Rethinking mobile learning for development:

Using the Capability Approach and a mixed-methods systematic review to conceptualise the application of mobile technologies as an educational tool in Low- and Middle-Income Countries

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Declaration

I, Laurenz Langer, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

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Abstract:

Mobile technologies are now ubiquitous in Low- and Middle-Income Countries (LMICs). Education in LMICs is among the latest disciplines set out to explore how mobile technologies' particular affordances can be used to support programme interventions and practice. However, neither the effectiveness of mobile learning programmes, nor the causal mechanisms and contexts through which teaching and learning with mobile technologies is assumed to support education and development in LMICs, have been systematically reviewed and conceptualised. Notwithstanding, learning and teaching with mobiles is regularly attributed as having the potential to change and improve education in LMICs. This thesis assesses the effectiveness and underlying theory of change of mobile learning programmes in LMICs through a mixed-methods systematic review, including meta-analysis and thematic synthesis. Building on the findings of the systematic review, it presents the Capability Approach as a theoretical lens through which to conceptualise the effects of mobile technologies on education and development in LMICs.

Reviewing the evidence-base and theory of change of the application of mobile technologies as an educational tool in LMICs, I find little evidence to support claims to mobile learning's potential to support development outcomes. These systematic review findings are then expanded in a qualitative case study of a mobile learning project in rural South Africa exploring teachers' use of mobile technologies from the perspective of the Capability Approach. The case study finds that teachers' use of mobile technologies can best be understood as an expansion in four dimensions of capabilities: informational, educational, societal, and economic capabilities, which taken together can enhance teachers' well-being and human development. I use the combined case study and systematic review findings to reposition mobile learning's role in international development. I argue that conceptualising mobile learning for development through the Capability Approach supports a focus on an endogenous transformation of education in LMICs anchored in the primary objective of enhancing the capabilities and agency of actors in the education system. In the absence of evidence supporting mobile learning's impact on development outcomes, a focus on the role of mobile technologies to expand teachers' and learners' valued functionings and capabilities is presented as an alternative conception of the links between mobile technologies, their use for educational purposes in LMICs, and development outcomes.

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Chapter 1. Introduction to the thesis

Mobile technologies are an integral part of our daily lives. Mobiles' ubiquity and penetration of most aspects of social and economic structures have left them the defining technology of the Information Age in the early 21st century—to an extent that a Mobile Age or Mobile Area has been proposed (Castells & Himanen 2014; UNESCO 2014). In this thesis, I am concerned with mobile technologies in one particular setting, education in Low- and Middle-Income Countries (LMICs), and to one particular end, their conceptualisation as a tool that can support development outcomes such as poverty reduction. As I will show in more detail below, there is a diverse set of interests that, for better or worse, have positioned mobile technologies as an intervention with vast potential to improve education and subsequently development in LMICs. It is my objective to examine the empirical validity of these claims, that is that mobile technologies as an educational tool can bring about development; and to propose a conceptualisation of the links between mobile technologies, education, and development in LMICs. To do so, I used the tools of research synthesis and Amartya Sen's Capability Approach (Sen 1999) to navigate the thesis's contribution in this contested area. In this, I position the thesis to approach the above three themes from a development perspective. That is, this thesis's angle of investigation is grounded in the domain of international development and its associated literature and theories, rather than in the domain of technology studies or educational research. Throughout the thesis, I will use the term 'Mobile Learning for Development' (ML4D) to underline the thesis's positioning and to place boundaries around its empirical investigation and contribution.

The point of departure for this thesis were a series of reports by international development and mobile vendors organisations operating in LMICs that claimed large-scale development and education outcomes through the use of mobile technologies to support teaching and learning[1]. To give a flavour of the tone of the narrative on the educational use of mobile technologies in LMICs, UNESCO (2014) ascribed a 'revolution' in education in LMICs to be caused by mobiles, while the GSMA (2010) identified mobile technologies as 'teachers in pockets' and 'classrooms at learners' fingertips'. The narrative of learning and teaching with mobile technologies in LMICs was (and is) framed in highly optimistic terms with strong confidence that mobile technologies make an important contribution to education and

[1] For example, UNESCO (2012a; 2012b), GSMA (2012a; 2012b), USAID (2014), WEF (2012).

development in LMICs. National governments in LMICs, too, have announced large-scale investments in educational mobile technologies, including in South Africa where I live and work.

At the same time, however, researchers concerned with the pedagogical underpinning of using mobiles to support teaching and learning as well as researchers concerned with the use of Information and Communication Technology (ICT) for development more broadly raised doubts about this strongly positive framing of the contribution of mobile technologies to education and development in LMICs[2]. My thesis enters these debates both from an empirical and conceptual angle aiming to understand the evidence-base behind the claims for mobile learning's contribution to education and development in LMICs as much as how such a potential contribution of mobile technologies can be conceptualised and positioned.

This inquiry has gained much currency throughout the time of research. From Facebook.org's rejected attempt to connect millions of Indians to the internet, to the spread of Bridge International Academies across Africa using scripted lesson plans that teachers access and read of tablet devices, and major development funder's experimentation with classrooms delivered in a box full of digital technologies to learners in LMICs, the perceived promise of mobile technologies, largely driven by top-down initiatives, continues to prevail[3]. Through this thesis, I contribute a more empirically- and conceptually-grounded perspective to this debate with a particular focus on using mobile technologies in educational settings in LMICs.

[2] For example, Winters (2013; 2015), Traxler (2013a; 2013b), Kleine (2013), Gigler (2015).
[3] Facebook.org: http://tinyurl.com/rejectfborg; Bridge International Academies: http://tinyurl.com/bridgeacademies; Classroom in a box: http://tinyurl.com/solar-classroom

1.1 Research background

As of 2017, there are 6.1 billion mobile phone subscriptions in LMICs resulting in 99 subscriptions per 100 people in LMICs (ITU 2017). While this does not necessarily mean that each individual in LMICs has access to a mobile phone or another mobile device, it indicates the ubiquity of mobile devices in LMICs more broadly. This is further underlined when taking into consideration the historic trend of these numbers. A mere 10 year ago, mobile subscriptions in LMICs stood at 39 subscriptions per 100 people and in 2002 only 2.2 billion subscriptions were recorded in LMICs (ibid). This rapid growth of mobile technologies has also affected the nature of the mobile devices and their technological abilities. For example, since 2015 the majority of phones sold in LMICs is made up of feature and smart phones (GSMA 2017) contributing to a more powerful application of mobile devices. This reflects in numbers such as ITU's recent announcement that 67% of youth in LMICs are able to accesses the internet (ITU 2017).

While stark inequalities in access and use to mobile devices remain, this trend of increasing access and use is reaching the poorest part of the world's population too. In the most disadvantaged quintile of households in LMICs, close to 7 out of 10 households own a mobile phone; and these households are more likely to own a mobile device than to have access to sanitation or clean water (World Bank 2016). Again, this increasing access to mobiles is correlated with more powerful applications of the technology and 30% of mobile users in the group of least developed countries can access the internet using their devices (ITU 2017; GSMA 2017). Though, these numbers do not control for within country inequality in internet access (Donner 2016).

Against the background of rapidly increasing access to and use of mobile devices in LMICs, mobile technologies have become a popular platform to host various types of development interventions (World Bank 2012; Donner 2008). By just one count, this includes different development priorities such as using mobiles to support health outcomes (mHealth), financial inclusion (mFinance), gender empowerment (mEmpower/mWomen), agriculture (mFarm), and good governance (mGovernance) (World Bank 2012). This plethora of different development applications is often justified by the endogenous uptake of mobile devices, which are portrayed as technologies of choice by users in LMICs. Seminal research such as Jensen's (2007) observation of Indian fishermen's use of mobile phones to obtain the best market prices for their daily catch[4], or the World Bank's finding that almost three-quarters of Kenyan mobile phone users would skip a meal in order to finance mobile phone usage (World Bank 2012), fuel this narrative that mobile technologies are already integrated and valued in people's daily lives and therefore provide potent tools to host development interventions. Further, there is a range of well-covered success stories of mobile applications that have supported development outcomes such as Kenya's mobile payment systems MPESA[5] and the use of SMS reminders to enhance HIV/AIDS medication adherence (e.g. Lester et al 2010).

Given education's high profile within international development debates (Unterhalter et al 2015; Pritchett 2013), it is little surprise then that the education sector in LMICs has been positioned as to benefit from the potential of mobile technologies too. For example, the UNESCO is hosting an annual mobile learning week and has invested in a portfolio of work around the potential of learning and teaching with mobiles in LMICs[6]. USAID and other major development donors maintain an mEducation alliance aiming to reduce barriers to "access appropriate, scalable, and low-cost mobile technologies to help improve learning outcomes in formal and non-formal education" (mEducation Alliance 2017).

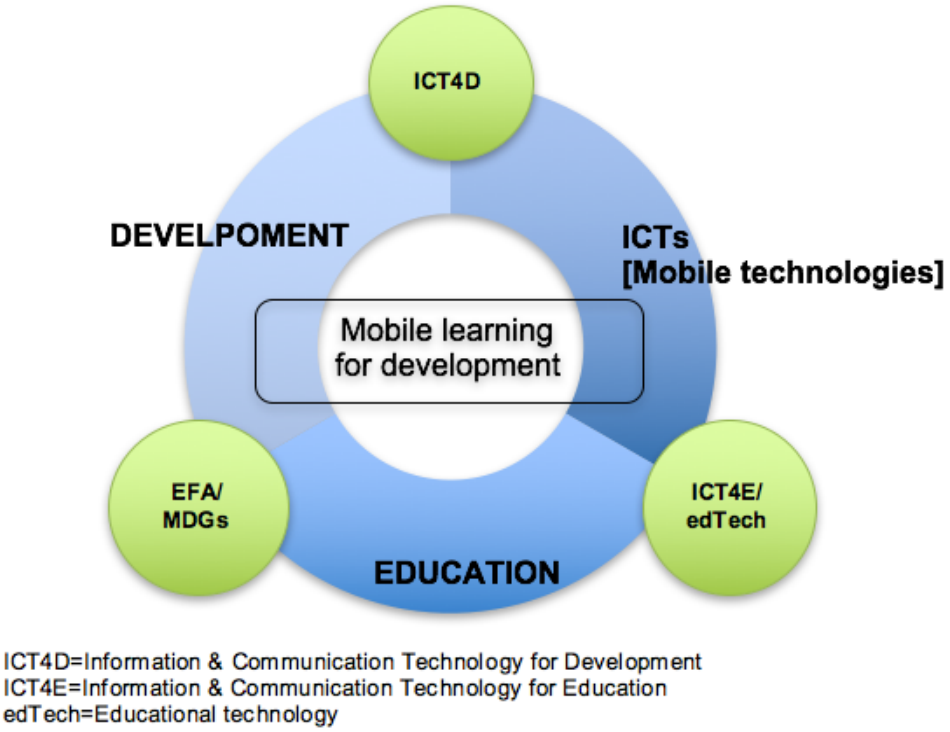
This high-level interest of development actors into the educational use of mobile technologies in LMICs has nurtured a vibrant and diverse body of development projects and programmes that aim to apply mobiles to support education and development in LMICs. As of 2015 the mEducation's Alliance database of mobile learning programmes in LMICs comprised 123 entries[7]. Some of these projects have rapidly gained scale. For example, the One Laptop Per Child (OLPC) programme claims to have reached over 2 million children and teachers in 42 countries and the Worldreader programme estimates to have provided 6.3 million people in LMICs with access to e-books on mobile devices (OLPC 2017; Worldreader 2017). Throughout 2013-2014, national governments in a range of LMICs (Thailand, Turkey, South Africa, Kenya) also announced investments in tablet devices at scale in order to support their education systems (Tamim et al 2015).

From an academic perspective, the introduction of mobile learning into the domain of international development overlaps with a number of existing discourses and research areas on education, development, and ICTs (Figure 1.1). First, ML4D enters existing conversations

[4] This portrayal persists despite ongoing critiques of this narrow and linear framing of technology usage and socio-economic outcomes (e.g. Donner 2016; Srinivasan& Burrell 2013; Vrasidas et al 2009)
[5] MPESA: http://tinyurl.com/7vgj6hx
[6] UNESCO Mobile Learning: http://tinyurl.com/unesco-ml
[7] Mobiles for Education Alliance resources: http://www.meducationalliance.org/?page_id=243

around development and education. Education and development form a symbiotic relationship in which enhanced education both contributes to development processes and presents a development outcome in its own right (Unterhalter 2015; Pritchett 2013). Education constituted a major development priority in the former Millennium Development Goals (MDGs) and continues to do so in the 2015 Sustainable Development Goals (SDGs). Moreover, supporting global progress in education presented an international standalone goal pursued by the UNESCO-led Education for All (EFA) movement and its six EFA goals, which is now taken forward in the Incheon Declaration as a framework for action for education in 2030 (UNESO 2016).

Figure 1.1 Overlap of ML4D with related bodies of literature



The global development policy interest on education has supported an unprecedented expansion in access to education (Evans & Yuan 2017). In 2015, primary education enrolment rates in LMICs stood at 91% (EFA 2015). Learners' average years of schooling have also increased significantly up from 3.9 years in 1980 to 7.5 years in 2010 (Lee & Lee 2016). This hides, however, regional and population-based inequalities in access to education with large segments of learners in the poorest quintile of household in LMICs and learners in conflict regions being much more likely to remain out-of-school than their peers in more affluent and secure contexts (EFA 2015).

What is more, despite the large progress, on aggregate, to increase access to schooling, improvements in education outcomes such as learning gains are lagging behind. A learning gap or learning crisis has been diagnosed to describe the discrepancy between a rise in access to schooling and a stagnation in learning outcomes (e.g. EFA 2014; Pritchett 2013; Evans & Yuan 2017). For example, it was estimated in 2014 that of the 650 million children attending primary school, at least 250 million did not gain basic proficiency in reading and mathematics (EFA 2014). Increased access to schooling thus has not automatically translated into improved learning outcomes and if the current rate of progress on learning outcomes is maintained, LMICs will require at least a century to achieve similar learning outcomes as high-income countries (Evans & Yuan 2017; Robinson & Winthrop 2016).

A complex and overlapping set of causes for this learning gap has been suggested such as a lack of funding for education systems (EFA 2014), teacher education and professional conduct (Chaudhury 2006), insufficient learning environments and pedagogical approaches (Westbrook et al 2014), and systematic challenging such as school governance and leadership (Carr-Hill et al 2016). In this context, mobile technologies are positioned as a means to remedy unequal access to education and to improve learning outcomes more broadly (e.g. UNESCO 2012a; 2012b). Learners without access to formal education services, for instance, are assumed to be able to access such services through their mobile devices. And, the integration of learning content, for example videos and e-books, as well as instant access to information on mobiles are framed as tools to support learners' educational attainment (e.g. USAID 2014; GIZ 2015)

Second, the use of mobile technologies to support teaching and learning also relates to ongoing debates about the educational use of ICTs in LMICs (edTech). Investments in ICTs have featured prominently on the educational agenda of policy-makers in LMICs driven by the assumption that IT skills are required for countries to meaningfully participate in the information age (infoDev 2012; UNESO 2009; Vrasidas et al 2009). As a result, a majority of LMICs government have adopted and implemented national ICT in education policies (Hennessey et al 2010; World Bank 2013). Some of these initiatives even extend to a regional scope such as the New Partnership for Africa's Development e-schools initiative (NEPAD 2013) and ICTs are also positioned as a tool for achieving the education SDG targets related to numeracy and literacy (World Education Forum 2016).

However, there remains controversy on whether investment in ICT in education in LMICs presents a cost-effective approach to support learning outcomes (Trucano 2013; Evans 2017). Impact evaluations and systematic reviews of ICT in education programmes contribute mixed results to technologies' impact and cost-effectiveness (e.g. Snilstveit 2016; McEvan 2015; Kremer et al 2013). This includes a range of evaluations of the OLPC programme at scale, which find learning outcomes to vary from insignificant effects (e.g. Cristia et al 2012) to small positive effects (e.g. Mo et al 2013)[8]. Reviews and syntheses of evidence on the barriers and facilitators to the effective use of ICT in education in LMICs, though, show more agreement. These suggest factors such as appropriate pedagogy, institutional readiness, teacher training competencies, leadership and management, and long-term financing models are important variables for the effective integration of ICTs into education systems (e.g. Sharmin et al 2017; Hennessey et al 2010; Gulati 2008).

Mobile technologies and mobile learning enter this debate on educational technology in LMICs as a sub-set of a more developed discourse. In this discourse, mobiles are assumed to contribute new technological abilities that fixed ICTs cannot contribute such as mobility, connectivity and social networking, and personalisation (Unwin 2015). The affordability of mobiles also means that educational actors are more familiar with their use and that technology investments are less cost-intensive. Mobiles are also seen as supporting a set of unique mobile-specific pedagogies such as context-crossing (Wali et al 2004) and ubiquitous learning (Ogata 2004), which cannot be implemented using fixed ICTs.

Third, the research and practice on the educational use of mobile technologies in LMICs relates strongly to an existing body of literature exploring the role and contribution of ICTs to development more broadly. Under the umbrella term Information and Communication Technologies for Development (ICT4D) (Unwin 2009), a diverse set of research strands has explored the conceptual and empirical relations between access to and use of ICTs in LMICs and development outcomes (e.g. Avgerou 2010; Zheng 2009; Kleine 2013; Heeks 2010). This literature and discourse also includes mobile ICTs, in particular mobile phones (e.g. Donner 2008; 2016; Galperin & Viecens 2017; Porter et al 2016).

A key feature of this body of literature is a vibrant debate about the nature of the contribution of ICTs to development in LMICs. A range of scholars largely frame ICTs' contribution in terms of economic outcomes such as increased productivity and rates of economic growth. The 2016 World Development Report, for example, investigates the digital dividends of ICTs understood as ICTs' ability to enhance "growth, jobs, and services" (World Bank 2016: 5).

[8] Despite laptops technically constituting mobile technologies, the OLPC programme has been largely discussed within the wider literature on edTech in LMICs rather than the specific literature on ML4D. There is substantial debate around the relevance, appropriateness, and effectiveness of the programme (see e.g. Annay & Winters 2007; James 2010; Varly 2010). My thesis does not aim to contribute to these debates, which are largely programme specific.

This framing is in line with earlier much-cited research on the economic contribution of ICTs in LMICs in terms of an 1.38% increase in GDP growth for every 10% increase in broadband connectivity and access to ICTs (Qiang et al 2009; World Bank 2009). More recent research subscribes to a similar line of argument in order to conceptualise the use of ICTs to support development in LMICs (e.g. Galperin & Viecens 2017; Cirera et al 2015).

This economic framing of development in ICT4D has been challenged on empirical and conceptual grounds. Systematic reviews and in-depth investigations of ICT4D programmes at a more micro-level have found mixed effects of ICT4D programmes (e.g. Geldof et al 2011; Brown & Skelly 2017; Adera et al 2014). Conceptually, too, scholars have developed a richer understanding of how ICTs might support development outcomes in LMICs taking into account structural inequalities and people's abilities to use ICTs in a self-determined manner and to self-determined ends (e.g. Kleine 2013; Andersson et al 2012; Zheng 2009). The latter discussions are of particular relevance to the literature on ML4D and the conceptual rigour of debating ICT4D's positioning within theories of development contributes a range of analytical lenses in order to position the educational use of mobile technologies in relation to development in LMICs.

1.2 Research outline and questions

As indicated above, this thesis commences on the premise that there is large interest in the use of mobile technologies to support education and development in LMICs, but that proponents of ML4D have not offered convincing empirical evidence or conceptual models for the claimed transformational potential of mobiles on education in LMICs and subsequent development. Rather, the potential of mobile learning is understood in a techno-centric manner in which the wide-spread access and use of mobiles in LMICs and mobiles' powerful technological features justify mobile learning's positioning as a development intervention. However, neither the effectiveness of mobile learning programmes, nor the causal mechanisms and contexts through which teaching and learning with mobile technologies is assumed to support education and development in LMICs, have been systematically reviewed and conceptualised.

This absence of a convincing evidence-base on mobile learning's effectiveness and of a thorough logic model for how the use of mobiles technologies can contribute to education and development presents a serious challenge to the field of ML4D. Mobile technologies cannot uncritically be positioned as a benevolent input in education in LMICs with guaranteed positive impacts on poverty reduction and human development. First, any social intervention or policy has as much potential to do good as to cause harm (Chambers 2002; Oakley 2000). This naturally applies to the educational use of mobile technologies in LMICs too, which might disrupt education processes and cause conflict among educational actors. Investments into mobile technologies also divert scarce public resources away from other educational inputs in LMICs, which could leave education systems at a net loss if mobile technologies do not contribute proportionally to learning outcomes. Unequivocally advocating for the use of mobiles devices in education without a detailed evidence-base is thus not ethical and runs the risk of hindering, rather than supporting, development processes.

