-10 years over a period of three years. The principles are primarily intended to inform the design of mobile learning activities for primary-aged children, working in groups on science topic work in outdoor settings. They should, however, have applicability in other age ranges and curriculum areas.

8.4.2.1 General Principles

The following general principles were considered key to designing activities with a focus on motivating and engaging young learners using mobile devices for learning in natural outdoor settings. The principles were derived from evidence gathered during the eight design-based cycles described in chapters 5, 6 and 7, where analysis of data led to the identification of relationships between codes and categories (such as correlations between the use of child-centred learning and learner enthusiasm, for example). As described in section 4.3.1, any recurring patterns or themes that emerged during the analysis process that demonstrated a high degree of confidence between the theoretical claims made and the evidence collected were fed into the generation of the principles listed in Table 8.5 below.

Principle		**Location of Supporting Evidence**
1.	*Harness enthusiasm and foster learner autonomy by designing activities which are underpinned by a child-centred learning approach.*	Sub-sections 5.4.3, 5.5.5, 6.2.1.2, 6.3.2, 6.2.6.3, 7.1.3.1, 7.2.2.1
2.	*Provide adequate time and space for children to immerse themselves in the natural environment.*	Sub-sections 3.2.3, 5.3.5, 5.4.5, 6.2.6.4, 6.2.9, 6.4.4.2, 6.4.6.2, 7.2.3.2
3.	*Make the most of context by exploiting exploratory and kinaesthetic forms of learning.*	Sub-sections 5.5.1.1, 6.2.6.3.3, 6.4.4.1.1, 6.4.7, 7.1.2, Tables 5.4, 5.6
4.	*Design preparatory activities to ensure learners have the necessary skills to achieve their learning objectives.*	Sub-sections 5.2.3, 5.3.5, 5.4.3.2, 5.4.7, 5.5.3.1, 5.5.4, 6.2.5.1
5.	*Provide adequate, age-appropriate scaffolds, either adult or digital, to enable learners to progress their understanding.*	Sub-sections 5.3.5, 5.4.3.2, 5.5.3.2, 6.4.4.1.2, 7.1.2, Tables 5.4, 6.4, 6.5, 7.5, 7.6
6.	*Where adult helpers are used to support activities, clearly prime them on their role.*	Sub-sections 3.1.3, 3.2.3, 5.5.3.2, 6.2.6.1, 6.2.6.3.3, 6.4.7,Table 6.2
7.	*If mobile devices are shared, ensure measures are put in place to enable equality of access.*	Sub-sections 3.1.3, 5.5.3.2, 6.2.5, 6.2.6.1.3, 6.4.4.1.2, 7.1.3.1, 7.1.4.3, 7.1.4.2
8.	*Provide an easily-accessible repository to store learner digital artefacts, to support constructionist and cross-contextual forms of learning.*	Section 5.1, sub-sections 5.2.2, 5.3.7, 5.5.4, 6.3.2 , 6.4.5, 7.1.1, 7.1.4.2
9.	*Promote the growth of mobile capital by providing opportunities for children to edit, share and showcase their digital artefacts.*	Sub-sections 5.5.4, 6.4.6.1, 6.3.1, 7.1.5, 5.2.6, 7.1.4.2, 7.1.4.3, 7.2.3.1

Principle		Location of Supporting Evidence
10.	*Share best practice to build mobile capital in learners and teachers, enhancing teachers' awareness of the educational affordances of mobile devices as a corollary.*	Section 5.2, sub-sections 5.2.4, 5.2.5, 5.5.4, 6.2.6.3, 6.2.8.2, 6.4.6.1, 7.2.3.1, 8.4.1.3
11.	*Design activities with assessment in mind, to lighten the administrative burden.*	Sub-sections 5.2.6, 6.4.7, 7.1.1, 7.1.4.1, 7.1.4.2, 7.2.3.3
12.	*Adopt a creative approach to addressing cross-curricular learning objectives.*	Sub-sections 6.2.6.3.1 6.2.6.3.3, 6.4.6.2; 7.1.1, 7.1.4.2, 8.4.1
13.	*Use digital artefacts children have created in outdoor settings as a focus for class discussions and to clear up misconceptions.*	Sub-sections 5.3.1, 5.4.4, 5.4.6, 5.5.4, 7.1.4.1, 7.1.4.2, 7.2.3.3

Table 8.5: Listing of general design principles and location of supporting evidence

8.4.2.2 Production-focused Learning: Film-making and eBooks

The following principles were intended to inform the design of mobile learning activities with a focus on the production of learner-generated video clips or eBooks. These principles were generated as a result of evidence gathered during the 'production-focused' design-based cycles described in chapters 6 and 7, and followed a similar process to that described in section 8.4.2.1 above, where analysis of data led to the identification of patterns occurring across cycles.:

Principle		Location of Supporting Evidence
1.	*Enable children to hone film-making skills by practising in class or on school grounds, with a focus on team-work skills if using collaborative learning.*	Sub-sections 6.2.6.1, 6.2.6.1.3, 6.2.6.3.3, 6.2.8.1, 6.4.7, 5.5.3.2, 7.1.4.2, 7.2.3.2
2.	*Provide opportunities for children to watch video clips of experts (e.g. naturalists) to help develop presentation skills and vocabulary.*	Sub-sections 6.2.6.3.3, 6.4.6.2, 7.1.3.1, 7.1.4.1, Tables 7.3, 7.6
3.	*Encourage children to move to a quiet spot to practise and create their video clips.*	Sub-sections 6.2.6.1, 6.4.4.2, 7.1.3.1
4	*If using eBooks to support cross-contextual learning, aim to engender flexibility in learners between prior creation of pages as 'place-holders' for content, and creating pages on-the-fly while in the outdoor setting.*	Sub-sections 7.1.3.1, 7.1.4.2

Table 8.6: Listing of production-focused design principles and location of supporting evidence

8.4.2.3 Discovery-based Learning: Exemplar Activity

Alongside the generation of theory and design principles, design-based research also recognises and encourages the development of innovative learning interventions as outputs (Amiel & Reeves, 2008). The following activity was praised highly by teachers for its ability to both motivate and cognitively engage primary-aged learners, and is included here as an exemplar.