Second, a linear and techno-centric understanding of the use of mobiles to support teaching and learning in LMICs risks introducing reductionist notions of education and development, which carries negative implications for the actors and institutions involved in both. Positioning mobile technologies as all-powerful tools to fix long-standing issues such as underperforming education systems risks marginalising other educational inputs such as training teachers and investing in curricula. Similarly, a techno-centric focus on access to technologies risks defining education and development progress in terms of inputs and easy-to-measure outputs. Such a focus on access to educational inputs might overlook structural inequalities that mitigate how different education actors can translate access to inputs into meaningful educational experiences and outcomes.

The above are but two illustrations of why generating an evidence-base and detailed conceptualisation of ML4D cannot be an afterthought in the pursuit of providing teachers and learners in LMICs with mobile technologies. To be clear, I am not negating that mobile learning can make a positive and important contribution to development in LMICs[9]. Rather, I am questioning whether the current thinking and modus operandi in the international development domain regarding the educational use of mobile technologies have sufficiently engaged with the more challenging aspects of mobile learning; in particular, whether the practice and understanding of ML4D has gone beyond the question of access and beyond strong claims to positive impacts based on anecdotes, good intentions, and simple theories.

As a result, the main research question for my thesis and subsequent sub-questions refer to:

1. How can the use of mobile technologies as an educational tool in LMICs be conceptualised as to contribute to development outcomes?

    1.1 What are the effects of the educational use of mobile technologies in LMICs on learning outcomes, teaching practice, and empowerment?
    1.2 What is the programme-level theory of change for mobile learning for development?
    1.3 Does the Capability Approach serve as an effective analytical framework to investigate ML4D?

In order to answer the above research questions, I divide my thesis into two parts: in part 1, I investigate the empirical and conceptual evidence-base for mobile learning's impact on development outcomes; in part 2, having found an absence of such evidence in part 1, I then develop my own conceptualisation of mobile learning's contribution to development using the CA. Both parts of the thesis are concerned with the same overall objective of investigating how the use of mobile technologies as an educational tool in LMICs can be conceptualised as to contribute to development outcomes. In part 1, I assess how the *existing* empirical and conceptual research on ML4D has positioned mobile learning's contribution to development and whether this positioning is empirically justified given the existing evidence-base. In part 2, having rejected the existing claims to mobile learning's contribution to development outcomes based on a lack of evidence, I then assess

[9] For example: Leach (2005); Aker et al 2010; Kaleebu et al (2013); Vu Henry et al 2016).

prospectively whether and how an alternative conception of mobile learning's contribution to development from a capabilities perspective can be constructed. Combining both parts of the thesis, i.e. the assessment of ML4D's empirical and conceptual evidence-base and the development of an alternative conception of ML4D, allows me to suggest a rethinking of mobile learning's contribution to development.

I use a range of different research methods across both parts of the thesis. Taken together these research methods give rise to three main investigations: (1) a mixed-methods systematic review to appraise and synthesise the existing evidence-base on mobile learning to assess its effects on development outcomes; (2) a qualitative case study of a mobile learning programme in rural South Africa using the CA as an analytical lens; and (3) a conceptual inquiry to develop a conceptualisation of ML4D from a capabilities perspective. Each investigation makes its distinct contribution to my rethink of ML4D as outlined below.

My research commences with the mixed-methods systematic review of existing primary research that has investigated the educational use of mobile technologies in LMICs. The review serves two purposes: examining the impact of mobile learning on education and development outcomes and examining how ML4D programmes have outlined the processes and causal links between the use of mobiles, education, and development in LMICs. Taken together, the systematic review therefore allows me to conclude whether empirical and conceptual claims to mobile learning's contribution to development are warranted. The review thereby constitutes my first key empirical component in rethinking ML4D based on an assessment of its current evidence-base.

Empirically speaking, the mixed-methods systematic review of ML4D interventions presents the departure point of this thesis. However, while its findings support an assessment and deconstruction of current conceptions of mobile learning's impact on education and development, the review is bound to assessing *existing* research on mobile learning. As a result, the systematic review findings cannot support me in developing a *new* conceptualisation of mobile learning's role and contribution in international development.

For this inquiry—the development of a new conceptualisation of ML4D—I first require an explicit conceptual framework that could define and outline the contribution of mobile learning to development; and then after having identified such a conceptual framework, I need to test it through new primary research for its validity and relevance[10]. I identified Amartya Sen's Capability Approach as a potent conceptual framework to guide a conceptualisation of ML4D. The choice for the CA was informed by its application as a conceptual lens in related bodies of research, the ICT4D domain in particular (c.f. Kleine 2013; Zheng 2009).

Having identified the CA, I then use a qualitative case study of a mobile learning programme in rural South Africa to apply the CA as a conceptual lens in practice. This serves to test whether the CA can be operationalised as a conceptual framework in research on ML4D. I then apply the findings of my case study research to develop an explicit conceptualisation of ML4D based on the CA. This enquiry is purely of conceptual nature but uses the empirical validation of the CA as a useful analytical lens to assess mobile learning's contribution to development outcomes as a starting point. The developed capabilities conception constitutes my second key component in rethinking ML4D based on a small empirical case study and subsequent conceptual inquiry.

In a last step, I then combine my developed capabilities conception of ML4D with my systematic review findings of the empirical evidence on ML4D. This constitutes my rethink of ML4D and explores how a conceptualisation of ML4D based on the CA and the empirical evidence-base on ML4D's impacts changes the understanding and positioning of mobile learning's contribution to development.

[10] An alternative approach could have been to rely on the theoretical validity and relevance of a new conceptual framework rather than testing it empirically. However, given the detailed review of existing empirical evidence to justify the need for a new conceptual framework, this approach does not seem justified.

1.3 Contribution of the thesis

This thesis offers a range of contributions to the research and practice of using mobile technologies to support education and development in LMICs. In terms of empirical research findings, this thesis contributes knowledge on what works, how and why in using mobile technologies as an educational tool in LMICs. It systematically collects, appraises, and synthesises the available primary research evidence on the educational use of mobile devices in LMICs. The thesis thereby collates an evidence-base on ML4D and then uses this evidence-base to assess the impact of ML4D. This investigation goes beyond individual impact evaluations of mobile learning programmes in LMICs and allows for conclusions to be drawn on mobile learning's effectiveness that are based on the body of evidence available.

The collated evidence-base further allows me to systematically unpack the specific manner and approach in which mobile learning programmes in LMICs have attempted to contribute to education and development outcomes. That is, I can investigate the processes, mechanisms, and contexts that facilitate the effects of mobile learning programmes. Based on this, my thesis constructs a theory of change for the use of mobile technologies as an educational tool in LMICs. This theory of change makes the assumed links between mobile technologies, education, and development explicit allowing for a detailed investigation of their empirical and conceptual validity. This contrasts with most of the literature on mobile learning and development produced by international development and mobile vendor organisations in which the link between technologies, education, and development is largely implicit and not detailed.

The thesis also contributes empirical primary research findings on the investigation of a mobile learning programme from a capabilities perspective. To my knowledge, my case study presents the first attempt to analyse the educational use of mobile technologies in LMICs using the CA. I use the case study findings to construct an analytical framework for teachers' use of mobile technologies based on the CA. The case study research primarily illustrates that the CA can be operationalised to investigate mobile learning programmes in LMICs and how the results of such an investigation present a novel perspective on the educational use of mobiles.

In terms of conceptual findings, my thesis contributes the development of a conceptualisation for ML4D. This contribution is in three parts. First, I review existing literature on the understanding and positioning of using mobiles to support education and development in LMICs. This investigation highlights a range of empirical and conceptual gaps, which I then fill through my systematic review findings. Based on this, I reject existing suggestions that mobile learning, in its current form and practice, can be positioned to contribute to development outcomes. Second, I then use the CA to develop a detailed definition and conceptualisation of how the educational use of mobile technologies could contribute to development in LMICs. Third, I review this capabilities conception of ML4D against the existing evidence-base and highlight how it changes the positioning of mobile learning in international development towards a more opportunity-, people-, education-, and transformation-focused understanding of ML4D.

In terms of methodological developments, my thesis contributes to a nascent body of work on mixed-methods systematic reviews of development policies and programmes (e.g. Langer & Stewart et al 2014; Snilstveit & Langer 2016; Oya et al 2017). I conduct a two-module mixed-methods review comprising distinct review modules to synthesise quantitative and qualitative primary research. My thesis also makes a minor methodological contribution to the operationalisation of the CA as an analytical lens by illustrating the CA’s versatility in a body of research in which it had not been applied before.

1.4 Structure of the thesis

The remainder of the thesis is structured as follows:

PART I: A systematic review of the empirical and conceptual evidence-base for mobile learning's contribution to development outcomes, including chapters 2–6.

Chapter 2 presents a literature review of ML4D to indicate the gaps in the empirical and conceptual evidence-base on the use of mobile technologies to support education and development in LMICs. It outlines how ML4D has been positioned as a development intervention and questions whether the claimed development impacts are reflected in the available research evidence. It also illustrates that mobile learning's contribution to development is largely framed in a techno-centric manner and motivates the need for a detailed conceptualisation of the links between using mobiles in LMICs, education outcomes, and development impacts.

Chapter 3 presents an introduction to the CA as a theoretical framework to conceptualise the contribution of mobile technologies to education and development in LMICs. It outlines the CA and reviews literature on its application in ICT4D and education in LMICs in order to justify the relevance of the CA to guide a conceptualisation of ML4D.

Chapter 4 presents the research design and methodologies applied in this thesis. It outlines the methods followed for my mixed-methods systematic review of the effects of using mobiles to support education and development in LMICs as well as the methods followed for my qualitative case study of a mobile learning programme in rural South Africa.

Chapter 5 presents the first set of findings of my mixed-methods systematic review. It provides a systematic map of the empirical research on the application of mobiles in LMICs to support education and development outcomes in order to describe the nature and design of ML4D programmes. I then synthesise the quantitative effects of these programmes using statistical meta-analysis to understand the impact of mobile learning on education and development in LMICs.

Chapter 6 presents the second set of findings of my mixed-methods systematic review. It outlines the results from my thematic synthesis of qualitative evidence on the contexts and mechanisms influencing the educational use of mobiles in LMICs. I then combine these contexts and mechanisms with the results from the systematic map and meta-analysis to construct a theory of change for the use of mobile technologies to support education and development. Based on the combined systematic review results, I then question the claims laid to ML4D's impacts in the existing literature and how this perceived contribution of mobile learning to development has been framed.

PART II: Developing a capabilities conceptualisation of mobile learning's contribution to development, including chapters 7–9.

Chapter 7 presents the results of my qualitative case study of a mobile learning programme in rural South Africa. The case study uses the CA as an analytical lens to explore teachers' perceptions of how the educational use of tablet devices has supported their professional and personal development and agency. The case study introduces four dimensions of capabilities that teachers valued and explored using the tablets.

Chapter 8 presents an analytical framework for teachers' use of mobile technologies to illustrate the interplay between the four identified dimensions of capabilities. The chapter then develops the case study findings further into a conceptualisation of ML4D that is informed by the CA. This capabilities conception of ML4D is then proposed as a foundation to define mobile learning's contribution to development in LMICs.

Chapter 9 presents a synthesis of my systematic review findings, my case study findings, and the capabilities conception of ML4D. It reviews the consistency between my systematic review findings and the developed conceptualisation of ML4D. It then highlights how the positioning of mobile learning's role in international development changes following my capabilities conception. This rethink of ML4D is then defended against selected lines of possible critique.

Chapter 10 concludes the thesis. It recounts the main findings presented and arguments developed before highlighting some of the implications thereof. It also indicates areas for future research.

1.5 Key terminology

I briefly introduce key terminology used in this thesis. This excludes definitions of mobile learning and mobile learning for development, which are discussed in detail in chapter 2, section 2.1–2.2, as well as definitions related to the CA, which are provided in chapter 3, section 3.1.1. In this thesis I define ‘development’ following Sen’s (1999) definition of development as freedom or, in other words, as an expansion of people’s capabilities to live a life they have reason to value. However, this definition does not prevail in most of the literature on ML4D, which defines development largely in terms of reductions in national poverty rates and other national and international economic and social indicators. There is therefore a mismatch between my conceptualisation of development and definitions of development in the secondary literature reviewed and synthesised in this thesis. In chapters 2–6, I rely largely on the prevailing definitions of development in the reviewed literature, while chapters 7–9 rely on my definition of development provided above. I indicate throughout each chapter what definitions of development are used and how these affect the development of my argument.

When referring to country’s levels of development, I adopt the World Bank’s classification of economies which groups countries according to four groups of economic development (World Bank 2017). This terminology is preferred over alternative terms such as developing/developed countries or global north/global south as it seems most empirically grounded and more nuanced in terms of possible grouping of countries. The terms ‘impact’ and ‘effectiveness’ are adopted in the context of evaluating programme and policy effects and connote a methodological understanding of using counter-factual evaluation designs to establish causality between the applied intervention and the observed effects (White 2009). The term mobile learning ’programme’ is used interchangeably with the term mobile learning ‘intervention’ and refers to a deliberate design of an activity or set of actives that directly intervene and affect participants lives. Lastly, I use the female pronoun throughout the thesis rather than mixed expressions such as she/he. This is to support clarity and consistency of the text.

PART I:

A SYSTEMATIC REVIEW OF THE EMPIRICAL AND CONCEPTUAL EVIDENCE-BASE FOR MOBILE LEARNING'S CONTRIBUTION TO DEVELOPMENT OUTCOMES

Chapter 2. Literature review 1: Mobile Learning for Development

Introduction

The literature review is presented in two chapters: the first focuses on mobile learning and the second on the Capability Approach (CA). The aim of the two chapters is to outline the wider discourse on the use of mobile technologies as an educational tool in Low- and Middle-Income Countries (LMICs). The literature review discusses relevant research and concepts related to mobile learning for development (ML4D) and the CA in order to set up the space for the specific contribution of the thesis in the context of the current knowledge base on ML4D. In doing so, the chapters specifically detail conceptual and empirical gaps in the current literature on mobile technologies, their application to support education in LMICs, and their relationship to development outcomes[11].

The literature review on ML4D presented in this chapter provides the background to how research and practice on the educational application of mobile technologies have developed[12]. It covers relevant research on the empirical performance of the use of mobiles to support education and further discusses how the educational use of mobile technologies has been justified and understood. In investigating this understanding, I pay particular attention to how different actors have positioned and outlined mobile learning's potential as a development intervention. I then contextualise these different positionings in the light of the empirical research and discuss their implications for the practice of mobile learning to support education and development. This then sets up the space for the CA as an analytical framework to guide a conceptualisation of ML4D.

This chapter is structured as follows. I commence with an introduction to mobile learning in general before detailing how mobile learning is applied in the context of education in LMICs. I track the historical development of the educational use of mobile technologies and present

[11] Unless specified otherwise, all of the discussions that follow relate to the context of low- and middle-income countries and I am therefore not making explicit references to education and development *in LMICs* throughout the text.
[12] This chapter does not cover a detailed review of the wider use of mobiles to support development outcomes outside the education domain.

different definitions and understandings of this use. I next outline three approaches to conceptualise the contribution of mobile learning to development and how they vary in their positioning of the developmental potential of teaching and learning with mobiles. This discussion includes examples of applied interventions and their relation to development initiatives such as Education for All. I lastly illustrate three key critiques that explore a range of gaps and shortcomings in the understanding and positioning of ML4D as a development intervention. The chapter concludes with a brief summary to set up for the review of the CA.

2.1 Mobile learning

2.1.1 An introduction to mobile learning

Mobile learning in its broadest sense refers to the use of mobile technologies to support educational processes, in particular learning and teaching activities (Ally 2009; Sharples et al 2007). The research domain has largely been driven by academics and practitioners based at US and European research institutions, which influences its research tradition and concepts (Traxler 2013a; Winters 2013). The idea of the educational use of hand-held devices that combine advanced computing powers and communication abilities has been conceptualised as early as 1972 (Kay 1972), but only gained currency with the near universal uptake of mobile technologies since the early 2000s (Sharples et al 2007; Pachler et al 2010; Unwin 2015). As mobile technologies have become ubiquitous and started to influence most aspects of our lives, in particular how we communicate and access information, the presumed potential to use these technologies to support education has grown (Castells & Himanen 2014; Toyama 2015; Donner 2016). Though, this presumed positive potential of mobiles is certainly not without critique (e.g. Turkle 2016; Elliot & Urry 2010).

Learners' social realities are increasingly shaped by constant connectivity, instant access to information, and a contextualised and customised experience of using this information (Sharples 2007; Traxler 2009). Consequently, children's learning activities are already being influenced by mobiles, regardless of formal education interventions (Ally 2009). The ubiquity, appeal, and wide applicability of mobile devices therefore necessary affect established processes of learning and teaching (Pachler et al 2010). The theory and practice of mobile learning, at its core, aims to investigate how these mobile technologies can be used to support informal and formal learning activities and how the technological affordances[13] of mobiles can be integrated within teaching and learning processes (Sharples et al 2007). However, this acknowledges that learners differ in their individual abilities and social opportunities to access and apply mobile technologies for educational purposes. Socio-economic contexts and structures and practices do shape mobile learning and need to be carefully considering when designing teaching and learning opportunities with mobiles (Pachler et al 2010; Wali et al 2008).

[13] The term and concept of 'affordances' has some important shortcomings as discussed by Oliver (2005) and other terms such as 'abilities' and 'functionalities' have been suggested. However, the technical language of the CA refers to capabilities and functionings. I therefore retain the term affordances throughout the thesis, which should be understood as a linguistic substitute for functionalities.

Learning processes, to some extent, have always been mobile (Wali et al 2008). Learners have read books inside and outside of classrooms and interactions between teachers and learners have rarely been fixed to a single context. Humans have for the most part of our history developed tools and artefacts to allow us to learn ‘on the move’ or access information across different contexts (Wali et al 2008; Unwin 2015). What is new then about current understandings of mobile learning is the increased technological abilities that mobile technologies provide; and how these abilities can be harnessed to support learning and teaching activities.

As a result, conceptions of mobile learning distinguish it from other educational technologies by means of the applied devices. For example, whereas initial e-learning activities using desktop computers required fixed educational infrastructure such as computer labs, mobile technologies can be used without special educational infrastructure being in place. The most common referenced unique affordances associated with mobile technologies compared to other educational technologies are: mobility of devices (size and battery life), constant connectivity (either using fixed or mobile internet connections), ubiquity (based on their accessibility and ease of use), and mobiles being more personally adaptable than fixed educational technologies (e.g. Unwin 2015; Ally 2009; Winters 2007). These affordances have led mobile phones, tablets, personal digital assistants (PDAs), and laptop computers to be positioned as the main technologies associated with mobile learning (Wali et al 2008; Ally 2009).

2.1.2 Definitions of mobile learning

Definitions of mobile learning have changed over time from a device-based, techno-centric conception towards a learning activity-based, pedagogical conception (Pachler et al 2010; Winters 2013; 2015; Traxler 2013a). Changing definitions of mobile learning also influenced the practice and research agenda of using mobile technologies to support learning and teaching, which evolved in line with definitions and conceptions of mobile learning. Pachler and colleagues (2010) identify three broad phases in the evolution of mobile learning: (1) a focus on the technical feasibility of mobile devices in an educational context from the mid-1990s; (2) a focus on the use of devices to guide learning ‘anytime, anywhere’ outside the classroom from the mid-2000s; and (3) a current focus on the mobility of the learner and the learning activities supported by mobiles.

In the first phase, mobile learning in essence was equated with the mere use of mobile devices to support educational activities. Research and practice of mobile learning focused narrowly on assessing the technical feasibility of the educational use of emerging devices such as PDAs and the first mobile phones without much attention being paid to the pedagogical underpinnings of such use. This reflected in techno-centric definitions of mobile learning such as Traxler and Leach (2006: 1): "'Mobile learning' is the term increasingly being applied to the use of small, portable, handheld and lightweight electronic devices used for educational activities in classrooms, in fieldwork, at home, at work and when travelling".

With the increase in the technological abilities of mobiles starting in the early 2000s, this conception of mobile learning shifted. Mobile devices now allowed for a much broader range of applications, and research interest and practice clustered around the use of smart phones and PDAs to support learning activities outside the classroom such a field trips. Mobile learning came to be understood as a "personal, unobtrusive, spontaneous, 'anytime, anywhere' way to learn and to access educational tools and materials" (Kukulska-Hulme & Traxler: 2005: 1). However, this understanding of mobile learning remains techno-centric merely shifting the emphasis on a new set of technological affordances of the devices (Wali et al 2008).

In the third and current phase, a range of scholars provided strong critiques of device-based, techno-centric definitions of mobile learning, which were seen as, first, unstable and in need of constant updating due to the pace of technological innovation (e.g. Traxler 2009; Kukulska-Hulme 2009), and, second, were not integrated with formal theories of learning (e.g. Sharples 2007; Wali et al 2008). Many of these critiques can be traced back to Roschelle's (2003) seminal paper on unlocking the learning value of mobiles. Investigating the educational use of mobile technologies from an explicit pedagogical perspective, he showed that while mobiles "preform a small, well-defined function uniquely well, much of the rest of teaching and learning is left to social practice" (Rochelle 2003: 8-9). His critique emphasised the potential of these small and well-defined functions that mobile technologies do uniquely well, but stressed that these functions only become powerful educational interventions through their interplay with and embeddedness in social practices.

On the back of this critique a diverse body of literature has offered different models and theories of how mobiles' particular affordances can best be integrated with theories of learning to design powerful educational mobile learning interventions. Sharples and peers (2007) for example propose a theory of learning for the mobile age in which they draw on Laurillard's (2002) Conversational framework for learning and Engestroem's (1987) expansive activity model. This leads them to define mobile learning as "the processes of coming to know through conversations across multiple contexts among people and personal interactive technologies" (Sharples et al 2007: 4). This definition presents a large shift away from applying a device-based conception of mobile learning focusing on the role of mobiles to support conversation, interactions, and context-crossing which are positioned as the channels through which learning occurs. Similar shifts in definitions can be observed in Pimmer's (2010) conception of mobile learning from a socio-cognitive perspective and Bell's (2010) use of actor network theory to conceptualise mobile learning.

For the purpose of my thesis, I will follow Wali and colleagues' (2007: 55) definition of mobile learning as: "learning that occurs as a result of pursuing learning activities that are directed towards achieving the same objective across multiple contexts (both physical and social)". This definition refines Sharples and colleagues' theory of learning in a mobile age. It defines mobile learning in terms of context-crossing allowing for a shift away from the use of mobile technologies towards a focus on the forms of learning practices supported by mobiles and how these practices are mediated by social and physical contexts. In the context of my thesis on ML4D, however, the intricacies of current definitions of mobile learning are less of a concern. What is more important here, is the outlined shift of definitions of mobile learning from a device-based, techno-centric understanding towards a learning activity-based, pedagogical understanding.

2.1.3 Mobile learning's pedagogical contribution

The progression of mobile learning's definition towards a learning-activity, pedagogical understanding of mobile learning has led to an exploration of a range of rich mobile learning pedagogies. I define pedagogies here in line with Watkins and Mortimor (1999: 3) as: "any conscious activity by one person designed to enhance learning in another". There is now consensus among mobile learning scholars in the educational domain that mobile learning can best be understood as a socio-cultural form of practice (Winters et al 2017; Pimmer et al 2014; Kearney et al 2012; Frohberg et al 2009; Koole 2010). Based on a review of 102 Mobile Learning projects, Frohberg and peers (2009), for example, identify the following underlying pedagogical approaches to mobile learning as most frequently applied: constructivist, situated, collaborative, and informal and life-long learning. However, this hides a rich field of specialised mobile learning approaches that have emerged such as 'context-aware ubiquitous mobile learning' (Chen & Li 2010) and 'RFID-supported immersive ubiquitous mobile learning' (Liu et al 2009).

The benefits that learners might derive from these mobile learning pedagogies, that is mobile learning's pedagogical contribution, have been outlined in different ways (e.g.

Winters 2007; Kukulska-Hulme 2009; Ally 2009). Kearny and colleagues' (2010) framework for viewing mobile learning from a pedagogical perspective provides a helpful synthesis of these benefits. The authors define the three distinctive features of mobile learning as fostering personalisation, authenticity, and collaboration in the learning process across time and space. Each of these three features can enrich the learning experience of students. Personalisation of learning supported by mobiles is assumed to enhance learners' choice, agency, self-regulation and customisation. Authenticity of the learning is linked to an educational use of mobiles to facilitate learning tasks of real world relevance and personal meaning to the learner. Collaboration, lastly, links to learning fostered by social interaction and conversation as assumed by socio-cultural perspectives on learning as referenced above. Notable sub-domains from Kearney and colleagues' framework refer to mobile learning approaches using mobiles to support game-based learning, augmented reality learning, and learning analytics (Kearney et al 2010).

All in all, Kearney and colleagues' framework reflects a wider agreement in the literature that mobile learning can be positioned to support more learner-centred educational activities (e.g. Traxler 2009; Pachler et al 2010; Winters et al 2017). From an educational perspective, mobile learning has centred around how mobile technologies can support learners to create and acquire knowledge through an interaction with their socio-cultural contexts and practices. This positioning is perhaps best captured by Pachler and colleagues (2010: 6):

> ”Mobile learning—as we understand it—is not about delivering content to mobile devices but, instead, about the processes of coming to know and being able to operate successfully in, and across, new and ever changing contexts and learning spaces. And, it is about understanding and knowing how to utilise our everyday life-worlds as learning spaces. Therefore, in case it needs to be stated explicitly, for us mobile learning is not primarily about technology.”

2.2 Mobile learning in LMICs

I next discuss the application and development of mobile learning in LMICs. In this, it is important to keep in mind that the origins of the research and practice on mobile learning are predominately from US and European institutions. Concepts and models of mobile learning are thus contextualised by this research tradition and it is crucial to keep this in mind when investigating the application of mobile learning in LMICs. Within HICs themselves, there are large inequalities in learners' abilities to use the full pedagogical potential of mobile learning. This is even more so in LMICs and discourses around 'connected learners' and learners developing agency to take control of learning activities, for example, need to be carefully interrogated for their applicability across contexts. The values embedded in mobile learning and its assumed educational contribution cannot be uncritically positioned to apply to marginalised learners with different educational needs. Mobile learning needs to be reflexive of its origins; and its theory and practice requires adaptation in LMICs contexts, in particular when attempting to influence development outcomes. My thesis is only concerned with the latter aspect of mobile learning's *conceptual adaptation* in LMICs—i.e. to support development outcomes—with the conceptualisation of a pedagogical theory of mobile learning adapted for LMICs being beyond my scope.

2.2.1 An introduction to mobile learning in LMICs

As mobile technologies have become ubiquitous in most parts of the world, so has the rationale to use mobile devices to support education. The initial uptake of mobile learning in LMICs followed the above-outlined conceptual development (Traxler 2013a; 2013b). Early mobile learning projects applied a device-based and techno-centric approach. The first mobile learning projects reported in LMICs in the mid-2000s focused on providing access to mobile devices in order to enhance the reach of education programmes, distance learning in particular (e.g. Brown 2005; Matthee & Liebenberg 2007; Traxler 2005). However, in line with conceptual developments in HICs, mobile learning projects in LMICs soon began to apply more pedagogically-rich project designs exploiting the whole range of technological affordances provided by mobile devices. Prominent examples of early mobile learning programmes in LMICs with rich pedagogical underpinnings can be found in Zurita and Nussbaum's research in Chile on mobile computer-supported collaborative learning systems based on Activity Theory (Zurita & Nussbaum 2004; 2007); Kim's mobile learning model of literacy development for underserved migrant indigenous children in Peru and Bolivia (Kim

2009); Sahni and peers' Digital StudyHall mobile learning programme drawing on critical pedagogy to support situated and participatory learning approaches (Sahni et al 2008); and Leach's Digital Education Enhancement Project using mobiles to support teacher professional development in reference to more learner-centred teaching approaches (Leach et al 2005).

However, in parallel to this pedagogical development of mobile learning as an educational intervention, both mobile technologies and education received increased attention in the international development sector. First, mobile technologies fuelled by success stories such a Kenya's MPESA mobile finance application and Jensen's (2007) research on fishermen's use of mobile phones to access market prices came to be understood as endogenous platform on which development interventions could be hosted (World Bank 2008; Donner 2009; Banks 2014). Mobile technologies due to their ubiquity in LMICs were ascribed vast potential to support various development sectors leading to a plethora of development domains aiming to 'maximise mobile' such as mHealth, mFinance, mPowerment, and mFarm (World Bank 2012; 2016; Donner 2009; 2016).

At the same time, education itself received renewed policy interest in LMICs due to an enhanced emphasis on supporting education systems as a key mechanism in international development (Unterhalter 2015; McCowan & Unterhalter 2015). This renewed policy interest in education is evident in large-scale multilateral development initiatives such as the former MDGs and EFA targets. The rise of mobiles for development as well as the increased focus on education in international development therefore began to contextualise the conceptual development of mobile learning in LMICs. This contextualisation led to a shift in understandings of mobile learning, which from a development perspective was increasingly referred to as the use of mobile technologies to support education, rather than an explicit pedagogical education intervention (Traxler 2013a; 2013b; Kinuthia & Marshall 2014; Winters 2013; 2015). This drifting understanding led to different foci of mobile learning practice and research depending on whether the topic was approached from an education or a development perspective (Traxler 2013b). This resulted in a somewhat silo nature of ML4D in which existing educational research on mobile learning (in particular when developed in HICs) was often not considered to inform programme and policy design (Kinuthia & Marshall 2013; Winters 2013).

This shift in an understanding of mobile learning in international development is also evident in a change in terminologies used to refer to the educational application of mobile devices. Starting with the first use of the term 'Mobile learning for development' to describe a set of workshops run in Nigeria in 2010 (Winters et al 2010), ML4D has been adopted mainly by the educational research community. Examples of this can be found in Kinuthia and Marhsall's (2013) volume 'On the move: Mobile learning for development', the work of John Traxler (Traxler 2013a; 2013b; 2013c) and Niall Winters (Winters 2013; 2015; 2017). Development actors, on the other hand, have preferred a more device-focused language such as UNESCO's (2010) 'Mobiles, learning, and development' and USAID's 'mobiles for education for development' (USAID 2010). Here, mobile education is distinguished from mobile learning to position it "as an extension of mobile learning defined as the exploitation of ubiquitous handheld technologies, together with mobile and wireless networks, to facilitate, support, enhance or extend the reach of teaching and learning" (GSMA 2011: 3).

This presents a deliberate shift away from the pedagogical understanding of mobile learning towards a techno-centric definition emphasising the technology over the learning processes and contexts. This is even the case for publications by development actors that adopt the term 'mobile learning'. UNESCO's Working Paper Series on Mobile Learning of 2012, for example, defines mobile learning as "modern ways to support learning process through mobile devices, such as handheld and tablet computers, MP3 players, smartphones and mobile phones" (UNESCO 2012d: 6). This implies a conception of mobile learning in line with very early understandings of the theory and practice of mobile learning in the educational domain. From a pedagogical perspective, therefore, mobile learning in LMICs is essentially going backwards neglecting a rich and long-standing body of educational research on mobile learning (see 2.3.3). Given this discrepancy between the positioning of mobile learning in international development by education researchers and development actors, Traxler (2013b; 2013c) goes as far as to identify two distinct schools of thought on ML4D.

2.2.2 Defining mobile learning for development

From the above discussion, it emerges that the term ML4D is likely to be interpreted differently depending on the research and policy background of scholars. For an educational audience, the term indicates an explicit use of mobile learning pedagogies to support education in LMICs (e.g. Winters 2015; Traxler 2013a). For a development audience, it indicates the use of mobile technologies to support education. Neither of the two audiences has proposed an explicit definition of ML4D. In my thesis, I therefore define ML4D as:

> 'the process of both teaching and learning with mobile technologies in LMICs, building on the unique affordances of mobile devices (Roschelle 2003) to provide learners and teachers with an educational tool that can be used to address some of the specific educational challenges

faced by LMICs.'

I thus position myself alongside pedagogical definitions of mobile learning and further aim to distinguish my conception from the mere use of mobile technologies in education by emphasising the use of mobiles to address some of the specific educational challenges faced by poorer countries. This also aims to position myself in relation to mobile learning *in* LMICs, which I would argue should not be equated with Mobile Learning *for* Development (see 2.2.3). Lastly, in my definition, the process of learning and teaching with mobile devices can assume diverse forms and is not restricted to formal education.

However, within the wider field of international development current understandings and practices of ML4D are more in line with a techno-centric conception. Of the 123 mobile education projects listed on the online database of USAID's Mobiles for Education Alliance, only 18 projects referenced an explicit pedagogical approach as part of the project design. Likewise, while there is ongoing innovative mobile learning research and practice investigating the links between mobile learning pedagogies and their support to development processes and outcomes (e.g. Vu Henry et al 2016; Pimmer 2016; Piper 2016; Hennessey et al 2015), large-scale mobile technology programmes in LMICs are not designed around explicit mobile learning pedagogies. For example, Worldreader, an NGO claiming to have supported literacy development of over 6 million people in LMICs, focuses on the provisioning of reading materials through e-books and mobile phone apps (Worldreader 2017). Worldreader does not design the use of their mobile technologies around any explicit theory or framework of learning. The same holds true for other frequently cited mobile education programmes such as TeacherMate (e.g. Masperi 2008) and Project ABC (Aker et al 2012; 2015). Lastly, from a public sector perspective, there also is a strong interest in the use of mobile technologies in education. But, national-scale mobile technology programmes in education in countries such as Kenya, Turkey, and Thailand, only reference an investment in the supply of technologies without an explicit educational framework for how this technology is supposed to provide benefits to and be integrated with existing teaching and learning activities (Tamim et al 2015).

2.2.3 Mobile learning's assumed contribution to development

The definitions and understandings of ML4D have important implications on the assumed potential of teaching and learning with mobiles to support development outcomes[14]. As explained above, understandings affect programme design and practice, which in return

[14] In the below, I rely on the definitions of development adopted in the ML4D literature and group these into three categories; note that these do not correspond to Sen's definition of Development as freedom, which I suggest as an alternative definition of development.

determines the conceptual linkages between the use of mobiles, education, and development. Within both understandings of ML4D, there is consensus that the use of mobiles is linked to development outcomes through enhancing educational processes and outcomes (Traxler 2013a; Traxler & Vosloo 2014; UNESCO 2012a). However, there is no clarity or conceptual model on what the exact contribution of teaching and learning with mobiles is to educational processes and outcomes that allows mobile learning programmes to be linked to development outcomes such as reductions in poverty and inequality. Some commentators assume that any mobile learning project in LMICs inherently carries a developmental agenda and contribution (e.g. Brown 2005; Agence Française de Developpement 2014; ITU 2015). However, albeit education being a main factor contributing to development, it cannot be equated with development. Questions of access to and quality of education, for example, negate a linear pathway from the provisioning of educational services to socio-economic development (Tikly & Barrett 2011; Lewin 2009; Unterhalter 2015). Similarly, just because a mobile learning project is conducted in an LMIC does not mean it involves disadvantaged learners and teachers. South Africa, an upper-middle income country, for example, has a vibrant mobile learning research and practice community, but much of its work is focused on well-equipped urban schools in affluent suburbs (Batchelor 2007; Ford et al 2014). As a result, mobile learning's contribution to development needs to be investigated and understood in detail in order to allow for careful programme design and consistent conceptualisation.

Mobile learning's pedagogical contribution to development

From an educational perspective, mobile learning's contribution to development is defined through its pedagogical value (Winters 2013; 2015; Unwin 2015; Traxler & Vosloo 2014). That is, by supporting new teaching and learning practices that can cater to the specific educational challenges in LMICs, mobile learning assumes developmental potential. Such challenges can refer to large classroom sizes with few individual and tailored learning opportunities, frontal and teacher-centred lesson designs, a lack of locally-relevant educational content, among other (Westbrook et al 2015; McCowan & Unterhalter 2015). Applying Kearney and peers' (2010) three-level framework of mobile learning's pedagogical value, a range of scholars have outlined how the particular pedagogies supported by mobile devices might be well-suited to address some of the specified educational challenges in LMICs (e.g. Asabere 2013; Motlik 2008; Iqubal 2012; Rao 2013)[15].

In terms of personalisation, mobile learning is assumed to be able to support more self-

[15] This overlaps with related work in the domain of mHealth, which is however outside the scope of my thesis (c.f. Winters 2017; Pimmer 2013)

directed learning under the agency of learners and tailored to their preferences (Asabere 2013; Masperi 2008). Frias-Martinez and colleagues (2013), for example, show how a game-based mobile learning tool in both formal and informal settings at a low-income school in Peru facilitated a more engaging and learner-centred educational experience. In terms of authenticity, mobile learning is linked to the facilitation of more contextualised and less-bounded learning activities. Resources for field trips and school excursions in many LMICs are limited and educational content is often not tailored to the ethnic and linguistic diversity of learners. Ekayanke (2013), for instance, illustrates how science teachers in Sri Lanka explored mobile phones to relate subject knowledge to authentic locations and activities during teaching. In terms of collaboration, reference has already been made to Zurita and Nussbaum's experiments in Chile with further examples of collaborative mobile learning pedagogies aiming to support more learner-centred teaching strategies in LMICs being presented by Jere-Folotiya and peers (2014) and Kumar and colleagues (2012).

Mobile learning's contribution to international development goals
A second way in which mobile learning's contribution to development has been framed is through its assumed contribution to international development goals such as the MDGs (now SDGs) and EFA targets. This is perhaps most strongly articulated by UNESCO's (2012) working papers series on mobile learning (UNESCO 2012a; 2012b; 2012c). Based on a synthesis of six regional papers on mobile learning, UNESCO (2012c) positioned mobile learning to support the MDGs and EFA targets through four key mechanisms: the use of mobiles to (1) increase access to education; (2) build lifeskills; (3) support gender equality; and (4) enhance learning outcomes. Access to education in this conception is one-dimensional and refers to the use of mobiles to extend educational opportunities to learners currently not integrated in the formal education system. It also relates to creating access to educational content on mobiles such as Text2Teach's video recordings of model lessons provided to teachers (UNESCO 2012b; Deriquito & Domingo 2012). This conception is in line with a supply-driven emphasis of educational policy in international development during MDGs (McCowan & Unterhalter 2015).

UNESCO's focus on lifeskills is largely defined in relation to the former MDGs and EFA targets on increasing numeracy and literacy rates in LMICs. Here again, there is an emphasis on extending the reach of educational opportunities through mobile devices to learners currently not able to access the formal education system. A similar reasoning underpins UNESCO's positioning of mobile learning in relation to gender equality. Gender empowerment is framed as a function of a lack of access to educational opportunities and relevant information for women. For example, access-orientated mobile learning projects such as Niger's adult literacy programme for women, Project ABC, or Text4baby, a free mobile health education for women who lack access to the internet and other sources of health information are positioned to support gender empowerment (UNESCO 2012c). It is only in relation to the fourth contribution of enhancing learning outcomes in which UNESCO for the first time references the need for explicit pedagogical models of mobile learning in relation to the MDGs and EFA targets. Alas, this is not further specified and the report concludes that "at mobile learning's present stage of development, what is most important is offering new kinds of learning opportunities that were not available previously, rather than just making marginal improvements to traditional education" (UNESCO 2012c: 25). However, what these new kind of learning opportunities and improvements refer to is not discussed.

UNESCO's positioning of mobile learning's contribution to the former MDGs and EFA is echoed in subsequent reports of international development organisations (e.g. GIZ 2015; USAID 2015; AFD 2015). Further refinement of UNESCO's positioning towards the end of the MDGs added an emphasis on lifeskills for workforce development (Traxler & Vosloo 2014) as well as a calls for a greater emphasis on quality education (EFA 6) rather than a mere access to education (Unwin 2015). Lastly, a separate body of literature on school-based decision-making and community-based monitoring also has begun to explore the use of mobile devices in reference to the EFA goals (e.g. Cilliers 2015; Aker et al 2015). Scholarly or policy work on mobile learning's relevance to the 2016 SDG goals has not yet emerged.