<u>Discovery-based Spatial Orientation Activity</u>

QR-code trails can be used in outdoor settings in conjunction with an annotated map to enhance understanding of map-reading skills in primary-aged children, while also engaging them on themed topic work.

This activity-type requires: (i) a fact-finding visit to an outdoor setting to determine appropriate locations to secure a set of QR-codes; (ii) annotation of a map to highlight the locations of the codes (see Appendix Two for an example); (iii) development of a bank of questions or instructions to frame the activity; and (iv) creation of the QR-codes, using functionality freely-available on numerous websites.

While the activities reported on made use of an illustrated map already available as a learning resource, teachers have access to a variety of freely-available online versions which could be printed, annotated by hand and then photocopied. Alternatively, dependent on a teacher's technical skills, this could all be achieved digitally, with the caveat that screen size may be an issue if the annotated maps were to be accessed on a mobile device.

QR-code trails appear to be exceptional in supporting contextualised learning in natural outdoor settings and can encourage primary-aged learners to connect with their environment, where carefully-located codes are used in conjunction with thoughtful questions. Questions or instructions posed by the codes can harness the educational benefits of exploratory and kinaesthetic learning, for example, by asking learners to locate a particular natural object as part of a scavenger hunt, or can be more open, such as asking learners to take photographs or create video responses.

8.4.3 Summary of Implications for Practice

This section addressed the secondary research question: *"What barriers and challenges are associated with the integration of mobile learning within teachers' professional practice, and how might this be modelled?",* presenting findings that emerged from working in close collaboration with teachers on the design of a series of MLAs. Teachers cited a lack of time, technical issues and a lack of experience as the key barriers to incorporating mobile learning in their teaching, with some suggesting that many still see ICT as an add-on, highlighting a digital disconnect between primary-aged learners and their teachers (see sub-section 8.4.1).

In seeking to bridge this disconnect, a set of theory and practice-informed design principles were generated for use by practitioners interested in exploring the potential of mobile learning activities for primary learning in outdoor settings.

8.5 Reflections on the Methodology

Design-based research (DBR) justified its selection as the underlying methodological approach to address the research questions in this study, due to its particular emphasis on: (i) maintaining strong collaboration with practitioners in naturalistic settings (e.g. Barab & Squire, 2004); (ii) working in iterative design research cycles to develop, evaluate and refine learning interventions (DBRC, 2003); (iii) its opportunistic, flexible and emergent approach (e.g. Kucirkova, 2017); (iv) enabling the incorporation of a variety of methods and techniques (Looi et al., 2011); and (v) generating theory and practice-informed design principles of use to practitioners (e.g. Wang & Hannafin, 2005).

While the majority of the research was conducted with participants of a single school, this is considered a strength by the Design-based Research Collective:

> *successful examples of design-based research often are conducted within a single setting ...the success of the innovation and the knowledge gained from its study depend in part on being able to sustain the partnership between researchers and teachers.* (DBRC, 2003, p.7)

During the study, this ongoing partnership between researcher and teacher appeared to feed into teachers' technological pedagogical content knowledge (TPACK) (Mishra & Koehler, 2006), not only in helping foster reflexivity (perhaps due to the pause away from day-to-day commitments), but also in familiarising teachers with the potential of using mobile learning within their teaching. As mentioned in sub-section 8.4.1.2 above, this process appeared to increase confidence in using technology in participant-teachers, and resulted in all but one generating their own ideas for incorporating mobile learning activities within their teaching.

From the children's perspective, my taking on the role of adult helper rather than researcher appeared to have lessened the impact that being observed may have had on them, accustomed as they were to the presence of unknown adults supporting outings, with only one instance of a child asking why I was filming during the study. My indirect recording approach, where I primarily filmed what children were seeing rather than they themselves, also appeared to mitigate issues relating to self-consciousness, and I noted no instances of the children showing disquiet at my presence, for example, by moving away.

As mentioned in sub-section 4.6.1, I conversed with children freely where they initiated conversations; in general, however, I noted that conversations in the outdoor setting were far more common between the children themselves than between children and adults. Such interactions were either captured as part of the observational process or from learner-generated video clips, and were analysed and fed directly into the evaluation of the research cycle. The iterative nature of the design cycles enabled findings resulting from the evaluation of one activity to inform the design of the next; for example, the use of eBooks in DBRC_P3 was responding to findings that emerged in DBRC_P2 (see sub-section 6.4.7). This ensured that the learner voice remained central in the design of activities.

The flexible nature of DBR enabled certain data to be collected 'on the fly'; for example, following up on chance conversations held with children or adult helpers in the nature reserve, or taking up opportunities for data collection as they arose. This, combined with the use of grounded theory (Glaser & Strauss, 1967), provided valuable opportunities to get close to the data, both helping to guide the study and drive the refinement of activities, while also addressing practitioner interests and theoretical considerations.

8.5.1 Progression through the DBR Cycles

As expected when using DBR to guide the design of MLAs for the 'messy' conditions of primary school children learning in outdoor settings, the research approach needed to be responsive to changing circumstances as they arose, such as teachers not following through on agreements (as in the use of blogs in DBRC_D1 and DBRC_D2), the unexpected requirement for two classes to attend an outdoor session together rather than as two separate sessions (as in DBRC_P2), or teachers no longer being available due to personal circumstances. Changes made to the original design specifications, including the unforeseen need to work with alternative teachers and/or year groups, while having an obvious impact on the clear progression of refinements within a research activity stream, did however serve to highlight authentic issues of a kind that may arise during the trialling of such interventions, and were therefore considered to be of value to other practitioners or researchers and worthy of report.