Revolutionising education in LMICs through the use of mobiles

A third body of literature defines mobile learning's contribution to development through a fundamental disruption and change of current education systems. In this conception, mobile learning is assumed to foster a "revolution" in education in LMICs breaking with existing practices and facilitating learning opportunities and outcomes of unprecedented scale. This conception is particularly expressed by mobile vendor organisations, foremost the GSMA, but can also be identified in selected UNESCO and USAID reports. For example, mobile learning's potential to "revolutionise" learning in LMICs is explicitly referenced in Banks (2013: 6), UNESCO (2014: 83; 2015), and GSMA (2012a: 5).

The assumed potential of mobile technologies to fundamentally disrupt and alter education in LMICs is most comprehensively outlined in three GSMA reports on mobile learning in 'emerging markets' (GSMA 2010; GSMA 2012a; GSMA 2012b). In the report mLearning: A Platform for Educational Opportunities at the Base of the Pyramid*,* the vendor organisation claims that mobile learning programmes can “give our most vulnerable children, a teacher in their pocket, a classroom in their hand, and a future at their fingertips” (GSMA 2010: 3). The report estimates that mobile learning could enhance future income of learners by as much as 20% and that a failure to transform education through innovative approaches such as mobile learning risks leaving youth “imprisoned by poverty, immobilised by insecurity, and beyond the reach of traditional aid” (ibid). In a subsequent report GSMA goes as far as claiming that 180 million children will have the opportunity to stay in school between 2013 and 2017 due to advancements in mobile learning interventions (GSMA, 2012b)[16]. The organisation thus urges educational policy-makers in LMICs to transform learning through mEducation as “few (education) services are as rich with potential as mLearning or have the potential to create such positive change (on life prospects of young people)” (GSMA 2012a: 36-37). This GSMA position on mobile learning in LMICs, however, has been critiqued strongly (Winters 2013) and needs to be contextualised with the vendor organisation’s commercial interest.

Yet, the GSMA is by far not alone it the creation of a narrative that positions mobile learning to carry the potential to revolutionise education in LMICs in order to support development. The UNESCO, too, describes mobile learning’s impact on education as to be “without precedent” (UNESCO 2012b: 10) proclaiming the already mentioned mobile reading revolution in LMICs. The World Economic forum likewise assumes that “mobile learning provides a level of scope, reach and flexibility that is largely unattainable through traditional classroom environments” (WEF 2012: 5–6), attributing it the potential to be able to “systemically redefine the way that individuals and communities can contribute to society” (ibid). And, neither are academics and NGOs immune to subscribe to this revolutionary narrative of mobile learning in LMICs. For example, Kim and peers (2008) refer to their mobile learning interventions in Latin America as a ‘Pocketschools’ and Worldreader has described its provisioning of eBooks to community libraries in Ghana as to provide a clear link between the development of literacy skills and positive effects on poverty, health, gender equality, and social mobility (Worldreader 2015: 10).

What is particular striking in the revolutionary narrative of mobile learning’s contribution to development is the strong emphasis on access to devices. A mobile phone is positioned as a classroom at hand or in the pocket; potential increases in access to educational content such as e-books and access to informal educational opportunities are linked to increases in life earnings and social mobility. Little reference is made to how exactly access to mobile

[16] I am not aware of a follow-on report or evaluation of this claim.

technologies can be translated into these massive assumed development outcomes. It might also be asked whether such big claims to revolutionary impacts are backed up by equally strong research evidence (Langer et al 2014; Traxler 2013a; 2013c). In the next section, I therefore aim to unpack the outlined potential contributions of mobile learning to development illustrating to what extent scholars agree with them and what critiques have been offered.

2.3 Critiques of mobile learning's positioning as a development intervention

Mobile learning's positioning as a development intervention, that is the assumption that mobile learning programmes in LMICs can contribute to development outcomes, is not without critique. Winters (2013: 402), for example, posits that "*despite many years of research, and countless implementation projects, there has been little advancement in understanding the contribution mobile learning can make to development goals".* The three propositions above of how mobile learning can contribute to development thus need to be carefully interrogated. Below, I provide a synthesis of three key challenges levelled against current understandings of mobile learning as a development intervention identified in the literature: (1) a lack of evidence of effects; (2) a focus on simplistic causalities; and (3) an overly techno-centric conception of ML4D.

2.3.1 Critique 1: Mobile learning's empirical performance in LMICs

A range of scholars have expressed concerns that proponents of mobile learning in LMICs have provided little empirical evidence that allows for the attribution of the educational use of mobiles to claimed development impacts[17]. The 2016 World Development Report describes the current evidence-base on mobile learning's impact as weak (World Bank 2016: 146). Trucano (2013) as well as Traxler (2013b) claims that ML4D's proponents might subscribe to a 'faith-based' assessment of mobiles' educational and development impact, rather than a research-based view. Isaacs (2012: 7) concurs with this assessment explicitly illustrating a "dearth of evidence-based research and the limited credibility and trustworthiness of available information on mobile learning in the Africa and Middle East region".

This perceived lack of an absence of rigorous research evidence on mobile learning's effects on education and development outcomes applies equally to all three contributions of mobile leaning outlined above. Traxler (2013b), for example, highlights that outside of small-scale pilot studies the ability of mobile learning to fundamentally alter teaching and learning approaches in LMICs has not been assessed. Likewise, there has been no explicit evaluation of mobile technologies' educational contribution to either the MDGs or EFA targets[18]. Large-scale mobile technology programmes in the education sector in LMICs, however, have been terminated with neither the government of Kenya, Thailand, or Turkey

[17] Development impact here refers to prevailing definitions of development in the literature, e.g. changes in poverty rates, the Human Development Index, economic growth rates, and the MDGs.
[18] Unwin (2015) provides an assessment of the evolution and prospects for the use of mobile technologies to improve education access and learning outcomes for the 2015 Education Global Monitoring Report though.

completing the roll-out of the nation-wide mobile technology programmes in schools (Tamim et al 2015).

The need for rigorous evidence of mobile learning's impact is arguable most acute for proponents of a mobile learning revolution in LMICs. Given the magnitude of their claims, the burden of proof weights particular heavily on these actors[19]. It is concerning then that UNESCO's claims to mobile learning's revolutionary effects on education in LMICs are based on an online survey of the Worldreader programme, which found that female participants read seven minutes per day on their mobiles, while male participants used their mobiles to read for a sole minute per day (UNESCO 2014: 30). Albeit, this being an extreme example, it pays testimony to a wider pattern of ambitious claims for ML4D's potential and impact that are rarely grounded in reliable research evidence. Donner (2016: 89) dubbed this pattern as mobile learning's 'enthusiasm gap' and Tamim et al (2015: 2) conclude that launches of government-led tablet initiatives in 11 countries was, by and large "driven by the tablet hype rather than by educational frameworks or research-based evidence".

In recognition of this thin evidence-base, an increased investment in quantitative and qualitative impact evaluations of ML4D programmes can be observed since the early 2010s (Langer et al 2014; Traxler 2013a)[20]. However, the results of these evaluations do not provide a coherent picture of mobile learning's effects. While some evaluations of individual mobile learning pilot programmes find evidence of improvements in learning outcomes (e.g. Aker et al 2010; Kaleebu et al 2013), other studies fail to replicate such effects (e.g. Cole et al 2012; Chen et al 2010) and even identify potential for harmful effects (e.g. Potter et al 2016). This situation of a growing and diverse evidence-base provides an opportunity for methods of research synthesis such as systematic reviews to be applied.

However, there has been no systematic investigation of the impact of mobile technology's provision as an assumed educational tool in LMICs at a research synthesis level. While a number of high-profile meta-analyses and systematic reviews (Petrosino et al 2012; McEwan 2013; Snilstveit et al 2016) of educational interventions in LMICs have identified *ICTs* as an effective tool, these synthesis studies have not included mobile technologies. There have been a number of literature reviews and landscape reviews on the use of mobiles to support education in LMICs (e.g. Valk et 2010; Wagner et al 2014; GIZ 2015), but

[19] For a detailed discussion on the relationship between claimed impacts for an intervention (in any area) and the size and nature of evidence required to support these claims, see Guyatt et al (2011), White (2015), and Glennester (2017).
[20] This acknowledges important contributions on the challenges of evaluating the effects of mobile learning programmes (Vavoula & Sharples 2009).

these do not conduct a formal methodological synthesis of mobile learning intervention effects. The only studies to do so are presented by Tamim and peers (2015) and Hassler and colleagues (2016), but both reviews are only focused on tablets and do not limit their scope to LMICs exclusively.

In sum, there is a strong challenge that claims of ML4D's effectiveness are rarely based on reliable systematic evidence and that there is a current gap in ML4D's evidence-base at a research synthesis level. Despite a growing number of rich and diverse primary research studies, no attempts have been made to analyse or synthesise the combined knowledge in the domain using formal methods of research synthesis such as systematic review and meta-analysis. This evidence gap is particular concerning given the magnitude of claims to mobile learning's large and disruptive impact on education and development in LMICs (Traxler & Vosloo 2014; Unwin, 2015; Langer et al 2014).

2.3.2 Critique 2: Simplistic causalities between mobile technologies, education, and development

A frequent explanation offered for the absence of evidence on mobile learning's effects relates to a second critique on mobile learning's assumed contribution to development: that ML4D proponents have adopted overly simple causalities between access and use of mobile technologies, education outcomes, and development (Wagner 2014; Traxler 2013b; Unwin 2015). This critique is particularly targeted at the assumed integration of ML4D with the former MDG an EFA targets (Traxler 2013b; Leach 2008). It holds that ML4D proponents such as UNESCO have not sufficiently conceptualised either the use of mobiles, educational outcomes, nor development. First, all three components of ML4D remain under-defined in most policy documents on ML4D (Traxler 2013b; Unwin 2015). Second, the causal links and pathways between the three components are outlined in a narrow linear fashion. Endogenous access to and use of mobile devices is assumed to lead to educational applications of the technologies; these applications in return are assumed to lead to improved educational outcomes; which then somehow translate into a black box of development impact (Traxler 2013a; Wagner 2014). In this linear pathway, key questions such as why access to and the use of mobiles is able to circumvent systemic challenges in LMICs, which negated other educational inputs desired educational outcomes, are not addressed. Unfortunately, neither the introduction of technology, nor the process of education, let alone development, seems to follow such a linear pathway in practice (Leach 2008; Unwin 2015).

As a result, ML4D seems to lack a viable theory of change (Wagner 2014). Assuming direct causalities between three complicated to complex problems in their own right (i.e. effective use and integration of mobile technologies in educational processes; enhancing educational performance and outcomes; and reductions in poverty and inequalities) is described as 'naïve' (Unwin 2015) or as 'a failure to think clearly' (Traxler 2013b). In this pathway, mobile technologies essentially act as a magic bullet in education in LMICs which 'ought to be successful' seeing the impact mobile technologies had on other development domains (ibid). If mobile learning were to be able to support such a wide range of development outcomes—improving educational attainment, building lifeskills, supporting gender empowerment, and integrating disadvantaged groups into the educational system (UNESCO 2012c)—mobile learning requires multiple and overlapping pathways linking technological inputs to causal changes on these diverse education and development outcomes. For example, if mobile learning is embedded within existing educational structures that are subject to systemic limitations—say an exclusion of certain groups of learners—ML4D's theory of change needs to be explicit about the processes and outcomes that mobile learning triggers which are different from the educational status quo and therefore allow the assumption that these systemic limitations will be circumvented. In short, while mobile devices might feature intrinsic affordances that could facilitate transformative pedagogical innovations, mobile learning programmes—and since ML4D interventions as well—need to be explicitly designed for this objective.

This critique is thus not so much about whether mobile learning's contribution to development follows effective or meaningful pathways; rather it is about the absence of an explicit definition of these pathways, for example in form of a theory of change for ML4D programmes (Wagner 2014; Traxler 2013a; Unwin 2015). There is thus much conceptual development left for ML4D scholars and Traxler (2013b) further cautions that the development of a programmatic theory and logic model is just the first of many steps in ML4D conceptual development, flagging the need to unpack mobile technologies inherent ideologies and the impact of political realities in education in LMICs.

Yet, a range of scholars have expressed concerns with this line of argument (e.g. Ally 2009; Asabere 2013; Leach 2008; ICCD 2013; Donner 2016; Kinuthia & Marshall 2013). While not disputing that mobile learning programmes in LMICs suffer from simplistic causalities, they dispute that ML4D has no theoretical grounding at all. Leach (2008) and Donner (2016) in particular make a strong case that many mobile learning programmes in LMICs supported by development agencies can be seen as to follow a human capital approach (Becker 1964) to both education and development. This argument seems to be able to at least partially explain how development actors such as the UNESCO assume an implicit link between education outcomes and development. Framing education with a narrow purpose of contributing to increased human capital allows for a linear link between increased education outcomes, such as skills, and economic definitions of development, such as increases in productivity and Gross Domestic Product (GDP).

2.3.3 Critique 3: A techno-centric approach to ML4D and its risks

A third line of critique on mobile learning's positioning in relation to education and development unpacks the implications of following a techno-centric approach to ML4D. This critique is broader than the above critique of simplistic causalities, which is an inherent issue in device-based, techno-centric conceptions of ML4D[21]. In a narrow techno-centric conception of ML4D, access to mobile devices or access to educational content on mobile devices becomes the primary contribution of mobile learning to education and development in LMICs. I have shown above that such a focus on access was particular prevalent in the positioning of mobile learning to contribute to formal development goals and in the positioning of mobile learning as to disrupt and revolutionise education in LMICs. This focus on access and the provisioning of technologies as the key component of mobile learning interventions is problematic in two ways: one, it neglects mobile learning's pedagogical potential and underpinning, and, two, it fuels a deficit model of education in LMICs risking to undermine its current structures through the creation of parallel educational processes.

First, as outlined in 2.1.3 and 2.2.3 the innovation and educational contribution of mobile learning rests on the different pedagogies, often more learner-centred educational approaches, that the affordances of mobiles can support. From an educational perspective, the mere provision of mobile devices and educational content on mobile devices excludes this innovation and contribution. The progression of definitions of mobile learning in the educational sector has for good reasons moved away from a device-based, techno-centric understanding of mobile learning towards a learning activity-based, pedagogical understanding. In the development sector, however, this progression has stalled and both Traxler (2013b) and Winters (2013) highlight that current definitions of mobile learning in international development are directly at odds with definitions in the educational sector. This

[21] To be clear, this is not to suggest that techno-centric approaches to ML4D by design are inherently problematic. For example, in cases where the educational environment is stable and the applied device has a close fit with the educational need, the provision of technologies might be all that is needed as an intervention design (e.g. Aker et al 2010; Velghe 2014). I would argue, however, that these conditions are rarely given in the educational contexts of LMICs.

outdated techno-centric understanding of mobile learning has negative implications for the potential of ML4D programmes. For example, in a review of the application of mobile learning in LMICs during the course of the Millennium Development Goals, Unwin (2015) identified a techno-centric approach as the main obstacle to a transformative role of mobile learning. This overlaps with similar conclusions reached by an earlier review of teachers' roles in mobile learning in LMICs (Isaacs 2012) and experiences of selected pedagogical-rich ML4D programmes (e.g. Buckner & Kim 2014; Ekanyanke 2013).

Second, a techno-centric approach to ML4D runs the risk of fuelling a deficit model of education in LMICs and to undermine its current structures through the creation of parallel educational processes (Winters 2013; 2015; Traxler 2013b; Smith et al 2011). Introducing the mere provisioning of mobile technologies or content on mobiles as on a par with or even as a solution to existing educational processes requires a reframing of education in LMICs as a series of absences; for example, a lack of text-books, a lack of access to information, a lack of motivated teachers, and so forth. Only through reframing education in this matter can simple inputs such as access to mobile technologies be positioned as a solution to educational challenges in LMICs. Only through presenting existing educational structures and systems as 'dysfunctional', 'broken', or 'in crisis' can the need for mobile technologies as an appropriate solution be delineated (Traxler 2013b; Winters 2013). Access-driven positionings of ML4D such as the need for a 'teacher in the pocket' or 'a classroom in your hand' seem to rapidly lose their appeal once existing classrooms and practicing teachers were framed in a more positive way.

By presenting existing educational structures and the actors shaping them as part of a dysfunctional education system, a techno-centric approach to ML4D allows mobile learning programmes in LMICs to be positioned as an adjunct to the formal education system, rather than an integral part of it (Winters 2013; 2015). The introduction of mobile technologies then serves to construct alternative, inherently more effective structures and, in doing so, instead of transforming the existing system, sets up parallel educational structures. This parallel set-up has clear negative implications for the existing educational system and its actors, which at best are viewed as non-relevant, and at worst regarded as obstacles to be removed in order to not hinder educational 'progress' (Traxler 2013b). The consequences of framing education in terms of access to and delivery of educational content on sophisticated mobile devices are particularly grim for cost-intensive investments into teaching staff and qualifications, educational infrastructure, and curriculum development. For example, if applications on mobile devices (e.g. the Worldreader app) are attributed the power to 'revolutionise' reading and thus literacy in LMICs, there is little need to invest scarce public

resources into the training of teachers to more effectively facilitate literacy lessons.
To be clear, the above narrative is observed in practice. UNESCO and UNICEF are pioneering the development of a ‘Digital school in a box’, a literal box featuring a solar-powered multimedia kit built around a laptop, projector, document camera, and speaker, that is assumed to deliver formal education in remote rural areas (UNESCO/UNICEF 2017). A similar concept is applied by the DFID-funded solar classroom in the box (SolarClassRoom 2017). Tamim and peers’ (2015) also report on an OLPC-inspired tablet programme in rural villages in Ethiopia which lacked access to formal schooling. Here, “tablets were dropped off in the villages in boxes taped closed, with no instruction, and the children were followed to investigate how much they could learn without training or teacher support” (Tamin et al 2015: 18). These practical examples reflect attempts to develop exogenous mobile education solutions that could provide an easy fix to bypass or revolutionise the existing, cost-intensive education system.

Subscribing to a techno-centric approach to ML4D thus carries the risk to undermine existing educational structures in LMICs. Rather than supporting these structures and the actors shaping them, mobile learning is positioned at best as adjunct to them and at worst as in direct conflict to them. It is in the context of this conflict that the need for an explicit and conceptualisation of the role and contribution of mobile learning in international development has emerged.

Conclusion

This chapter has reviewed the existing research and practice of ML4D. In particular, it has investigated how the use of mobile technologies to support education in LMICs is conceptually linked to development outcomes. It thereby outlines the rationale for my main research questions evidencing the conceptual and empirical gap on mobile learning's contribution to development. Following a review of the pedagogical grounding of using mobiles technologies to support learning processes, that is mobile learning, I contrasted this pedagogical understanding of mobile learning with its understanding in the development literature. This juxtaposition illustrates that mobile learning is largely understood in a techno-centric manner in the context of development with an emphasis placed on the access to mobiles and the educational content hosted by them. I also illustrate that mobile learning's contribution to development outcomes is often framed as to disrupt and revolutionise education in LMICs with the ability to generate vast gains in learning outcomes.

However, I then provide three key critiques in the literature that question the conceptualisation of mobile learning as a development intervention. First, there is a disconnect between the assumed vast development potential of ML4D and the empirical evidence-base on the effects of using mobile technologies to support education in LMICs. This justifies the needs for my systematic review of the overall effectiveness of ML4D interventions. Second, there is a lack of an explicit theory of change for how the use of mobile technologies is assumed to support education in LMICs and subsequent development outcomes. Current ML4D programmes and policy positions assume simplistic causalities and under-define both education and development. This gap justifies my second systematic review objective of developing a theory of change of ML4D. Third, due to its techno-centric positioning, ML4D interventions run a risk of circumventing and undermining the existing education system. This positioning presents ML4D as exogenous to existing educational efforts and is at odds with a people-focused perspective of education and development in LMICs. Based on the above, I then conclude that the positioning and conceptualisation of ML4D as a development intervention is doubtful. An explicit conceptual framework is required to outline and define mobile learning's contribution to development, and I propose the CA as such a framework, which is discussed next.

Chapter 3. Literature review 2: the Capability Approach

Introduction

This chapter presents the second of my two literature review chapters and introduces the Capability Approach (CA) as conceptual framework to analyse development processes and outcomes. It outlines the rationale for introducing the CA as a conceptual framework to mobile learning for development (ML4D) based on the empirical and conceptual gap on mobile learning's role and contribution to international development illustrated in the previous chapter. It also reviews the theoretical foundation of the CA. The chapter's introduction of the CA aims to explore whether there are sufficient synergies between the CA's conceptual devices and the needs of my targeted conceptualisation of ML4D; and whether such synergies would provide a space in which to apply the CA as a conceptual framework to ML4D.