In addition, and in line with the emphasis on close collaboration with teachers to design authentic activities that directly related to the National Curriculum, the design of the MLAs was led by those learning objectives highlighted by participant teachers as their key attainment targets. This resulted in one activity being trialled, DBRC_D2, which did not directly relate to those that had come previously and that did not generate expected design implications for those that followed (as teachers did not use a blog for learning as per the activity specification). As mentioned in section 8.2, such issues led to a disparity between the specification of activities, such as the time allocated, the number of children taking part or the degree of adult help, which rendered direct comparison of activities difficult. The relative measures of learner engagement referred to in Tables 8.1 to 8.3 were therefore primarily provided to enable comparison of positive and negative levels of engagement *within* an activity rather than *across* activities, to highlight the effectiveness (or otherwise) of a particular activity in engaging child learners. Despite these disparities, findings from one activity were subjected to member-checking and referral to expert witnesses for alternative interpretations, prior to being fed into the refinement of subsequent activities where appropriate.

A summary of the relevant findings resulting from the Pilots is presented below, followed by a summary of the progression through the design-based cycles of both the *Discovery* and *Production-focused* research activity streams; where a finding fed into the generation of a particular design principle, this is indicated in brackets. It should be noted that, at points, both activity streams occurred contemporaneously, as was illustrated in Figure 4.2, and that pertinent findings from activities in one stream informed the design of activities in the other.

Beaver Scout Pilot (June 2013)

These pilot activities were designed to assess the potential of mobile devices for engaging school-age children in an informal outdoor setting, harnessing the motivational pull of a child-led QR-code treasure hunt and the viewing of web-based video clips as preparation for a bug hunt.

Findings:

- QR-code nature trails appear to be engaging for scouts aged 6-8 years *(Principle 1)*;
- A QR-code trail can be seen as a race by some children;
- Video clips were sometimes difficult to view due to glare of the sun, or hear, due to proximity of other groups;
- Internet access provided by mifi devices can be inconsistent in an outdoor setting;
- Some 'hogging' issues noted *(Principle 7).*

Refinements fed forward to the Y3 Pilot:

1) Encourage groups to slow down when scanning QR-codes by including more complex instructions for them to follow and priming adult helpers;

2) Encourage groups to sit further apart and in the shade, if necessary, for viewing of video clips.

Y3 Pilot (July 2013)

These activities broadly followed the format of the first and incorporated the suggested refinements.

Findings:

- QR-code nature trails appear to be engaging for school children aged 7-8 years *(Principle 1);*
- Incorporation of more complex instructions helped, but some still saw trail as a race *(Principle 6);*
- Sitting in the shade and further apart helped watching of insect-related video clips;
- Internet access was again inconsistent;
- One group spontaneously created video clips of their bug hunt, and another member created solo clips of Greendale reserve;
- Some issues related to problems with 'hogging' *(Principle 6 and 7).*

Recommendations fed forward to design of subsequent cycles (indicated in brackets):

1) If using web-based QR-codes, have text-only versions as a back-up (DBRC_D1);

2) Incorporate targeted adult input to resolve sharing issues (DBRCs D3, D4, P1, P2, P3, P4) and to slow groups down (DBRCs D3, D4);

3) Consider use of learner-generated videos in activities (DBRC_P1).

Table 8.7: Findings and recommendations from Beaver Scouts and Y3 Pilot Activities

8.5.1.1 Discovery-based Research Activity Stream

The key findings from the design-based research cycles of this activity stream are summarised below, together with the specific refinements that were fed into the design of subsequent activities. As mentioned in sub-section 8.4.2.1, those findings that demonstrated a high degree of confidence between theoretical claims and evidence gathered across cycles were fed into the final set of design principles, and these are also highlighted.

DBRC_D1: *Museum QR-code Trail* (February 2014)

- QR-codes appear to engage primary-aged school children aged 9-10 years with class topic work *(Principle 1);*
- Neither class was noted as treating the trail as a race;
- Text-only versions of QR-codes were used as school iPads were inconsistently-configured;
- More training was needed in photographic techniques *(Principle 4);*
- Teachers do not always implement agreed courses of action, ostensibly due to time pressures.

Refinements that were fed forward to design phase of subsequent cycles (indicated in brackets):

1) Provide training to ensure learner skills are matched to activity (DBRCs D2, D3, D4, P1, P2, P3, P4);
2) Design activities to feed into assessment (DBRCs D2, D3, D4, P1, P2, P3, P4);
3) Design activities that do not rely on internet access if access is inconsistent (DBRCs D2, D3, D4, P1, P2, P3, P4);
3) Make contingency plans (DBRCs D2, D3, D4, P1, P2, P3, P4).

DBRC_D2 *Staged Activity* (March/April/May 2014)

Note: No new findings to feed forward, as no use made by teachers of class blogs.

DBRC_D3 *QR-code Nature Trail and Annotated Map* (February 2016)

- QR-code nature trails in combination with annotated map can be highly-motivating for primary-aged school children aged 6-7 years *(Exemplar activity);*
- QR-code trails in combination with annotated map can enhance map-reading skills for 6-7 year olds *(Exemplar activity);*
- Contextualised QR-code nature trails can engage 6-7 year olds with science topic work, fostering disciplinary conversations within groups *(Exemplar activity);*
- Input of adult helpers can be valuable in scaffolding learning of science topics for children aged 6-7 years in outdoor setting *(Principles 5 and 6).*

Refinements that were fed forward to design of subsequent cycles (indicated in brackets):

1) Visit setting in advance to determine location and questions for QR-codes (DBRC_D4);
2) Prime adult helpers on their role (DBRCs D4, P3, P4).