To explore these conceptual synergies, I first review literature on the theoretical and conceptual foundations of the CA itself. This aims to facilitate a basic understanding of the CA and its contribution to development theory and practice. This introduction is then followed by an investigation of the operationalisation of the CA in two bodies of research closely related to ML4D: ICT4D and education in Low- and Middle-Income Countries (LMICs). These serve to underline my proposition that the CA indeed presents a relevant conceptual framework to define and outline the contribution of mobile learning to education and development in LMICs. The chapter concludes with a brief summary.

3.1 Introducing the Capability Approach to ML4D

The conceptual space for the introduction of the CA to ML4D arises from four gaps and shortcomings in current understandings of ML4D reviewed above:

(1) A narrow view of access to mobile technologies.
(2) A reductionist notion of the processes and outcomes of education in LMICs.
(3) A reductionist notion of the processes and outcomes of development in LMICs.
(4) An exogenous positioning of mobile learning as an adjunct rather than integral part of the education system in LMICs.

Using the CA as a conceptual lens, I show how ML4D can be moved away from a techno-centric, access-based view of mobile technologies towards a view that prioritises what educational actors can do with these technologies in their respective contexts. I illustrate how a CA perspective on ML4D guides a more holistic conception of education outcomes and definitions of quality education in LMICs. This directly relates to a similar conceptualisation of what constitutes 'development' in ML4D using the CA's definition of 'Development as Freedom' (Sen 1999).

My assumption that the CA could be operationalised in this pursuit is based on its existing application in two bodies of literature closely related to ML4D: ICT4D (e.g. Kleine 2013; Zheng 2009; Zelezny-Green 2017) and education in LMICs (e.g. Walker &Unterhalter 2007; Unterhalter 2005). Below, I first provide a brief introduction to the CA and its underlying theory and concepts, before then describing the application of the CA in ICT4D and education in LMICs. Having reviewed its application as a conceptual lens, I then justify my assumption that the CA can similarly guide a conceptualisation of the role of mobile learning in international development.

3.1.1 The Capability Approach: theory and key concepts[22]

The Capability Approach is a normative and evaluatory framework to conceptualise the space in which human well-being and development should be assessed (Sen 1992; 2009; Alkire 2005; Zheng 2009). It was developed by Amartya Sen beginning with his 1979 Tanner Lecture on Human Values titled 'Equality of What?' (Sen 1982) and subsequently refined over the last four decades (Sen 1985a; 1985b; 1992; 1999; 2009). Much of Sen's work on

[22] The purpose of this section is not to provide a comprehensive introduction to the complexities and subtleties of the CA. Rather, it aims to provide an introduction to the core concepts and theoretical underpinnings of the CA with a particular focus on how they have been applied in the context of technology and development.

the CA is highly economic and philosophical and not easily accessible to a wider development studies audience (Kleine 2013). As a result, his comprehensive overview of a capabilities perspective on international development, “Development as Freedom” (Sen 1999) is most associated with the CA by a development audience. However, Sen’s work, as well as the CA itself, has applicability to human development and well-being in any research domain. Sen’s development of the CA bore out of a dissatisfaction of different approaches to conceptualise human well-being and development, most notably utilitarism (Bentham 1789; Mill 1861), resource-based approaches such as income-, wealth-, and asset-based measures (e.g. GDP and other indicators of national accounts including monetary poverty lines as applied by the World Bank), and means-orientated evaluatory approaches such as John Rawl’s ‘primary goods’ (Rawls 1972) (Sen 1999; 2009). His aim was to provide an alternative informational space that could better capture an individual’s real opportunity to choose and pursue a live she has reason to value; which he argues is not sufficiently provided for when focusing on individual’s levels of utilities, income, primary goods, etc. (Sen 1999).

It is important to consider though that Sen is explicit that the CA is not a theory but an approach that constitutes of a range of analytical devices that can be applied in different ways (Sen 1999). Some scholars therefore prefer the term ‘capabilit*ies* approach’ to reflect the plurality of perspectives comprising the CA’s analytical devices (e.g. Kleine 2013; Venkatapuram 2011). A key iteration of the CA refers to Nussbaum’s development of the CA from a moral and political philosophy perspective, the intricacies of which are not discussed here. It is important to recognise, however, that the CA’s association with the concept of human development in the field of international development, which results from its contribution to UNDP’s Human Development Reports, is more prevalent in Nussbaum’s conception of the CA as ‘The Human Development Approach’ (Nussbaum 2010; Venkatapuram 2011). Lastly, before turning into more detail to the analytical devices of the CA itself, it is important to acknowledge that the CA remains deliberately open-ended and receives ongoing conceptual development (Sen 2009). Key developments in the broad field of international development refer to Alkire (2005), Deneulin (2009), and Fukuda-Parr (2003).

Capabilities and functionings

As an analytical and ethical framework, the CA asserts that the right space or informational basis on which to assess human well-being and development are capabilities and functionings. Functionings refer to “the various things a person may value doing or being” (Sen 1999: 75). For example, valued being and doings in the context of ML4D could refer to 'being connected' or 'generating content'. Capabilities, then, refers to "the various combinations of functionings (beings and doings) that the person can achieve (Sen 1992: 40). This positions capability as a freedom, the freedom of a person to "lead one type of life or another" (ibid). In short, "a functioning is an achievement, whereas a capability is the ability to achieve" (Sen 1987: 36). Taken together, capabilities and functionings are thus the key analytical devices of the CA.

The CA's core inquiry is what each person is able to do or be. Such an investigation is necessarily focused on choice or freedom and Sen asserts that it is crucial to make a distinction between a freedom or opportunity to be and do certain things (i.e. capability) and the achieved outcome of being and doings these things (i.e. functionings). To illustrate, a teacher in an affluent and well-resourced school and who has been trained in technology usage may have the same educational functioning in terms of being promoted for achieving certain pass rates as a teacher in a remote school without resources and professional development. However, the capability set or opportunity of both teachers to achieve this functioning is not equal.

The normative dimension of the CA then posits that the focus of social interventions and social arrangements should be firmly on the expansions of people's capabilities. It holds that "the crucial good society should be promoting for their people is a set of opportunities, or substantial freedoms which people then may or may not exercise in action" (Nussbaum 2011: 20). This is the rationale for Sen's definition of development as "the process of expanding the real freedoms that people enjoy" (Sen 1999: 3)[23]. In this conception, the expansion of effective freedoms to live the life one has reason to value becomes both the principal means and primary end of development. That is, an expansion of human freedoms has intrinsic value and the assessment of development has to be informed by it (freedom's constitutive role); but an expansion of people's freedoms (i.e. capability) to pursue their valued being and doings is likewise a key mechanism to support development outcomes (freedom's instrumental role). This conception of development differs strongly from a definition and assessment of development in terms of income, consumption, or economic activity.

Resources, commodities, and conversion factors

In the CA, capabilities and functionings do not exist in a black box. Capabilities are generated by inputs, which refer to resources or commodities and the characteristics thereof

[23] This includes the removal of major sources of 'unfreedoms' such as tyranny, poor public facilities, repressive social norms (Sen 1999: 3).

(Sen 1992). Mobile technologies provide a good example of a resource. In the language of the CA, resources present the ‘means to achieve’ (Sen 1992; Rosebyn 2005). However, the ability of ‘means to achieve’ to translate into capability crucially depends on a person’s conversion factors. For example, a person might have access to mobile technologies, but might not explore the capability to be able to connect with friends through the device due to a lack of network reception. Sen identified three different types of conversion factors—personal, social, and environmental—which mitigate the extent to which people can generate capabilities from resources provided. This conception reduces the importance attributed to the provisioning of resources such as mobile technologies, which only become meaningful developmental inputs through the capabilities that people are able to generate of them.

If a person is able to transform access to a resource through her conversion factors into a capability, she has gained the ‘freedom to achieve’ (Sen 1992; Rosebyn 2005). The freedom to achieve thus represent her set of available capabilities that her conversion factors allow her to explore based on the provided resources. However, freedom to achieve is distinct from the actual achievement or valued functioning. For a range of reasons, a person might choose to not translate a freedom to achieve into an actual functioning. As an example, a teacher might be provided with a mobile device (resources) and possess the skills (conversion factor) to use it to generate more learner-centred lesson designs (educational capability), but chose not to do so in practice (functioning) as she might prefer a different type of lesson design. This distinction between freedom to achieve and actual achievement is important to note as it highlights the need for choice and agency to be taken into consideration in addition to the focus on resources and conversion factors as the only determinants of capabilities and functionings (Sen 1992; Haenssgen & Ariana 2017).

Agency and well-being

The full set of capabilities of a person represents her freedom to achieve well-being and agency in Sen’s CA. Sen derives his definition of agency in terms of an agent’s ability or freedom to pursue and shape her own destiny and perception of ‘the good life’. This leads to a people-focused (or, more formally, agent-orientated) perspective in which “people have to be seen as being actively involved—given the opportunity—in shaping their own destiny, and not just as passive recipients of the fruits of cunning development programmes” (Sen 1999: 53). This central importance of agency underlines the need for people themselves to be able to define a life they have reason to value including the ability to explore different capabilities and to choose whether or not to translate them into functionings.

Well-being then is constituted of the actual opportunities or real freedoms a person enjoys and her agency and choice to translate these into the achievement of valued beings and doings. In short, capabilities are the basis for the achievement of functionings, subject to people's agency and choice, from which they may derive well-being and human development. The language of human development here is closer to Nussbaum's interpretation of the CA. She holds that it is not necessary to make a distinction between agency-well-being, and capabilities-functionings—in particular in relation to the further distinction of well-being and agency freedom vs. achievement—as the latter (capabilities-functionings) sufficiently incorporate the notion of former (Nussbaum 2011: 200; Oosterlaken 2015)[24]. Her language of human development, though, essentially captures the same process and outcomes as described by Sen as well-being[25].

Concluding remarks on the theory and concepts of the CA

To conclude this abstract introduction to the theory and key concepts of the CA, I provide below an example of their application related to mobile learning in LMICs. Gigler (2015) proposes to evaluate the provisioning of ICTs in development in terms of informational capabilities. Using the CA, this would investigate the capability or opportunity of a recipient of these ICTs to transform access to ICTs into human agency and real opportunities in society to achieve the things she values doing or being, such as learning online. The CA just allows us to investigate how a person's access to ICT can be converted into her ability to integrate the use of ICTs into the pursuit of her own conception of a good life. It also highlights important differences in people's ability to transform access into effective opportunities and valued actions and outcomes such as social norms and power relations.

It is also important to remember that the CA is not a prescriptive theory of development. That is, the CA does not intend to explain poverty, inequality, agency, and well-being or what type of programmes to design in order to address them (Robeyns 2005; Oosterlaken 2015; Zheng 2009). Rather, it presents a "tool and framework with which to *conceptualise* and *evaluate* these phenomena" (Robeyns 2005: 94, emphasis in original). In relation to my investigation of a conceptualisation of ML4D, the CA is thus not applicable to provide guidance on the detailed practical causal pathways between using mobile technologies in an educational context, how this use might support learning outcomes, or how these learning outcomes might be linked to development processes. It only enters my efforts to

[24] This is sometimes also referred to as a distinction between a narrow or broad application of the CA. A narrow application only focuses on the capabilities-functioning aspect as a concept of well-being, whereas a broad application includes issues of agency, procedural fairness, justice, etc. (Oosterlaken 2015; Robeyns 2011)

[25] Throughout the later chapters, I will use well-being and human development interchangeably given the association of the CA in international development with the Human Development Index and the often vague and contested nature of the term well-being.

conceptualise ML4D as a broad conceptual framework providing me with analytical devices required to unpack and investigate these detailed practical causal pathways. In short, the CA provides me with an analytical space or informational basis on which to guide the conceptualisation of what constitutes development in ML4D. As there is currently no existing theoretical and empirical work linking the CA to mobile learning in LMICs, I next present a short detour into the rich literature on the use of the CA in the related research area of ICT4D and education in LMICs. This serves to support my conceptual case for the application of the CA to ML4D providing empirical examples of how the CA has been operationalised to guide similar conceptual inquiries in related bodies of research.

3.2 Investigating technology and development from a capabilities perspective

The role of technology in development is contested and a rich body of evidence testifies to both its creative and destructive potential (Castells & Himanen 2014; Zheng 2007; Oosterlaken 2015; Haenssgen & Ariana 2017). Modernisation theories to development present technological change as a key driver of productivity and therefore economic growth, which is assumed to lead countries onto a pre-defined way towards socio-economic 'progress' (Rostow 1960). In this process, technology is an exogenous input to be adopted in LMICs following the path of technological innovation in HICs. Examples of this model of technology transfer include industrial machinery, green revolution technologies, and most recently ICTs (Castells & Himanen 2014). Scholars investigating the discourse of the latter in development in particular claimed technologies' impact to be overly framed in economic terms. Kleine (2013), for example, shows how the internet was positioned in the context of development as a neutral instrument that would allow economies in LMICs to 'leapfrog' stages of development reaching the pre-defined desirable notion of progressing into 'knowledge economies'. ICT4D scholars have criticised this techno-centric and growth-focused approach as overlooking issues of injustice in access and use, ownership and participation, as well as social and cultural impacts of technology adoption (Oosterlaken, 2015; Kleine 2013; Zheng 2009; Zheng & Stahl 2011). ICT4D initiatives—it was claimed—did not pay sufficient attention to what people can effectively do with the introduced technologies and whether they had the power to decide on the terms and desired outcomes of technology usage and access.

To synthesise and conceptualise these critiques into a coherent framework, the CA has been suggested as a normative lens to investigate the nexus of technology and development by a number of ICT4D scholars (e.g. Oosterlaken 2015; Kleine 2013; Zheng 2009; Haenssgen & Ariana 2017; Andersson et al 2012)[26]. In this, using the CA as a conceptual framework to investigate the impact of ICT4D interventions is positioned to shift attention from the technological artefact towards the individual's effective opportunities to transform the access and usage of the artefact into valuable beings and doings that enhance her well-being. A number of in-depth case studies have shown how this changes the narrative of ICT4D in practice.

For example, Gigler (2015) assesses the impact of an ICT for indigenous development programme in rural Bolivia on ICT users from a capabilities perspective. Entitled

[26] See Oosterlaken (2012) for an extensive overview of the literature.

‘Development as freedom in the digital age’, he conducts a mixed-methods case study on how indigenous people in Bolivia perceive, access, and use ICTs; and how such use influences their livelihoods. ICTs refer to desktop computers mainly and the spread of the internet in rural areas more broadly. He applies the CA to conceptualise the impact of ICTs in rural livelihoods in order to track how access to ICTs can translate into changes in indigenous people’s well-being and human development. His research finds that ICTs can significantly enhance indigenous peoples’ human and social capabilities, which translated into increased well-being and human development. However, the catalyst for this process are people’s ‘informational capabilities’, which Gigler argues should be understood as a catalytic capability akin to literacy or health. Approaching ICT4D from a CA perspective, he urges to “deemphasizes the role of technology” in favour of individual’s and communities’ abilities to appropriate and transform new technologies into their socio-cultural contexts and aspirations about life (Gigler 2015: 27).

Kleine (2013) also uses the CA in a related setting examining how access to telecentres in Chile and a new national ICT policy affect the lives of rural entrepreneurs. Her case study supplements the CA with DFID’s Livelihoods’ framework (DFID 1999) and Aslop and Heinson’s (2005) empowerment framework in order to operationalise the CA as a tool to evaluate the development outcomes associated with access and use of ICTs in Chile. Using the CA, she develops a ‘choice-focused’ view of ICT and development showing how ICTs might function as multipurpose technologies which—depending on users’ choices—can support (and prevent) a variety of social and economic outcomes. She then applies this choice framework in her empirical case study and argues that ICTs made a contribution to human development and well-being for Chilean rural entrepreneurs when applied in a bottom-up fashion to support entrepreneurs’ freedom and agency to explore ICTs in line with the live they had reasoned to value. As much as expanding choice and agency, the investigated ICT policies also carried the potential to constrain choice and agency highlighting the need for a careful design and interrogation of facilitating access and use of ICTs to further a people-centred pursuit of development.

To turn to an example of mobile technologies and the CA in ICT4D, Oosterlaken (2015) highlights how an iPod-facilitated agricultural extension programme in rural Zimbabwe expanded a range of functionings and capabilities of importance to farmers. Investigating the ‘Local content, local voice’ project, she outlines how farmers integrated the provided digital extension opportunities to pursue their well-being goals such as increased income from their livestock. She illustrates how many of the well-being achievements of farmers were not initially targeted by the project design and how a CA investigation highlighted the importance of conversion factors in farmers' well-being achievements. However, Oosterlaken also cautions that technological design choices, such as not opting for constant connectivity and communication affordances, limited the agency achievement of the project. The mobile technology design chosen for the project thus limited its ability to contribute to people's self-determined pursuit of other well-being goals not related to the project objectives.

Lastly, Poveda and Roberts (2017) provide an ICT4D example using the CA that is somewhat related to education. The authors merge critical theories (critical pedagogy and critical feminism) with Sen's CA approach in two cases studies of ICT4D programmes in Zambia and Brazil. They find that in both case studies participants were able to appropriate technologies to support their practical needs, but further to also develop a critical conscious of the structural inequalities surrounding them and how they could use the technologies to uproot these. They use these findings to argue that the CA complemented with critical theories can provide an effective means to guide a conceptualisation of ICT4D that focuses on people's critical agency to unlock ICTs' transformational potential in relation to existing social structures.

These four cited examples show that in the research area of ICT4D the CA has served as an effective conceptual framework to gain a richer understanding of the relations between technology and human development. There are clear parallels in the rationale for using the CA between the research area of ICT4D and its proposed usage to guide the framing of mobile learning programmes in LMICs: a doubtful positioning of access and usage of technology as an end rather than a means; narrow conceptions of intended benefits of technology usage; and a neglect of local realities and participation in the design of programmes and technologies, among other.

However, from a mobile learning perspective the current work of ICT4D and the CA has a number of important gaps. First, there is little work on mobile technologies and the potential capabilities that users might develop from their particular functionalities. Most work on ICT4D has focused on ICT policies and fixed infrastructure such as telecentres, desktop computers, and access to the internet in general. This overlooks important aspects of mobile technologies, which are far more widespread in terms of access, and personal in terms of use, than other ICTs. Frankly, mobile technologies might be relevant to a more diverse set of valued opportunities and functionings. Second, technologies are not discussed in an educational setting, and neither is the role of education, or pedagogies within education, investigated. Education might be presented as required to build basic human capabilities, but is not discussed as a dimension of capabilities in its own right.

Third, as ICTs often cannot assume such a diverse role in users' pursuit of a good life as mobile devices can, the capabilities associated with the use of ICTs are at times framed overly sectoral. For example, Gigler (2015) sees one set of capabilities, i.e. informational capabilities, to serve as a catalyst for another set, i.e. social capabilities. Mobile technologies due to their constant and personalised use in all areas of life might be able to help users explore multiple types of capabilities simultaneously. On account of these gaps, conceptual frameworks operationalising the CA in ICT4D such as Kleine's (2013) Choice Framework cannot simply be transferred to guide the conception of ML4D. Mobile learning is both an educational and a technological intervention and its investigation from a capabilities perspective is required to reflect this.

3.3 Capabilities, mobile technologies, and education in LMICs

The observation that mobile technologies constantly connected to the internet might occupy a special space in the nexus of technology and human development is not novel to this thesis and has been raised in the literature before (Sen 2010; Oosterlaken 2015; Smith et al 2011; Kleine 2013). Most prominently, in a brief article Sen himself presents mobile phones to be “generally freedom-enhancing” (2010: 2). Elsewhere, mobile technologies are seen as driving “one of the greatest expansions of human capabilities in known history (…)” (Smith et al 2011: 77) and have been described as “technologies of choice” (Kleine 2013: 8).

While this should not be read as portraying mobile technologies as anything but mere means, mobile devices seem to combine a number of particular affordances that might allow them to relate to different types of opportunities valued by users (Kleine 2013; Oosterlaken 2015). Mobiles’ ease of use and affordability have made access to the technology ubiquitous and allow a majority of people the opportunity of personal and contextualised usage. Mobile users might then be able to translate this usage into different information and communication opportunities, which in return might support human development, for example allowing users to build social networks and to explore alternative livelihood opportunities. It thus might be worth exploring whether the combination of these unique affordances of mobiles—in particular accessibility, personalisation, contextualisation, connectivity, access to information, and networking effects—might allow mobile technologies to assume a multidimensional role in the expansion of people’s capabilities and well-being.

Mobile learning as an educational approach builds on these particular affordances of mobile devices and the pedagogical innovations and opportunities they can create for learners and teachers (Roschelle 2003; Wali et al 2008). As explained above, a major criticism on the current application of mobile learning in LMICs is the focus on the technological artefact rather than its pedagogical value (Winters 2013; Traxler 2013a). Mobile learning as a socio-cultural educational approach might be well-suited to support some of the specific challenges of education systems in LMICs, for example frontal teaching methods, foreign curricula, and low levels of agency for teachers and learners alike. It is due to this specific contribution that mobile learning has been positioned to be of particular relevance to support education in LMICs.

However, it is important to unpack what is meant when referring to ‘quality education’. In this remit, the CA has found wide application too (e.g. Unterhalter 2005; Walker & Unterhalter 2006; Vaughan & Walker 2012). Concerning education and international development, the

CA has been used as a tool to generate a richer understanding of the perceived ‘low quality’ of education in some LMICs (Unterhalter 2015; Walker 2006; Tao 2013; Tikly & Barrett, 2011). Framing ‘quality education’ in terms of capabilities and functionings shifts the discourse from educational inputs and resources to the agency of teachers and learners to own and determine the educational process. This shift might re-define quality education as an education that supports what each person has reason to value and that provides equality of opportunity rather than equality of resources and outcomes (Walker & Unterhalter 2006; Tikly & Barrett 2011).

A capabilities perspective on education therefore provides an alternative to a range of evaluatory educational approaches such as assessing education in terms of learners’ attainment, human capital, or structural and power issues. Unterhalter (2005) outlines how a CA perspective on education highlights two key issues in education in LMICs: one, teachers’ and learners’ conversion of educational inputs and resources and the inequalities and obstacles in this conversion; and, two, that educational outcomes cannot be narrowly defined in terms of test scores or investments in inputs. As much as being an instrumental capability, education itself is of intrinsic value and, if aimed at supporting development, learners in LMICs require equal educational capabilities, not equal educational inputs (Unterhalter 2005).

A range of practical applications show how a CA perspective alters the conception of quality education in LMICs. Walker (2006), for example, highlights the implication of a capabilities view on education for girl learners in South Africa. She identifies eight capabilities valued by learners (e.g. being able to have choices; being able to participate in learning; bodily and emotional integrity) and shows how these expand the nature and scope of what to consider when aiming to facilitate ‘quality education’ in LMICs. In the context of the Implementing Education Quality in Low Income Countries (EdQual) programme, Tilky and Barrett (2011) also apply the CA for a practical assessment of education interventions. They propose to marry the CA with a social justice perspective to highlight three dimensions of quality education: inclusion, relevance, and democracy, which are assumed to reflect the capabilities that educational actors have reason to value.

Lastly, the CA has also been used to assess the educational realities of teachers in LMICs (e.g. Buckler 2015; 2016; Tao 2013; Cin & Walker 2013). The role of teachers in supporting quality education in LIMCs has been particularly contested and educators’ behaviours, such as absenteeism, lack of preparation, and rote teaching, are often claimed as main causes of quality issues (Carr-Hill & Ndalichako 2005; Chaudhury et al 2006). Using the CA, Tao

(2013) explains how these behaviours can be reframed as “products of the constraints on teachers’ valued functionings inside and outside of schools” (2013: 7). She identifies a number of valued personal and occupational functionings (e.g. being able to take care of family; being able to help students learn) from whose achievement teachers are hindered by surrounding structures and working conditions. Teachers’ behaviour and performance are mitigated by navigating these constraints in the pursuit of their valued beings and doings. Lastly, Buckler’s research on teachers’ professional ambitions and desires in five Sub-Saharan countries comes to similar conclusions (2015; 2016). She identifies 16 capabilities of teachers that overlap to a large extent with Tao (2013). Her work illustrates how teachers own conception of quality teaching is shaped by a range of educational capabilities and functionings, but directly at odds with educational policy-makers’ definitions of quality teaching.

The CA has thus been operationalised as an analytical lens in a range of educational settings in LMICs. None of these, however, have focused on the use of technology—either mobile or fixed—as an educational input. There seems to be good reason to believe that learners and teachers can generate different types of capabilities and valued functionings of the conversion of mobile technologies as an educational resource. For example, mobile learning from a pedagogical perspective is associated with the ability to cross contexts and to personalise and tailor learning and teaching. As explained above, mobiles’ particular affordances might allow for a range of different educational opportunities to be created should teachers and learners wish to do so. Current work on the CA in education in LMICs has not explored these opportunities and there thus remains a gap on investigation mobile learning in LMICs from a capabilities perspective.

3.4 ML4D and the Capability Approach

In sum, there seems to be reason to believe that the CA can be applied as an effective conceptual framework to investigate mobile learning in LMICs. Theoretical and empirical work in the related field of ICT4D has shown that the CA can be operationalised to yield a richer understanding about the role of technologies in human development. Further, there seems to be synergies in the pedagogical underpinning of mobile learning and the perception of mobile technologies as potentially supporting a variety of human capabilities simultaneously. The CA has also emerged as an important voice in debates on improving 'quality' of education in LMICs and the role of teachers in this process. In short, using a CA conception of ML4D can go beyond a simplistic understanding of access to technology and content as mobile learning's main contribution to development. It also enhances the conception of both education and development, which I argued above as currently being under-defined in ML4D.

While these synergies can justify the application of the CA to ML4D in general, an important gap remains as the literature has not investigated the interplay between mobile technologies, education, and capabilities. Capability frameworks and lists of capabilities or functionings developed in the context of ICT4D and education in LMICs cannot simply be transferred to ML4D (e.g. Kleine 2013; Gigler 2015; Walker 2006; Rao 2013). The nature of using mobile technologies to support education and development in LMICs seems to intersect across a range of relevant areas of capabilities as it presents both a technological and educational input. It thus needs to be investigated in its own right rather than adopting of-the-shelf conceptual frameworks developed elsewhere. To conclude, mobile learning might be able to support the expansion of a different set of capabilities, which thus far have been overlooked in previous research applying the CA in education and technology.

Despite the vacant conceptual space in ML4D to allow the introduction of the CA as an analytical lens, there is, to my knowledge, no existing empirical or theoretical work making the case to apply the CA to ML4D. A small body of work on the educational use of mobiles in LMICs references the CA, but does not use its analytical devices in practice (Andersson & Hatakka 2010; Balasubramanian et al 2010; Sahni et al 2008). My thesis aims to contribute to this an explicit empirical exploration of a ML4D programme from a capabilities perspective in order to investigate the operationalisation of the CA as a conceptual framework for ML4D.

Conclusion

This chapter has reviewed the CA as a conceptual framework to understand and define the contribution of mobile learning to development. It has introduced the theory and concepts underlying the CA and outlined its application in bodies of research closely related to ML4D, namely ICT4D and education in LMICs. Based on this review and the synergies between the CA and the needs of my targeted conceptualisation of ML4D, I conclude that there is indeed a sufficient conceptual space in which to apply the CA as a conceptual framework for ML4D. I conclude that the CA with its alternative conception of development as freedom and consequential focus on the notions of capabilities, functionings, and agency as means to live the life one has reason to value (Sen 1999) does present an effective framework to guide a conceptualisation of ML4D in which the link between mobile learning and development might hold.

In summary, the combined two literature review chapters have set up the empirical and conceptual gaps that my thesis is trying to contribute to. In chapter 2, I have indicated how neither the empirical evidence-base nor the current conceptual approaches of ML4D justify the claims and positioning of mobile learning to support education and development in LMICs. In this chapter, I have proposed the CA a relevant conceptual tool to address this lack of conceptualisation regarding mobile learning’s role and contribution in international development. Taken together, my literature review chapters therefore set up the thesis’s research questions and contributions to the literature. In the next chapter, I will outline the research design and methodologies applied in addressing these questions before presenting my empirical research findings in chapters 5–9.

Chapter 4. Research design and methodologies

Introduction

This chapter presents the research design and the applied research methodologies. It provides a detailed description of the research process and the data collected and analysed. I also discuss the ethics involved in these processes. In brief, this thesis employs a mixed-methods systematic review followed by a qualitative case study. The chapter justifies how and why the two applied research methodologies were chosen in order to answer the thesis's research questions.

The chapter is structured as follows. I first discuss the overall research design of the thesis before discussing the two respective research methodologies in return. I begin with the design of my mixed-methods review and emphasise the rationale to adopt a mixed-methods approach. I then provide detail on each step of the review process. Thereafter, I discuss the design of the qualitative cases study. I discuss the chosen case of the Information Communication Technology for Rural Education Development (ICT4RED) programme and describe the primary research process in detail. Finally, for both types of research I flag key ethical considerations.

4.1 Research design: overall thesis

My thesis combines a secondary research methodology with a primary research methodology. The secondary research methodology is presented by my mixed-methods systematic review and the primary research methodology is presented by my qualitative case study. Within the systematic review I combine qualitative and quantitative review approaches whereas the case study follows a purely qualitative approach. I use the findings from both research methodologies to answer my overall research question of how the use of mobile technologies as an educational tool in Low- and Middle-Income Countries (LMICs) can be conceptualised as to contribute to development outcomes. Both research methodologies, however, make distinct contributions in answering this question. Figure 4.1 below provides a visual guide to how the different methodologies contribute differently to answering my research question.

My research commences with the mixed-methods systematic review of existing primary research that has investigated the educational use of mobile technologies in LMICs. The review serves two purposes: examining the impact of mobile learning on education and development outcomes and examining how mobile learning for development (ML4D) programmes have outlined the processes and causal links between the use of mobiles, education, and development in LMICs. Taken together, the systematic review therefore allows me to conclude whether empirical and conceptual claims to mobile learning's contribution to development are warranted.

In order for my systematic review to do so, I need to apply a mixed-methods systematic review design. The mixed-methods design allows me to not only assess and synthesise quantitative evidence on the impact of ML4D programmes, but to also assess and synthesise qualitative evidence on the mechanisms and contexts configuring this impact. Only by combining the synthesised quantitative and qualitative evidence on mobile learning programmes in LMICs can I construct a detailed theory of change for mobile learning and plot the identified review findings against this theory of change. The theory of change thus combines the results from the existing quantitative and qualitative research evidence to assess the empirical and conceptual claims to ML4D's impact.

Empirically speaking, the mixed-methods systematic review of ML4D interventions presents the departure point of this thesis. However, while its findings support an assessment and deconstruction of current conceptions of mobile learning's impact on education and development, the review is bound to assessing *existing* research on mobile learning. As a result, the systematic review findings cannot support me in developing a *new* conceptualisation of mobile learning's role and contribution in international development. For this inquiry—the development of a new conceptualisation of ML4D—I first require an explicit conceptual framework that could define and outline the contribution of mobile learning to development; and then after having identified such a conceptual framework, I need to test it through new primary research for its validity and relevance. I identified Amartya Sen's Capability Approach (CA) as a potent conceptual framework to guide a conceptualisation of ML4D. This decision was based on the application of the CA as a conceptual framework in related bodies of research, namely ICT4D and education in LMICs. In chapter 3, I further reviewed the synergies between the CA and the needs of a conceptualisation of ML4D in more detail to justify my choice of the CA as a conceptual lens.

I then use my qualitative case study research of a mobile learning programme in rural South Africa to apply the CA as a conceptual lens in practice. This serves to test whether the CA can be operationalised as a conceptual framework in research on ML4D. And, if so, to further develop an analytical framework for the educational use of mobile technologies based on the CA. It is important to keep in mind that my case study research does not aim to assess the impact of a ML4D programme, but rather attempts to explore how programme participants themselves experienced the use of technologies as an educational tool, and then to investigate how these experiences can be understood from the perspective of the CA. The main purpose of the case study is of instrumental nature to develop a conceptualisation of ML4D based on the CA.

In a last step, I then conduct a brief conceptual inquiry by combining my capabilities conception of ML4D with my systematic review findings of the empirical evidence on ML4D. This constitutes my rethink of ML4D and explores how a conceptualisation of ML4D based on the CA and the empirical evidence-base on ML4D's impacts changes the understanding and positioning of mobile learning's contribution to development.

Figure 4.1 Visual overview of the research design and methodologies

Research questions

1. How can the use of mobile technologies as an educational tool in LMICs be conceptualised as to contribute to development outcomes?

   1.1 What are the effects of the educational use of mobile technologies in LMICs on learning outcomes, teaching practice, and empowerment?
   1.2 What is the programme-level theory of change for mobile learning for development?
   1.3 Does the Capability Approach serve an effective analytical framework to investigate ML4D?

Secondary research:
Mixed-methods systematic review

The review contributes the following empirical data sets to answer the research questions:

(A) Quantitative evidence on the effects of mobile learning in LMICs
(B) Qualitative evidence on the mechanisms and themes unpacking the effects of mobile learning in LMICs
(C) Configuring a theory of change for mobile learning in LMICs based on (A) + (B)

The review and its findings are needed to:

- Empirically assess claims to ML4D's impact
- Empirically unpack the assumed links between the use of mobiles and education and development
- Conclude whether empirical and conceptual claims to mobile learning's contribution to development are warranted

Primary research:
Qualitative case study

The case study contributes the following empirical data sets to answer the research questions:

(A) Qualitative data on teachers' use of mobile technologies analysed using the CA
(B) A synthesis of the qualitative data in (A) into a analytical framework for ML4D from a capabilities perspective

The case study and its findings are needed to:

- Test the operationalisation of the CA to investigating ML4D
- Develop an explicit conceptualisation of ML4D based on the CA

Combined systematic review and primary research findings

Rethinking ML4D based on:
- a capabilities conceptualisation of mobile learning's contribution to development
- the empirical evidence-base on mobile learning's impact on education and development

4.2 Research design: systematic review

I first provide a justification and outline of the research design applied in my mixed-methods systematic review.

4.2.1 Introduction to systematic review as a research methodology

Systematic review is a research methodology to systematically and transparently identify, access, appraise, and synthesise all available research studies on a given research question or topic. Systematic review is therefore a methodology of secondary or meta research, that is a methodology to conduct empirical research based on data collected from existing research. Formally, systematic review can be defined as “a review of research literature using systematic and explicit, accountable methods” (Gough et al 2012: 2). The methodology’s guiding principles are to be transparent and systematic at any step of the research process (Oliver 2014; Petticrew & Roberts 2006; Stewart 2014). This translates into a set of methodological characteristics associated with any systematic review: a clearly stated set of objectives with pre-defined eligibility criteria for inclusion of primary studies; an explicit, reproducible methodology; a systematic search that attempts to identify all studies that would meet the eligibility criteria; an assessment of the validity of the findings of the included studies; a systematic presentation and synthesis of the characteristics and findings of the included studies (Higgins et al 2011; Gough et al 2102; Stewart 2014).

Different types of systematic reviews and review methodologies have been developed. In addition to conventional systematic reviews, different types of reviews include evidence maps and systematic maps (e.g. Snilstveit 2016); rapid evidence assessments (e.g. Thomas et al 2013) and review of reviews (e.g. Becker & Oxman 2008). Sometimes these reviews are confused with literature reviews. While literature reviews use existing research as a unit of analysis too, they usually lack an explicit empirical research methodology to identify, appraise, and synthesise research knowledge. Systematic review as a research methodology has been developed with direct reference to addressing the shortcomings of literature reviews as a way to draw conclusions based on a body of research (Chalmers 2002; Petticrew & Roberts 2006). In this, systematic review methodology aims to address two key biases within the process of research synthesis: one, biases in the trustworthiness and relevance of the included primary research studies themselves; and two, biases in the process of bringing together and synthesising the included primary research studies, that is biases in the review process itself. If unaccounted for, both biases undermine any type of research synthesis as neither the underlying research used in the synthesis, nor the empirical process of synthesising research is controlled for.

The underlying strength and contribution of systematic review as a research methodology is to provide research findings that are based on the full body of existing research rather than on single studies or on selected groups of studies. However, there are many different systematic review approaches and methodologies in order to synthesise different bodies of research and to answer different types of research questions. Historically, systematic reviews have been most widely conducted in the healthcare sector in order to assess the effectiveness of medical interventions (Higgins & Green 2011; Chalmers 2002; Gough et al 2012). Such effectiveness reviews are based on synthesising quantitative impact evaluations using statistical techniques to synthesise the reported effects, such as meta-analysis. However, systematic review is now widely applied in the social sciences too which has led to a range of iterations and adaptations of the initial methodology (Petticrew & Roberts 2006; Gough et al 2012; Stewart 2014; Langer & Stewart 2014)[27]. Current systematic review methodologies therefore range from more quantitative reviews to more qualitative reviews and the spectrum of review methodologies features a more diverse body of reviews such meta-ethnographies (Nolbit & Hare 1998), meta-narrative reviews (Greenhalgh et al 2005), realist reviews (Pawson 2006) or critical interpretive synthesis (Dixon-Woods et al 2005).

A way to classify and group this plethora of different review methodologies is to investigate them on a spectrum from reviews that aim to aggregate primary research findings to answer a review question and reviews that aim to configure and arrange primary research findings to answer a review question (Gough & Thomas 2016; Oliver 2014; Voils et al 2008; Sandelowski et al 2011). *Aggregative reviews* are associated with reviews that include predominately quantitative data as their main aim is to aggregate or add up findings from multiple, similar research studies. *Configurative reviews* are associated with reviews that include predominately qualitative data as their main aim is to configure or arrange findings from multiple, heterogeneous research studies. Aggregative reviews commonly are thought of as a more deductive review approach as they answer narrow and specified questions using a priori defined quantitative methods to test theory based on empirical observations (Gough & Thomas 2016; Sandelowski et al 2011). Configurative reviews, then, ask more open review questions with less pre-specification of concepts and apply qualitative methods that leave room for iteration and allow for interpretation of specific cases. Configurative

[27] In fact, the earliest attempts to use structured and transparent methods to make sense of a body of research evidence to inform decision-making is recorded in the US education sector in the 1970s (Oakley 2000). Systematic reviews have a longer than usual assumed history in the social sciences. For examples, the UCL Social Science Research Unit was funded in 2000 already to set up an education review facility.

reviews thus tend to explore and generate theory rather than test it in line with an inductive review approach (ibid). However, aggregation and configuration in reviews should be understood as different ends of a spectrum of review approaches rather than dichotomous concepts.

4.2.2 Mixed-methods reviews

Mixed-methods or mixed-knowledge systematic reviews are a growing innovation in research synthesis (Gough & Thomas 2016; Pluye & Hong 2014). They aim to synthesise diverse data sets featuring both quantitative and qualitative research evidence. Based on the concept of mixed-methods primary research, these reviews can address complex questions, drawing on broader types of evidence, and thus a larger pool of research findings. Mixed-methods reviews are further an effective tool to “explore implicit or partially developed theories” due to their ability to arrange different types of knowledge along a gradually developing framework (Oliver et al 2012: 77). Mixed-methods systematic reviews therefore present an adaptation to both, traditional effectiveness reviews and qualitative research syntheses. Mixed-methods reviews have the ability to concurrently test, explain, and develop theories. In reference to programmatic considerations, they therefore contribute knowledge not only on ‘what works’ or only on ‘how and why does it work’, but on both sets of questions.

Conceptually, the mixed-methods approach to systematic review presents a middle ground between aggregative and configurative reviews. Mixed-methods reviews have been operationalised in different forms depending on the specific review question. Van der Kaap and peers (2008), for example, advocate to first conduct an effectiveness review to test the impact of an intervention and subsequently to apply a realist synthesis to understand in what context and for whom the intervention worked. A more fluid mixed-methods approach is taken by Thomas and colleagues (2003), who develop different review questions, review these distinctively, and bring together the findings in a combined synthesis.

Mixed-methods review are particular attractive for reviewing the effects of social interventions (Sandelowski et al 2011; O’Mara-Eves & Thomas 2016; Langer & Stewart 2014).This is based on the assumption that a large body of experimental research in most areas of social science is not available; that interventions often differ in design across contexts and that the underlying mechanisms through which they work are complex and fluid; that implementation considerations and behavioural effects are crucial; and that contexts plays a larger role in determining intervention effects. As a result, mixed-methods reviews have seen an increase in application over the last five years, though they still present a small minority of conducted systematic reviews overall (Gough et al 2017; O'Mara-Eves & Thomas 2016).