DBRC_D4: *QR-code Nature Trail/Annotated Map with Video Responses* (April/May 2016)

- A learner-led QR-code nature trail in combination with an annotated map can be highly motivating for primary-aged school children aged 7-8 years *(Exemplar activity);*
- QR-code trails in combination with an annotated map can enhance map-reading skills for 7-8 year olds *(Exemplar activity);*
- Requiring children to formulate video responses to contextualised QR-code nature trails can encourage 7-8 year olds to use science terminology and the natural setting as evidence and inspiration within their clips (*Principle 3 - also corroborated by findings from DBRCs P1, P2*);
- Some children viewed the completion of the trail as the objective, so created brief video clips or had to be sent back to complete any they had forgotten *(Principle 6);*
- Lack of input from adult helpers can perpetuate learner misconceptions *(Principle 6);*
- Learner-generated video responses can be useful means of assessing understanding of topic work *(Principles 8 and 11);*
- Some children felt they had not demonstrated their true understanding in their clips *(Principle 1*3).

Refinements that were fed forward to design of subsequent cycles (indicated in brackets):

1) Carefully prime adult helpers on their role (DBRCs P3, P4);
2) Include follow-up sessions using learner-generated artefacts as a focal point for class discussions and to clear up misconceptions (DBRCs P3, P4).

Table 8.8: Findings and refinements from Discovery-Based stream DBR cycles

8.5.1.2 Production-Focused Research Activity Stream

Informed by findings from both pilots and DBRC_1, where internet coverage in the Greendale Reserve was found to be inconsistent, in conjunction with the findings from the Y3 Pilot, where children had spontaneously created their own video clips, activities in this stream were focused on the creation of digital artefacts by learners to showcase their knowledge of science topic work that were not reliant on internet access.

DBRC_P1: Film-making with Year 2 (February/March 2014)

- Creating video clips of insects can engage children aged 6-7 years with science topic work *(Principle 3);*
- Inadequate priming of adult helpers can lead to adults 'taking charge' *(Principles 1 and 6);*
- The *Bug Watch* app can act as a useful scaffold for children aged 6-7 years *(Principle 5)*;
- More practice required in speaking to camera and group work *(Principle 4);*
- Learner-generated video clips can be useful for assessing scientific vocabulary and knowledge *(Principle 11).*

Refinements that were fed forward to design of subsequent cycles (indicated in brackets):

1) Ensure adult helpers are adequately primed *(DBRCs P2, P3, P4, D3, D4);*
2) Provide more practice sessions at speaking to camera and working as a group *(DBRCs P2, P3, P4; D4).*

DBRC_P2: Film-making with Year 2 (June 2015)

- Creating video clips of insects can engage children aged 6-7 years with science topic work *(Principle 3);*
- Some children did not appear as enthusiastic as in previous sessions *(Principles 1, 2);*
- Need for an easily-accessible repository of learner digital artefacts *(Principle 8);*
- Learner-generated video clips are useful for assessing scientific vocabulary and knowledge *(Principle 11).*

Refinements that were fed forward to design of subsequent cycles (indicated in brackets):

1) Provide enough time and space for children to immerse themselves in the natural environment (DBRCs P3, P4, D3, D4);
2) Promote a stronger sense of ownership of the learner activity (DBRCs P3, P4, D3, D4);
3) Design activities to act as assessment pieces for the science curriculum (DBRCs P3, P4, D4).

DBRC_P3: Film-making with Year 2 using eBooks (May/June 2016)

- Creating eBooks containing text, photographs, drawings and video clips of insects can engage children aged 6-7 years with science topic work *(Principle 3)* while building ICT skills *(Principle 9);*
- Creating eBooks can encourage learner autonomy in children aged 6-7 years *(Principle 1)*;
- Watching exemplar video clips can provide children aged 6-7 years with useful presentation skills *(Production-Focused: Principle 2);*
- Some children expressed annoyance when insects flew off during filming or when they were unable to find insects to film that they needed for their eBooks *(Production-Focused: Principle 4);*
- Inadequate scaffolding can lead to perpetuation of misconceptions *(Principle 5)*;
- Inadequate adult input can lead to issues with group dynamics *(Principle 6);*

- Need for an easily-accessible repository of learner digital artefacts *(Principle 8)* that can be referred to in class *(Principle 13);*
- Learner-generated eBooks can be useful for assessing scientific vocabulary and knowledge *(Principle 11);*
- Cross-contextual activities can support child-centred, collaborative, kinaesthetic and experiential forms of learning *(Principles 1 and 3)*.

Refinements that were fed forward to design of subsequent cycle (indicated in brackets):

1) Provide adequate scaffolding and prime adults clearly on their role (DBRC_P4);
2) Design activities to act as assessment pieces for the science curriculum (DBRC_P4).

DBRC_P4: Film-making with Year 3 using eBooks (June/July 2016)

- Creating eBooks containing text, photographs, drawings and video clips of insects can engage children aged 7-8 years with science topic work *(Principle 3)* while building ICT skills *(Principle 9);*
- Creating eBooks can encourage learner autonomy in children aged 7-8 years *(Principle 1)*;
- Need for an easily-accessible repository of learner digital artefacts *(Principle 8)* that can be referred to in class *(Principle 13);*
- Some children appeared to lose their scientific focus when making videos in the outdoor setting, highlighting a need for follow-up classroom sessions to check understanding *(Principle 13)*;
- Learner-generated eBooks can be useful for assessing scientific vocabulary and knowledge *(Principle 11);*
- Cross-contextual activities can support child-centred, collaborative, kinaesthetic and experiential forms of learning *(Principles 1 and 3)*.