In international development, mixed-methods reviews are increasingly popular (Langer & Stewart 2014; Snilstveit 2012; White & Waddington 2012). Most development interventions refer to social interventions and the rationale for mixed-methods reviews outlined above applies. The Campbell Collaboration International Development Co-ordinating Group[28] actively advocates for the production of mixed-methods reviews and different methods for their production have been conceptualised by Snilstveit (2012). Her suggestion of conducting 'Effectiveness Plus' reviews has found wide-spread adoption and the majority of international development reviews—that is, systematic reviews of development interventions—conducted in the last five years have incorporated an assessment of qualitative evidence linked to the reviewed intervention (e.g. Oya et al 2017; De Buck et al 2017; Carr-Hill et al 2016).

The particular nature of my research questions as well as the encountered evidence-base of ML4D justifies the application of a mixed-methods systematic review design. In order to investigate not only 'what works' in ML4D, but further 'why and how' mobile technologies lead (or do not lead) to education and development outcomes, a broad range of research evidence is required. Further, different types of synthesis are needed as I aim to both explicate the theory of change underlying ML4D interventions and to test which steps of this theory of change are empirically supported. This requires processes of configuration as much as aggregation of research data. As a result, on its own, neither a conventional effectiveness review, nor a qualitative research synthesis, would have allowed me to meaningfully synthesise the diverse range of research evidence required to answer my research questions.

[28] IDGC guidelines: https://www.campbellcollaboration.org/resources-international/guidelines-for-reviewers.html

4.2.3 Mixed-methods review design

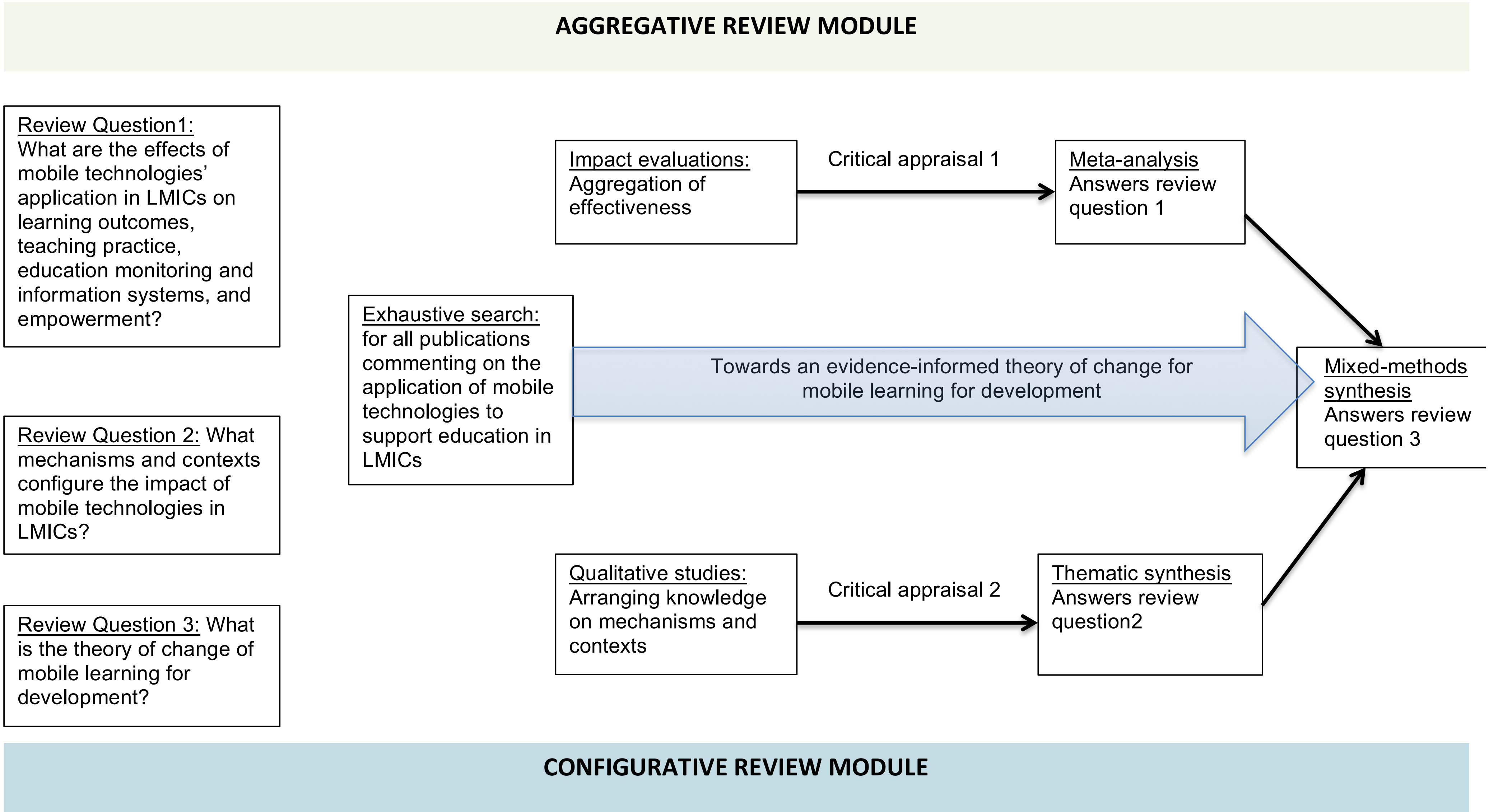
I follow a mixed-methods systematic review design in this thesis. This mixed-methods design is operationalised through a two-module review approach[29]. That is, the mixed-methods systematic review features a distinct aggregative review module and a second configurative review module. This two-module design was informed by the need to meet three research objectives in my systematic review:

(1) Generate evidence of ML4D's impact (or lack of impact).
(2) Generate analytical themes on mechanisms and contexts explaining this impact (or lack of impact).
(3) Construct an evidence-informed theory of change of 'what works, how and why' in ML4D.

In order to construct an evidence-informed theory of change of ML4D I require a synthesis of two types of information: (1) evidence of ML4D's effectiveness, defined as aggregative data measuring the impact of mobile learning in LMICs and (2) analytical themes of mechanisms and contexts to explain this impact (or lack of impact). These analytical themes will allow for a configuration of the potential impacts of ML4D, unpacking the black box of how the interventions might have led to the established outcomes. I therefore design two distinct review modules to be able to generate both types of information and to synthesise them in a mixed-methods synthesis. Each module follows its own logic and design applying an aggregative and a configurative approach respectively. This two-module mixed-methods review approach is presented in Figure 4.2.

[29] This two-module review approach is inspired by Thomas et al (2003).

Figure 4.2 Systematic review approach



The contribution of both review modules is of equal weight in generating the evidence-informed theory of change. The relation between the aggregative and configurative module can best be described as a ‘sequential explanatory’ design (Pluye & Hong 2014), with the configurative module arranging the aggregative findings. Yet, the combination of both types of knowledge to generate an evidence-informed theory of change thereafter is more adequately characterised as a ‘convergent’ design (ibid). There is a danger that the sequential approach might affect the identification of inductive themes in the configurative module, but this risk seems justified keeping in mind that the module’s main mandate is the arrangement and unpacking of the aggregative findings. As a result, after a combined systematic search and application of inclusion criteria, the review commenced with the conduction of the aggregative module. Both review modules used distinct critical appraisal tools and methods to synthesise research findings.

The aggregative module mirrors a traditional effectiveness review. It only includes rigorous impact evaluations of mobile learning programmes in LMICs, judges their quality thoroughly through a risk of bias assessment, and conducts a statistical meta-analysis of the included studies in order to yield a numerical value of ML4D’s effectiveness. This pooled effect size is interpreted as evidence of ML4D’s impact and since assumed to answer the thesis’s first sub-research question. Meta-analysis as a method to establish ‘what works’ in ML4D was chosen because the method presents the most rigorous tool in synthesising quantitative impact measures (Borenstein et al 2009).

The configurative module resembles a systematic review of qualitative research. It is not limited to a particular study design, places a greater focus on relevance and context in its critical appraisal of research, and applies a thematic synthesis in order to establish analytical themes on contexts and mechanisms at play when teaching and learning with mobiles in LMICs. It thereby aims to arrange the aggregative knowledge with the help of the analytical themes on context and mechanism configurations—a process required to design ML4D’s theory of change. Thematic synthesis (Thomas & Harden 2008) was identified as the most rigorous and transparent approach to extract codes and descriptive themes from the included studies, and further, to use these themes to identify mechanisms and contexts in ML4D.

Lastly, the findings of both review modules will be brought together in a mixed-methods synthesis to construct the evidence-informed theory of change of ML4D in graphical and narrative format. In this, the findings generated in the configurative review module allow me to unpack the links between the provision of mobiles, educational process and outcomes, and subsequent changes in socio-economic development. Having outlined these links and relations, I then plot the results of the aggregative module against this theory of change to highlight for which steps and processes in the educational use of mobiles in LMIC there is evidence of effects.

4.2.4 Summary of systematic review steps

This section presents a summary of my systematic review protocol. The full protocol can be accessed as an online appendix[30] and outlined all methodological steps pertaining to the conduct of my mixed-methods review a priori.

Acknowledging the importance of an explicit systematic review protocol to ensure transparency and rigour in the review process, I would have preferred to register my review protocol with a systemic review body. Alas, the only open-access register of systematic review protocols, Prospero, is limited to health systematic reviews. The umbrella body for social science reviews, the Campbell Collaboration, does not cater for the conduct of mixed-methods reviews with an independent qualitative research synthesis. Keeping this caveat in mind, I present below a summary of the most important methodological steps and decisions in the design of my systemic review.

Inclusion/exclusion criteria

I defined a set of pre-defined and explicit inclusion criteria to determine what type of research studies were included in my systematic review. Studies not meeting one of the below criteria were excluded from the review:

Region: All studies conducted in Low- and Middle-Income Countries (LMICs) were eligible for inclusion in the review[31].

Population: No criteria related to the study population were applied. That is, study populations could relate to individuals (e.g. teachers or learners), any other form of human organisation (e.g. communities), and administrative groupings (e.g. schools).

Intervention: As discussed, the term ‘mobile learning for development’ is not clearly defined in the literature. A broad operating definition of ML4D interventions was since applied and I included all studies referring to the use of mobile technologies to support education in

[30] Online appendix 1: https://africacentreforevidence.org/project-outputs-3/

[31] This follows the World Bank classification of economies as of 14 February 2014. Categorisations were applied based on the date of data collection in the primary studies: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

LMICs. Mobile technologies were understood as any ICT device capable of mobile usage[32]. The reference of explicit mobile learning events was not part of the inclusion criteria, but studies had to collect empirical data in reference to the use of mobiles in an educational context. Studies collecting data not linked to the active use of mobiles, for example general surveys of perceptions on mobile technologies not linked to a mobile learning intervention, were excluded.

Outcomes: The review focused on four primary outcomes of interest:

(1) *Learning outcomes*: were broadly defined as any change in the process, perception, and outcome of learning. This ranged, for example, from attendance to motivation and performance of learners.

(2) *Teaching practice*: was broadly defined as any change in the process, perception, and outcome of teaching. This ranged, for example, from changes in lesson designs to teachers' professional behaviour and indicators of teaching quality.

(3) *Education Monitoring and Information Systems (EMIS)*: referred to changes in the way information is collected, administered, and analysed in education systems.

(4) *Empowerment*: might either be an outcome or a process. As an outcome it was broadly defined to embrace various themes such as critical thinking, agency, opportunity, confidence, etc. Empowerment outcomes could be observed at any level (e.g. individual, school, community).

Study design: Two different eligibility criteria for quantitative and qualitative study designs were applied. Quantitative studies were required to use at least a quasi-experimental designs, reporting pre- and post-data of two experimental groups. Qualitative studies were not limited to a particular study design given the absence of accepted standardisations of qualitative research methodologies. In lieu of an inclusion criterion linked to an accepted terminology of qualitative research designs, eligible studies needed to at least report on the following: evidence of an explicit applied research design, and evidence of collected primary data, sampling strategy, and methods of data analysis.

[32] This excludes all studies assessing the impact of the OLPC programme. These were excluded for two reasons: (i) laptop devices at the time of the conception of the review in 2014 were still vastly superior in computing power and affordances to other mobile technologies; (ii) the OLPC programme has been evaluated rigorously elsewhere already (e.g. Beuerman et al 2015; de Melo 2014) and including these evaluations in my review would have inflated the sample of includes and led the review to become an evaluation of OLPC + other ML4D interventions.

Systematic search strategy

In order to identify all relevant literature in this review a transparent, systematic, and exhaustive search for research studies was designed. The search strategy was deliberately formulated to be over-inclusive and as exhaustive as possible to cater for the unstructured nature of the ML4D evidence-base and to reduce single reviewer bias. These two key features of being over-inclusive and exhaustive inform both the design of the search terms as well as the choice of search sources. The full search strategy and report is provided in Appendix 4.1. and was reviewed by an information scientist at the UCL Institute of Education.

Search terms: I combined three search concepts and related terms with each other using Boolean language (Box 4.1). This refers to the intervention concept of mobile learning, the outcome concept of education and development, and the population concept of LMICs. In order to be over-inclusive the intervention concept could be combined either with the outcome or the population term. With a similar objective in mind, no concept related to study design was applied. For each concept different terms were collected and wild cards were applied. A snapshot of the search string is provided below with the master string being reported in Appendix 4.1. The master string was adapted for use in each scientific database and its core concepts were used to guide the Grey literature search.

Box 4.1: Example of search strings

(1) Intervention terms: (e.g. mobile learning OR mobile educational OR mobile technology) **AND** (2) Outcomes terms (e.g. education OR learning OR development) **OR** (3) Population terms (e.g. South Africa OR developing countr*)

Search sources: I consulted a total of 108 search sources. This included both academic and Grey literature sources. The latter were in particular important given that a large body of the ML4D research is conducted by IGOs, NGOs, and vendor organisations. The consulted types of search sources are listed below with a full record being provided in Appendix 4.1.

Academic sources

- Scientific databases, e.g. EbscoHost, Web of Science;
- Hand-search of key journals, e.g. World Development, Information Technology for Development;
- Conference proceedings, e.g. elearning Africa; UNESCO Mobile Learning Week.

Grey literature sources

- Organisational websites, e.g. DFID Research for Development, World Bank;
- ML4D project websites, e.g. Worldreader, English in Action;
- Google scholar;
- Forward and backward citation searches of primary and secondary research studies;
- Contacting experts;
- Twitter searches.

I encountered a challenge in conducting the systematic search early during my first year of PhD registration in 2014 as this date meant that my searches would be out of date by submission of my thesis in 2017. To mitigate this issue, I experimented with using automatic search alters with the scientific databases used in the search. That is, I saved my search string in these databases and received an email update every time an item was added to the database meeting my string's parameters. I then screened the incoming citations on an ongoing basis. In practice, however, I realised quickly that I was not altered to all relevant studies using this technique. I therefore conducted a full search update two years post the initial search in April 2016.

Screening and application of inclusion criteria

All search hits were imported into EPPI-Reviewer software (v 4.6.4.1) and screened initially on title and abstract against the developed inclusion criteria. No information on reasons for exclusion were collected at this stage. Full-texts of studies included at title and abstract were then sought and screened. I recorded the reason for exclusion for each study at this stage. No inter-reviewer reliability assessment was conducted as I conducted this review as a single reviewer.

Coding and data extraction

I developed a detailed coding tool to extract relevant data from the included studies (Online appendix 2[33]). EPPI-reviewer software was used to generate coding sets and to facilitate data management. The coding strategy can best be described as 'mixed coding' (Oliver & Sutcliffe 2012). Codes for the aggregative review module were pre-defined, whereas codes for the configurative module were open codes. However, for the configurative review module I also predefined a list of descriptive themes, which the literature suggested to be of relevance to the construction of a theory of change for ML4D. It was required to define these

[33] Online appendix 2: https://africacentreforevidence.org/project-outputs-3/

deductive codes in order to assess an absence of evidence on these themes.

Critical Appraisal

Critical appraisal refers to the process of assessing the trustworthiness and relevance of the studies included in a systematic review. It is a required review step in order to ensure that the conducted synthesis is based on reliable research results. Due to the diversity of configurative and aggregative data a critical appraisal tool that can cater for both qualitative and quantitative studies was required. I developed a critical appraisal tool drawing on Pluye and colleagues' (2011) Mixed-methods assessment tool (MMAT) as well as Sterne and colleagues' (2013) risk of bias tool for non-randomised studies. My critical appraisal tool uses the MMAT's basic structure but extends its criteria to assess the quality of the qualitative and qualitative studies. To ensure the comparability of the appraisal of both types of studies, six domains of appraisal judgments were developed for each study type. The full tool is provided in the Appendix 4.2.

Critical appraisal of quantitative studies: For quantitative studies, the developed critical appraisal tool assessed the rigour of the impact evaluation design to establish the reliability of the reported aggregative effect. The tool needed to be able to assess both randomised and non-randomised impact evaluations. In this remit, a Cochrane risk of bias tool for non-randomised studies was adapted (Sterne et al 2013). The tool assessed six domains of bias: (1) selection bias; (2) bias due to baseline confounding; (i) bias due to ineffective randomisation[34]; (3) bias due to departures from intended interventions; (4) bias due to missing data; (5) outcome reporting bias; and (6) bias in selection of reported results. Studies were judged on a scale from critical to low risk of bias, and studies of critical risk of bias were excluded from the synthesis.

Critical appraisal of qualitative studies: For qualitative studies, the developed critical appraisal tool was based on the underlying principles of rigour (in the research conduct) and relevance (contribution to the research question). These were broken down into six domains of: (1) research is defensible in design; (2) research features an appropriate sample; (3) research is rigorous in conduct; (4) research findings are credible in claim; (5) research attends to contexts; (6) research is reflexive (CASP 2006; Dixon-Woods et al 2005). Diverting from the tool for quantitative studies, no scaled appraisal scale was applied to rate the qualitative studies. A study was either included as making a reliable contribution to the research question or excluded as not rigorous or not relevant. No distinction was then made

[34] This domain of bias was only applicable to RCTs, which by design can account for domain (1) and (2).

between the quality of the respective contributions.

Methods of synthesis

I applied two different methods of synthesis for the aggregative and the configurative review module. Statistical meta-analysis was used in the aggregative review module and thematic synthesis was used in the configurative module.

Meta-analysis: In the aggregative review module, I conducted a statistical meta-analysis to investigate the impact of mobile technologies on education in LMICs. Meta-analysis is the most rigorous method to synthesise quantitative research studies (Lipsey & Wilson 2001; Borenstein et al 2009). As a statistical approach, it aggregates the numerical effect sizes of research results to report a pooled overall numerical value. This numerical value—the pooled effect size—expresses the overall finding derived from the combined primary research results. The pooled effect size reflects the direction and magnitude of the observed primary effect sizes, which are allocated different weight in the analysis depending on sample sizes and variance.

I report calculated effect sizes in tabular format as well as using forest plots. Where sufficient contextual homogeneity prevailed, effect sizes were averaged across studies by using an inverse variance weighting of the individual effect size. This weighting results in the individual effect sizes of studies with larger study samples being given more weight in the combined, pooled effect size. The meta-analysis was carried out using random effects statistical models.

Statistical synthesis of educational outcomes needs to take into consideration the diversity of study designs and outcome measures. I envisaged that learning outcomes would be the main outcome reported, and likely be reported in form of test scores or grades. This presents a continuous outcome, and outcomes measures and scales were expected to differ between studies. As a result, the meta-analysis calculated standardised mean differences (SMD) in order to yield comparable effect sizes. Cohen's *d* as well as Hedge's *g* were calculated for each included study, with *g* being the effect size used in the meta-analysis due to its ability to adjust for small sample bias prevailing in *d* (Deeks et al 2001). SMDs express the measure of effect in a change of standard deviations making the effect size difficult to interpret. For ease of interpretation, I report SMDs in this thesis alongside the corresponding percentage change in the intervention group over the control group. All formulae for effect size calculations are reported in Appendix 4.3.

Given the assumed heterogeneity in the true effects of studies across, for example, geographical reach, educational systems, and socio-economic contexts, a random effect model was applied. In addition, I applied moderator and sensitivity analyses to test the robustness of the meta-analysis and to explore the expected large heterogeneity. Acknowledging the limitations of a quantification of heterogeneity and the different strengths of statistical approaches, I conducted the following test for heterogeneity: calculation of the Q statistic as a statistical test of heterogeneity (Hedges & Olkin 1985); calculation of the i^2 and tau^2 statistic to provide estimates of the magnitude of the variability across study findings caused by heterogeneity (Higgins & Thompson 2002; Higgins et al 2003). More in-depth discussions around the importance of single effect sizes, choice of outcome measures, heterogeneity testing, as well as sub-group analysis can be accessed in the review protocol (Online appendix 1) and appendix 5.4.