Table 8.9: Findings and Refinements from Production-Focused stream DBR cycles

8.5.2 Reflections on my Role as Researcher

Recognising the inherent tension in being both the *facilitator* and *researcher* within a DBR investigation (DBRC, 2003), alongside ensuring that good relationships were built and maintained with all participant-teachers during the study, teachers were asked at the outset to pass on their views, whether positive and negative, during all phases of a DBR cycle. All teachers appeared to understand the importance of being candid and seemed comfortable with raising any issues that occurred to them, for example, requesting alterations to an activity during the design phase or highlighting concerns regarding levels of learner engagement during the evaluation phase.

In addition, to guard against researcher bias tainting the study, findings were referred to teachers in their role as expert witnesses for corroboration or otherwise (Yin, 1989), and member-checking was used (Lincoln & Guba, 1985), particularly during semi-structured interviews, to verify that my understanding of what had been said matched that of the teachers. When creating interview and focus group guides (see sub-section 4.6.2), efforts were made to draft questions that were clear and unbiased (Kvale, 2008), and these were subsequently evaluated by trialling the questions with someone unconnected to the research to further strengthen confirmability.

Two issues that I had not foreseen when beginning this investigation were: (i) the high number of data files that would be collected; and (ii) the problem of storing and accessing large video files, some of which were over a gigabyte in size. This required a systematic approach to storage, and was helped by the use of *ATLAS.ti* (see sub-section 4.7.1) to organise and facilitate file retrieval. In the first few months of analysis, the large file sizes often resulted in *ATLAS.ti* crashing and coding work being lost, and a different approach to data collection was therefore adopted, wherein recording was temporarily halted and immediately restarted at intervals of around ten minutes, while any over-sized video files were edited to create multiple, small files in circumstances such as interviews where it had not been appropriate to employ the restart technique.

Another unforeseen issue that proved more intractable was that of teachers not always implementing agreed courses of action according to plan, as highlighted in sub-section 5.3.6. This had a direct impact on the data collected, but was not something I had control over. It did, however, give me further insights into the 'lived experience' of teachers, and was therefore valuable in terms of looking at the barriers and obstacles to their using mobile learning, particularly in outdoor settings where additional practicalities required consideration.

8.5.3 Recommendations for Researchers Considering the Use of DBR

It is important to note that while a design progression between the DBR cycles was not always obvious, the emergent nature of what might be termed 'true' DBR, i.e. where one is not imposing a context but is working within one that already exists, considers both theoretical and practical findings to be of value to practitioners, and that this concern should not therefore deter researchers considering a DBR approach to guide their study.

Following my experience, there are a number of suggestions or recommendations that I would make to researchers wishing to undertake DBR research in a similar setting:

• Start the ethics procedure early, as it may take a few months and several iterations for your consent forms and research to be approved; the strictures set will determine your research approach, for example by imposing limitations on your data collection and analysis methods;

• When working with schools, achieving genuine ‘buy-in’ from the school head teacher at the outset of the research will smooth your path when collaborating with teachers and technical staff, and is likely to act as a motivating force. Use your initial meeting to clarify practicalities and commitments on both sides;

• When collaborating with teachers, explain your research requirements clearly at the outset, clarifying what kind of data you will need to collect, and how you intend to collect it. Discuss research ethics requirements, including the need for informed consent forms and how to address both non-return of forms and any ethical concerns arising;

• Where feasible, design activities that feed into teachers’ assessment targets, to ameliorate time pressures on them and encourage engagement. Work with teachers to determine evaluation criteria for activities as part of the design specification, and enlist their expertise in evaluation. Discuss contingency plans when drawing up activity specifications, so teachers are aware of the research implications of decisions taken;

• Aim to build strong relationships and maintain regular contact with teacher-participants, particularly close to the date that outdoor activities are due to take place, to determine whether any changes to plans are envisaged;

• Carefully plan hierarchy of directory structure for storage of any data files at the outset, to facilitate recall, transfer and back-ups of data, and the use of CAQDAS software;

• If the research requires the analysis of a large number of video clips, create stills and accompanying transcripts that may be useful for inclusion in written reports *during* the process, rather than at the end;

• Finally, given the potential for large quantities of data sources with studies of this nature, limit the focus of the investigation to one research activity stream to reduce complexity.

8.6 Contribution to Knowledge

This research responds to an identified gap in the literature by reporting on findings from an empirical study of mobile learning activities (MLAs) for primary-aged children in outdoor settings, with a particular focus on activities that are not reliant on bespoke software or hardware (Figueiredo et al., 2016); and that can mediate learning undertaken in outdoor settings with learning occurring in class (e.g. Looi et al., 2009).

The research makes a contribution to the body of literature reviewed in Chapter 2, situating mobile learning against a rich and varied theoretical backdrop comprised of child-centred learning (Dewey, 1938), experiential learning (Kolb, 1984; Lai et al., 2007), socio-constructivist learning (Vygotsky, 1980), place-based learning (Zimmerman & Land, 2014), contextualised learning (Rikala & Kankaanranta, 2014), kinaesthetic learning (Pruet et al., 2016), constructionist learning (Papert, 1980; Kearney & Schuck, 2005), cross-contextual learning (Nouri et al., 2014; Sharples & Pea, 2014) and outdoor learning (Wells, 2000; Dillon et al., 2015).

With the design of a series of MLAs informed by this body of work, the design-based research cycles associated with the development of the MLAs also yielded further evidence and support for both Vygotsky's (1987) and Bruner's (1961) theorisations on the place of language in childhood learning, while delivering empirical evidence of the effectiveness of mobile learning interventions in promoting learner engagement in outdoor settings.

The research extends the work of: (i) Zimmerman and Land (2014) on constructionism and place-based learning; (ii) Kearney and Schuck (2006) on student-generated digital video; and (iii) Kearney (2011) on digital storytelling, by producing empirical evidence of the influence of mobile learning activities that incorporate learner-generated video and eBooks on learner engagement. While acknowledging the value of constructionist learning in deepening children's understanding (cf. Papert, 1980; Zimmerman and Land, 2014), the research also builds on Sharples and Pea's (2014) and Nouri et al.'s (2014) theorisations on cross-contextual learning and issues relating to conceptual thinking in complex outdoor settings.

The study builds on Rikala and Kankaanranta's (2014), Zimmerman and Land's (2014) and Pruet et al.'s (2016) work on contextualised learning, highlighting that mobile learning activities that are underpinned by child-centred and kinaesthetic learning approaches can foster high levels of learner engagement and promote disciplinary conversations in primary-aged children aged 6-8 years. It also supports the work of Brown (1992) and Nouri et al. (2014) in acknowledging the need to balance a child-centred approach with adequate scaffolding.

This research extends Fredricks et al.'s (2004) work on learner engagement, developing both a coding framework and a relative measure of engagement, the application of which produced empirical evidence that highlighted *enthusiasm* as the primary marker for emotional engagement, being *on-task* for behavioural engagement, and *learner autonomy* and '*focusing in'* for cognitive engagement. The research also supports the work around flow theory originally conceived by Csikszentmihalyi (1997), examining this theoretical construct in the novel context of mobile learning within an outdoor setting, while producing empirical evidence which identifies flow as emerging through a synergistic convergence of positive emotional, behavioural and cognitive states, highlighting a relationship between the work of Csikszentmihalyi (1997) and Fredricks et al. (2004).

This research extends the possibilities of contemporary theorisations around the notion of capital (Bourdieu, 1997), by building on recent work in this area which has seen the development of the concept of digital engagement into a model of *Digital Capital* (Park, 2017), adapting a framework based around economic, cultural and social capital to encompass the experience of primary-aged children within the domains of *Home*, *School* and *Classmates*, introducing the concepts of technological and educational capital, and taking steps towards the development of a model of *Mobile Capital*.

Finally, this design-based research investigation contributes to a growing body of recent studies that have adopted this methodological approach, producing a series of evidence-informed and theory-driven practitioner-focused principles intended to guide the development of mobile learning interventions designed for use in outdoor settings, supported by a practitioner-backed exemplar for a discovery-based spatial orientation activity.

8.7 Limitations of the Study

This study has seen the development and evaluation of the impact of a series of mobile learning interventions designed to enhance the engagement of primary-aged children with science education topics in outdoor settings. While the findings suggest that learner engagement has been promoted as a result of these interventions, it is acknowledged that this investigation has drawn participants from a single school, while working exclusively with teachers rather than with parents, highlighting the need to repeat the study with multiple institutions, to draw participants from a broader demographic, and to collect data regarding participants' proficiency in using mobile devices and patterns of usage in their home environment.

Due to limitations imposed by the nature and scope of doctoral investigation, the research has been conducted by a single researcher in a single outdoor setting over a relatively short timeframe, and the verifiability of the findings would therefore be strengthened by opportunities for this study to be conducted longitudinally by a larger group of educational researchers working across a range of settings.

It is also recognised that the research thus far undertaken has been of a purely qualitative nature, and that a mixed methods study which collected data from teachers and parents using quantitative instruments such as surveys might provide further opportunities for triangulation of different data types, thereby serving to strengthen the dependability of the findings. It is also acknowledged that a mixed methods investigation which adopted an alternative epistemological approach might allow for comparative analysis with a control group, for which no interventions would be introduced, enabling a null hypothesis to be tested.

Finally, while it is epistemologically consistent for findings emerging from a qualitative study to have *applicability* to other scenarios, the subjectivist-interpretivist approach adopted in this study acknowledges the limitations relating to the generalisability of these findings, and that it would be useful to undertake a quantitative approach to any expansion of the current investigation to strengthen any claims.

8.8 Suggestions for Further Research

Implicit in the exploration of the limitations of the study in Section 8.7 above is the suggestion that the trustworthiness and dependability of claims emerging from the findings would be strengthened by a demonstration of their transferability in other institutions. To this end there would be value in repeating the implementation of the mobile learning activities across a range of schools, and in a range of outdoor settings, as it is anticipated that findings relating to learner engagement, flow and the theoretical underpinnings, in particular, would be strengthened through further longitudinal research with a larger sample size.

It should also be acknowledged that the participant school may not be wholly representative of the larger population of UK primary schools, and it is therefore recommended that any repeat of the investigation should include a diverse range of participant institutions which can be shown to be representative of the whole demographic, thereby ensuring that participant representation from all socio-economic groups is accommodated.

This study has focused primarily on the impact of MLAs designed to promote engagement of primary-aged children with science topic work in outdoor settings; however, the location-independent nature of the MLAs enables many of the techniques and activities to be readily adapted for other subject areas and for implementation in other settings. For example, the ease with which QR codes can be produced means that the QR-code trail activities discussed in Chapter 5 could be deployed in school playgrounds, within buildings such as art galleries, and around distributed architectural structures such as universities, enabling schools to participate in research into the effectiveness of these activities to promote engagement with learning in subject areas as diverse as wayfinding, physical education, art or history, and for students in further and higher education to explore themes in subjects including library studies and architecture.

The analysis of data relating to the practical use of mobile devices by the study's primary-aged participants highlighted a need for further research into the design of MLAs to better support equality of access where learners were sharing devices, and it may also be useful to undertake a comparative analysis with the findings of a similar study in which one device was made available per child. An additional area for further research could consider how learners might use blogs as a repository for storing and showcasing digital artefacts such as videos, photographs and eBooks, to support cross-contextual approaches to learning.

While previous studies have explored teachers' use of mobile learning in UK primary schools, these have generally been restricted to classroom-based scenarios rather than outdoor settings (e.g. Burden et al., 2012; Gray et al., 2017), or were focused on the use of bespoke apps or learning environments (e.g. Wong, Chai, Zhang & King, 2015). In this study, Mishra and Koehler's (2006) TPACK framework provided a useful lens through which to analyse teachers' interactions with technology, with the majority of teacher-participants demonstrating improved levels of TPACK having engaged in collaboration on the design of the MLAs. Further research exploring teachers' use of mobile learning in outdoor settings with a stronger focus on the application of the TPACK framework is therefore recommended.

Finally, this investigation has opened up possibilities for further research which extends previous work in the domain of sociology through the development of the concept of mobile capital, and it is envisaged that extensive further research could be undertaken to further develop and evidence theorisations on this notion.

8.9 Conclusion

This investigation found that leveraging the educational affordances of mobile devices in an outdoor setting conducive to both experiential and kinaesthetic learning resulted in high levels of enthusiasm and on-task behaviour, promoted autonomous learning and encouraged focused disciplinary conversations around topic work, with learner-generated digital artefacts serving to mediate between outdoor learning and in-class activities.

In the realm of theory, the research extended the academic literature around engagement, establishing that a synergistic convergence of *enthusiasm*, being *on-task* and '*focusing-in'* can lead to a deeply immersive outdoor learning experience, and the emergence of a virtuous cycle of learning. In the realm of practice, the study identified barriers and challenges associated with teachers' adoption of mobile learning within their professional practice, while also promoting reflexivity in teachers and engendering the confidence necessary to successfully introduce innovative approaches in their work.

In conclusion, this investigation has taken steps towards addressing nature deficit disorder and the digital disconnect, challenging the perceived exclusivity between nature and technology, and uncovering a path along which mobile devices can help to bring children closer to their environment.

Appendix One: Category and Code Listing

#ACTIVITY *(Attribute code indicating activity-type and setting)*

#activitysetting:*Classroom*

#activitysetting:*Museum*

#activitysetting:*NatureReserve*

#activitysetting:*Playground*

#activitysetting:*SchoolPark* (small park next to school)

#activitytype:*FollowUp*

#activitytype:*InsectFocused*

#activitytype:*Staged* (series of linked activities)

#activitytype:*Natural (activity not using mobile device)*

#activitytype:*PhotoFocused*

#activitytype:*QRCode*

#activitytype:*SeasonalFocused*

#activitytype:*VideoFocused*

#PART PARTICIPANT *(Attribute code indicating participant characteristics)*

#part:*AdultHelper*

#part:*Female*

#part:*Male*

#part:*NatureExpert*

#part:*Researcher*

#part:*Teacher*

#part:*TeachingAssistant*

#part:*Y2(6-7)*

#part:*Y3(7-8)*

#part:*Y5(9-10)*

#SUPPORTMATERIALS *(Attribute code indicating type of supporting materials used)*

#supportmaterials:*ActivitySheet*

#supportmaterials:*CreatedInClass*

#supportmaterials:*Ebook*

#supportmaterials:*ExternalApp*

#supportmaterials:*Website*

#supportmaterials:*Map*

#supportmaterials:*Natural* (natural objects, such as leaves or flowers)

#supportmaterials:*VideoClip*

BEN BEHAVIOURAL ENGAGEMENT NEG *(Markers for negative behavioural engagement)*

BEN:*Arguing*

BEN:*Complaining*

BEN:*Disrespectful*

BEN:*Distracting*

BEN:*NotCollaborating*

BEN:*NotSharing*

BEN:*OffTask*

BEN:*Overbearing*

BEP BEHAVIOURAL ENGAGEMENT POS *(Markers for positive behavioural engagement)*

BEP:*Collaborating*

BEP:*Encouraging*

BEP:*EnergeticPos* (physically energetic, task-focused behaviour)

BEP:*LeadingWell*

BEP:*Negotiating*

BEP:*OnTask*

BEP:*Respectful*

BEP:*Sharing*

CEN COGNITIVE ENGAGEMENT NEG *(Markers for negative cognitive engagement)*

CEN:*LackingAutonomy (confused but not seeking support)*

CEN:*LettingOthersDoThinking*

CEN:*Misunderstanding*

CEN:*NotFocusingIn*

CEN: *ShowcasingSuperficial*

CEP COGNITIVE ENGAGEMENT POS *(Markers for positive cognitive engagement)*

CEP:*AskingGoodQuestions*

CEP:*FocusingIn*

CEP:*GrowingUnderstanding*

CEP:*ShowcasingGood*

CEP:*ShowingAutonomy*

CEP:*UsingApp*

CEP:*UsingMap*

CEP:*Wonder*

EEN EMOTIONAL ENGAGEMENT NEG *(Markers for negative emotional engagement)*

EEN:*Angry*

EEN:*Bored/Apathetic*

EEN:*NotEnjoyingCompany*

EEN:*NotEnjoyingNature*

EEP EMOTIONAL ENGAGEMENT POS *(Markers for positive emotional engagement)*

EEP:*Enthusiastic*

EEP:*EnjoyingCompany*

EEP:*EnjoyingNature*

EEP:*Happy*

LT LEARNING THEORIES *(Markers for underpinning learning theories)*

LT:*Child-centred*

LT:*Constructionist*

LT:*Contextualised*

LT:*Cross-contextual*

LT:*Experiential*

LT:*Exploratory*

LT:*Kinaesthetic*

LT:*SocialLearning*

LT:*Socio-constructivist*

PIEA POSSIBLE IMPACT ON ENGAGEMENT (ADULT) *(Adult-specific markers which may have impacted on child engagement with activity)*

PIEA:*Encouraging*

PIEA:*Enthusing*

PIEA:*Explaining*

PIEA:*ICT_pro* (in favour of using ICT)

PIEA:*ICT_unsure*

PIEA:*Instructing*

PIEA:*OutdoorLearning_pro* (in favour of outdoor learning)

PIEA:*OutdoorLearning_unsure*

PIEA:*Scaffolding_lacking*

PIEA:*Scaffolding_useful*

PIEM POSSIBLE IMPACT ON ENGAGEMENT (MLA) *(Activity-specific markers which may have impacted on child engagement with activity)*

PIEM:*ActivityTooLong*

PIEM:*ActivityTooShort*

PIEM:*Age_appropriate*

PIEM:*Age_inappropriate*

PIEM:*HoldingMobileDevice* (coded alongside relevant participant attribute code)

PIEM:*ICT_problematic*

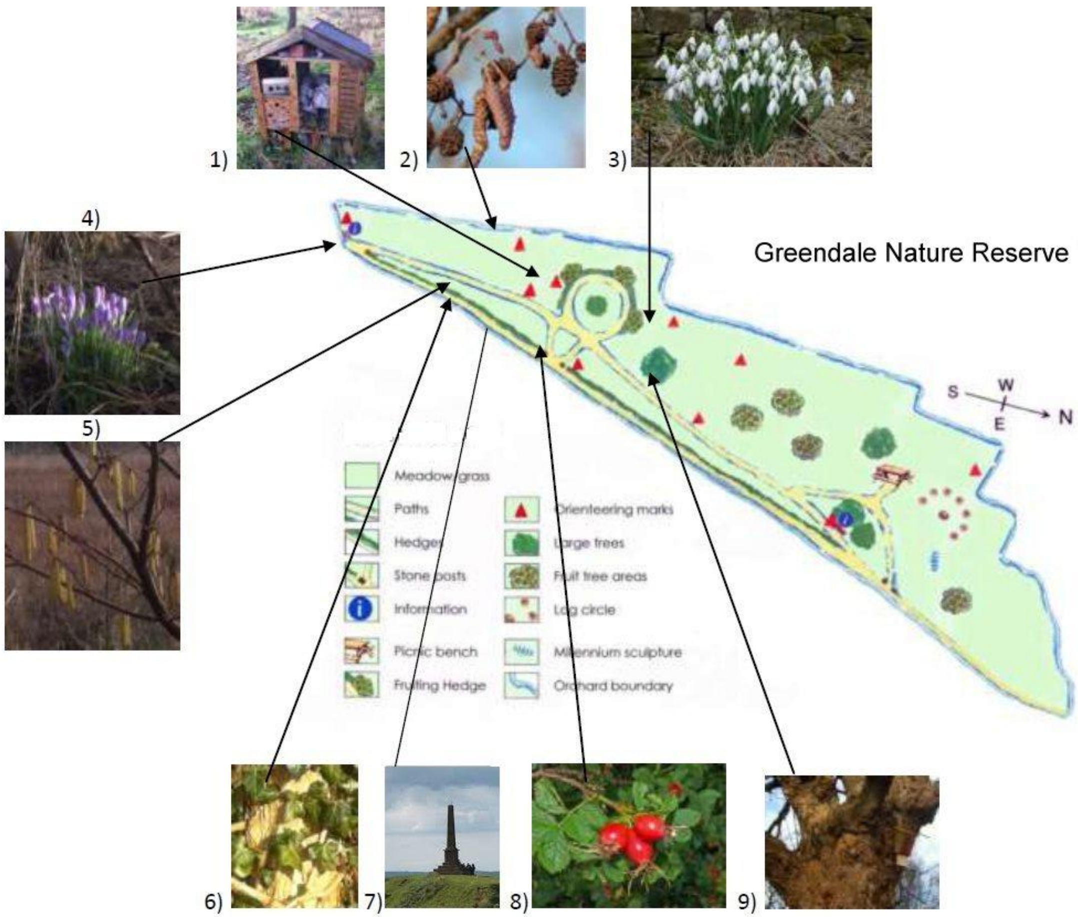
PIEM:*ICT_workingwell*

PIEM:*Setting_conducive*

PIEM:*Setting_problematic*

PIEM:*TooFewMobileDevices*

Appendix Two: Y2 QR-Code Explorers Activity (Scoping Document)



Notes:

i) Can restrict QR-code activity to one end of Orchard. Probably enough there to exclude 'Oak Circle' if required (no snowdrops tho', but there is another bird-house near the crocuses).

ii) The numbering isn't a route, it's just for ref purposes. Examples of text linked to these QR-codes could be:

1) Can you find somewhere that insects might like to live in winter? Take a photo of it.

2) Can you find any cones nearby – pick 4 up and put them in your container.

3) Can you find any snowdrops (small white flowers)? Take a photo if you find them as proof.

4) Can you find any crocuses (small purple flowers)? Take a photo but STAY IN THE ORCHARD.

5) Can you find any catkins? They look like long little yellow tails hanging from a tree. Take a photo.

6) Do all trees and plants go to sleep in winter? Can you take a photo to show whether this is TRUE or NOT TRUE?

7) Can you see the Memorial? Can you draw an arrow on your map to show where it is?

8) Can you find any red berries nearby? These are called rosehips and can be used to make jam.

9) Can you find anywhere that a bird might like to live? Clue: LOOK UP!

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