Thematic synthesis: In the configurative review module, I conducted a thematic synthesis to configure the impact of mobile technologies on education and development in LMICs. The findings of qualitative research studies were synthesised in form of analytical themes on intervention mechanisms and contexts to unpack how and why learning and teaching with mobiles might (or might not) have an impact. I followed Thomas and Harden's (2008) approach to thematic synthesis. They suggest three key stages in thematic synthesis based on thematic analysis in primary research: coding text; developing descriptive themes; and generating analytical themes.

In **stage one**, the reported research findings of the included qualitative studies were subject to line-by-line coding. Findings would ideally have referred to the primary data of each included study (e.g. interview excerpts), but due to limited reporting of this information, authors' analyses and conclusions represented study findings and the unit of analysis in my thematic synthesis. The line-by-line coding feature in EPPI-reviewer was applied to guide and manage the coding of the reported analyses and conclusions. Guidelines to thematic analysis, as applied in qualitative primary research, informed this process of creating thematic codes from the included studies.

In **stage two**, the identified codes were then grouped into descriptive themes. In addition to the inductive creation of descriptive themes from studies' codes, a number of pre-defined (deductive) descriptive themes were introduced in the synthesis and controlled for during line-by-line coding (see review protocol, online appendix 1). These themes relate to common claims and statements in the literature on ML4D, for example that females are discriminated against in access to mobiles. I needed to introduce these deductive descriptive themes in order to identify a possible absence of evidence on these themes, which would have not emerged in a purely inductive thematic synthesis.

In **stage three** of the thematic synthesis, I translated the descriptive themes into analytical themes. This translation is the key process in generating new data in the thematic synthesis. In the context of the thesis' research questions, analytical themes were formulated exclusively around mechanisms and contexts that can configure ML4D's impact or lack of impact. I therefore used a mechanism-context framework to guide my translation of descriptive themes into analytical themes. In this, I adapted Pawson's (2006) definitions of mechanisms and contexts in realist synthesis. I define mechanisms as 'changes caused by the use of mobile technologies that influence its impact'. For example, using mobile phones might change learner's ability to access information, which then might lead to better learning outcomes. Access to information is thus not part of the actual intervention, but a change induced by it that supports its effect. Subsequently, I define contexts as 'variables exogenous to the ML4D intervention that influence its impact'. For example, using mobile phones might only change learners' abilities to access information if a reliable internet connection exists. The contextual factor of a reliable network connection, which is not part of the actual intervention, thus also determines its effect.

I report the findings of the thematic synthesis in narrative tables of all identified analytical themes, divided into mechanisms and contexts, and illustrate the underling descriptive themes.

Mixed-methods synthesis: In a last step of my mixed-methods review, the findings of the aggregative meta-analysis and the configurative thematic synthesis are then brought together in a mixed-methods synthesis to construct the evidence-informed theory of change of ML4D. This construction involved three stages. First, it entailed the plotting of the intervention-to-outcomes pathways in the included ML4D interventions. In this, I used standard templates for developing theories of change in international development (Vogel 2012; Valters 2014). These suggest to break down intervention-to-outcome pathways into: inputs, immediate changes (or outputs), outcomes (on a spectrum from intermediate to final, or short-term to long-term), and impact. Second, I plotted the results of the meta-analysis against the outcomes represented on the theory of change. This provided a visual breakdown for what steps in the theory of change of ML4D there is reliable empirical evidence of effects. Third, I also plotted the mechanism and context themes against the outlined intervention-to-outcome pathways. This aimed to indicate conditions that are associated with the observed effects. Taken together, the theory of change thus presents a visual representation of (i) the assumed links between the provision of mobile devices, their impact on educational outcomes, and subsequently their link to development outcomes; (ii) the evidence of effects for each step in this process of an assumed link between technologies, education, and development; and (iii) the underling mechanisms and contexts that might explain these links and the observed effects. I then expanded in narrative on the theory of change highlighting what implications the combined systematic review findings have on the conception and positioning of ML4D.

4.2.5 Ethics in conducting the systematic review research

Ethics approval for the conduct of the systematic review was obtained from the UCL Institute of Education. Ethical concerns in systematic reviews relate to the nature of the underlying data used, for example, patient datasets in healthcare research. However, I did not collect or request any additional human data aside from the data published in included primary research studies. I therefore only used data in my systematic review that already was in the public domain.

4.2.6 Limitations of the systematic review

Despite following accepted guidelines and methodological protocols for gold standard systematic reviews in social sciences (Gough et al 2017; Campbell Collaboration 2015), the nature of conducting a systematic review as part of a PhD thesis necessarily limits some technical aspects of the review process. First, as a single reviewer technical quality assurance processes such as double-screening and double-coding could not be conducted. Second, the registration of the review with an umbrella review organisation such as the Campbell Collaboration was not possible as I could have no longer controlled the timelines of conducting and concluding the review. Third, as the timelines of the review and its publication are set by the period of PhD registration, the review is unlikely to be as up-to-date as usually expected for publication, in particular if conducted at the beginning of the PhD. This limitation applies to my systematic review in particular and despite experimenting with different methods to keep the search hits up-to-date, my review only includes primary research until June 2016 when I ran the last full search update.

In addition, I conducted a mixed-methods systematic review, a review approach which presents a minority among the systematic reviews in the social sciences (Snilstveit 2012; Langer & Stewart 2014). While this meant that I address common limitations of effectiveness systematic reviews, such as only including a narrow range of research and only investigating the question of intervention effects, on the downside, there is no agreement on methodological approaches to the precise conduction of mixed-methods reviews. I therefore developed a range of review steps more iteratively and while formulating an a priori review protocol, did not submit this protocol for publication. For the same reason, I did not report my systematic review following PRISMA reporting guidelines (though all PRISMA items are covered between chapters 5 and 6, and appendices 4.1–4.3 and 5.1–5.3) and did not conduct a strength of the evidence and recommendation assessment, such as the GRADE or CERQUAL frameworks.

4.3 Research design: case study research

I next provide a justification and outline of the research design applied in my qualitative case study.

4.3.1 Introduction to case study research as a research methodology

The second part of my empirical research presents a qualitative case study, following explicit methodological guidelines for case study research developed by Merriam (1988) and Yin (2003; 2014). Case study as a research methodology presents an in-depth investigation of a particular social phenomenon using multiple sources of data to construct an understanding of the essence of the phenomenon under investigation. Formally defined, the case study research method can be understood as “an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used” (Yin 2014: 18). One of the methodology’s key strength is therefore that it is able to include and bring together multiple perspectives on a single phenomenon and its context allowing for a conversation and interaction between perspectives to emerge. Analytical insights are then gained from this conversation and interaction to configure a rich construct of the case under investigation.

Case study as a research methodology is most widely applied in social sciences and often associated with a qualitative research paradigm, though this is not necessarily a feature of the methodology but rather a result of the pattern of its adoption (Yin 2003; 2014; Stake 1995; Baxter 2008). Likewise, case studies are often associated with a social constructivist research design due the method’s ability to facilitate the “social construction of meaning in-situ” (Stark & Torrance 2005: 33); again, however, this might be a reflection of how the methodology has been applied and there are also more deductive applications of the methodology, for example to evaluate the effects of public policies (e.g. Patton 2002; Vogel 2016). Thus, case study research can include both quantitative and qualitative data, follow different analytical strategies, and differ in the researcher’s positioning vis-à-vis the case under investigation.

Different types of case study research exist. The most common types refer to: intrinsic, instrumental, and collective case studies (Yin 2014) and exploratory, explanatory, and descriptive case studies (Stake 1995). Each of these types differ according to the purpose of the conducted research, which subsequently influences the case study research design.

All different types of case studies can further vary between a focus on a single case or multiples cases. However, there are a range of common characteristics between each type of case study design. The most frequently cited characteristics refer to: that the boundaries of the case under investigation are defined; that the unit of analysis in the case (e.g. individuals, policies, social behaviours) is clearly stated; that there is an explicit attempt to reflect the wholeness, unity, and integrity of the case; and that multiple sources of data and/or analysis are used (Yin 2014; Punch 2014).

4.3.2 Qualitative case study design

My case study research focuses on the case of the Information Communication Technology for Rural Education Development (ICT4RED) programme, a ML4D intervention in rural South Africa. The single case is bounded by the schools taking part in the programme and my unit of analysis are the teachers involved in the ICT4RED. I apply two main research instruments to collect qualitative data to construct my investigative case: semi-structured qualitative interviews and structured classroom observations. These are supplemented by focus group discussions and observations of policy roundtables and professional development courses.

I adopt a qualitative case study design subscribing to an instrumental approach to case study research for the purpose of my research. An instrumental case study approach seems most relevant in the context of my research question. My case study aims to explore teachers' own perceptions of how the use of mobile technologies in an educational context might support their pursuit of valued beings and doings. I am thus interested if teachers' use of mobiles can be investigated from a capabilities perspective. As a result, the case itself in my case study becomes secondary and I am more interested in using the case to provide insights into the feasibility of a CA investigation into teachers' use of mobiles. The case of the ICT4RED programme thus could be substituted for a different mobile learning programme and is used in an instrumental sense in my case study research.

I further position my case study in a social-constructivist research paradigm. I do not assume there to be a singular conception of the educational use of mobile technologies from a capabilities perspective. Teachers will vary in their use of the mobile devices to support their own exploration of valued being and doings. I am interested in how individual teachers themselves construct these usages in relation to their own definitions of the 'good life'. The case study therefore attempts to unpack these different perspectives and configures and contrasts them without losing their constructed meaning by teachers themselves. This nature of inquiry requires me to collect rich qualitative data on how teachers perceive and apply the mobile technologies as part of the ICT4RED programme. Lastly, I considered the conduct of an ethnography rather than a case study in my research. Ethnography as a research methodology seemed to be equally able to generate sufficient data and analysis to answer my primary research question; and, arguably would have yielded a richer data set. Resources constraints were the main factor in guiding my decision to conduct a qualitative case study.

In summary, I conducted an instrumental case study of the ICT4RED programme employing a range of research instruments to collect qualitative data on teachers' own perception on using mobile technologies in an educational setting. The ICT4RED programme was identified as an *instrumental* case to study a mobile learning programme from a capabilities perspective (more information on the programme is provided below). The aim of the study was to capture a bottom-up view on what teachers valued about technology usage and to then explore to what extent this view can be conceptualised from a capabilities perspective. In this, I chose a case study research design due to its ability to develop an in-depth understanding of the teachers' use of technologies which is situated within their own social and professional contexts and therefore allows me to explore multiple constructions of how technologies might support teachers' pursuit of valued beings and doings.

4.3.3 Overview of the primary research process

The case study research took place between July 2014 and March 2015, with the main period of data collection extending from January to March 2015. Research activities in 2014 were limited to piloting of the research instruments, introducing myself to all programme stakeholders, understanding the programme context, and setting up the logistics for the main research period in 2015. In total, four research visits were conducted in 2014, each lasting between three to four days.

In 2015, I resided in the research area in order to conduct the main data collection. In this research period, I accompanied teachers from five schools involved in the ICT4RED project during their daily teaching. At each school I first conducted an interview with the principal of the school on the first day of my visit. This was then followed by interviews with four to five teachers of the school over the next couple of days. I attempted to pair each teacher interview with an observation of a taught lesson of this teacher with the interview taking place after the observed lesson. In practice, this proofed challenging and the majority of interviews were conducted before observing the teachers' lesson. This resulted from the teachers' strong preference to conduct interviews in the mornings before they commenced their teaching duties. In total, I conducted 25 individual in-depth interviews with teachers, four principal interviews, and observed 18 lessons facilitated by the interviewed teachers.

In addition to the main data collection of individual in-depth interviews and classroom observations, I further conducted two focus groups including six and seven participants respectively. These were held as part of the teachers' monthly professional development classes facilitated by the ICT4RED programme. I attended all ICT4RED professional development courses facilitated during January to March 2015 as an observer, which comprised four days of training of the trainers' classes and five days of teacher training classes. Lastly, I also attended two ICT4RED graduations (phase 1 in 2014 and phase 2 in 2015), two policy roundtables (both in Johannesburg), and one policy site visit.

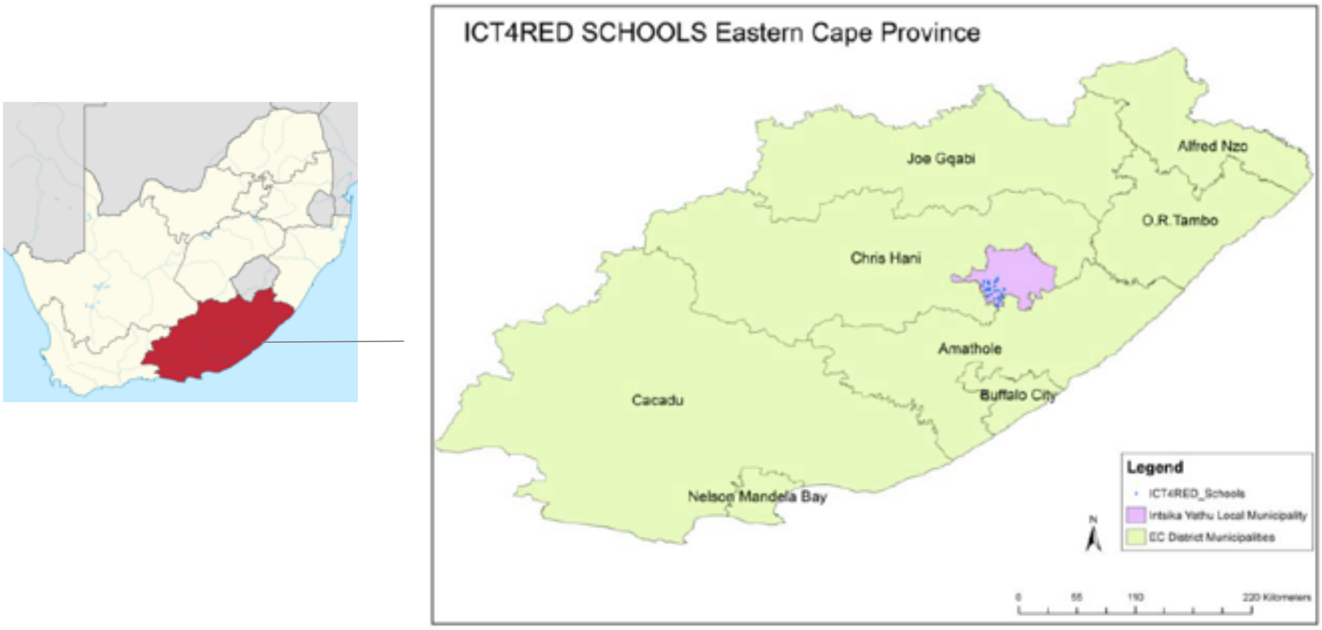
Following the data collection period, I cleaned and analysed my research data throughout 2015 with a first presentation of preliminary findings in September 2015 at the 17th Human Development and Capabilities Association annual conference in Washington. Upon completion of the first draft of the thesis in 2017, I returned to schools involved in my research to discuss my findings.

The case: the ICT4RED programme[35]

The investigated case—the Information Communication Technology for Rural Education Development initiative (Herselman & Botha 2015)—is a mobile learning programme conducted in the Cofimvaba school district, an administrative area within the South African Eastern Cape province (Figure 4.3). The Eastern Cape is the most impoverished of South Africa's nine provinces with 46.7 per cent of the population falling below the national poverty line (StatsSA 2015). The province also has the lowest educational attainment indicated by a provincial matriculation rate of only 65.4 per cent (Department of Basic Education 2015). The Cofimvaba district is categorised as a rural area and more than half of the schools in the district report not having reliable access to water and electricity (CSIR 2012).

[35] More detailed programmatic information on the ICT4RED programme can be accessed here: https://ict4red.co.za/ Additional academic work on the ICT4RED programme has been published including teachers' perception of the provided tablets (Phiri et al 2010; Nkula & Krauss 2014); the pedagogical approach to mobile learning (Botha et al 2014; Botha & Herselman (2015b); programme implementation (Ford et al 2014; Botha & Herselman 2015a); among others.

Figure 4.3 Geographical location of the ICT4RED



The ICT4RED programme is a large-scale mobile learning intervention with a teacher- and learner-centred programme component. The programme started as pilot in 2012 and over the course of three phases (2013; 2014; 2015) involved by 2015 a total of 26 schools within the district, ranging from primary to senior secondary schools. To be eligible to be part of the programme, schools have to be classified as quintile 5 schools[36]. ICT4RED is entirely funded by the South African government through a collaboration between the Department of Basic Education (DBE) and the Department of Science and Technology (DST).

In terms of teachers, the programme aims to improve rural educators' teaching methods through the provision of personal tablet devices[37] and integrated professional development. Following the provision of a tablet device, teachers are trained over a 14-week professional development course on different learner-centred teaching strategies (e.g. role play, jigsaw, gaming) and trained on how the tablets can be used to support these strategies. Teachers successfully participating in the training earn further IT equipment for their schools, step-wise attaining projectors and whiteboards, WIFI connectivity, and tablet devices for their learners. From each involved school, a minimum of five teachers are required to attend and complete the professional development course and the provision of the IT equipment is further dependent on a number of management structures being in place, including: a school

[36] DBE uses a quintile system to group schools in relation to the social deprivation of the communities in which they are located. Schools in more deprived areas are allocated a larger percentage of the public budget.
[37] Different tablet devices were used throughout the programme in different phases. All tablets were 10-inch Android-based devices.

ICT policy; a school ICT committee; explicit consent of the school governing body to the use of technologies; and providing a reserved space for the storage of the tablets, the charging device, and the WIFI server[38].

Figure 4.4 Examples of ICTs provided to schools and teachers

The professional development course is the integral programme component of ICT4RED and is primarily targeted at supporting learner-centred teaching strategies rather than technology usage. The full course curriculum is available online[39]. The course was held every second Saturday during the school terms and therefore extended roughly over nine months. Technology ownership by teachers was phased in through an ‘earn as you learn’ approach (Herselman & Botha 2015). This entailed that teachers initially received the tablets on loan and only gained ownership through the continued participation in the professional development course. Learners could not obtain ownership of the tablets. However, a 1:1 model of tablet provision for learners was targeted so that each learner would be able to work of their own device in school.

I identified the ICT4RED programme as a rich case to contribute primary data to the thesis for a number of reasons. First, the programme is a rare example of an ML4D intervention that is not technology-centred, but rather starts from a position of what value technology can add in the merit of improving teaching practice in deprived contexts. This directly links to the thesis’s interest in rethinking ML4D. Second, ICT4RED targets teachers as the main users of the mobile technology. Teachers receive the tablets before the learners, and only after teachers are comfortable in using the technology, and have acquired detailed skills on how to integrate it in their teaching, is the programme expanded into the next phase. The focus of the ICT4RED project since is placed firmly on the improvement of the quality of rural education through equipping teachers to apply more learner-centred teaching (Herselman & Botha 2015). This mechanism is of particular interest to thesis as it diverts from the learner-centred focus of most ML4D programmes.

[38] No pictures depict research participants. All pictures were taken with consent of individuals depicted.
[39] ICT4RED teacher professional development course curriculum: https://ict4red.co.za/courses/12-component-model/

Third, and linked to the focus on teachers, the ICT4RED entails an explicit attempt to build teachers as professionals. The programme actively aims to build teachers' confidence with and control over the tablet devices to portray rural teachers as 'tech champions'. This comes in the context of low perceptions of the teaching profession within South Africa. This focus on personal and professional development is of interest to the thesis as it overlaps with some of the theoretical underpinnings of the CA. Fourth, ICT4RED is one of the few ML4D interventions in Africa that have been applied at scale and are driven by the public sector. Lessons-learned from this programme might therefore be of particular relevance to other education departments. It also allows for the investigation of a ML4D intervention that is firmly positioned within, and not adjunct to, the existing education system.

Figure 4.5 ICT4RED professional teacher development course


Research sample

The five schools were chosen through a stratified-random sampling procedure. This was guided by pre-defined criteria in order to ensure that the sample schools provided an adequate representation of the total 26 schools involved in the project. Of the five sampled schools, four were Junior Secondary Schools (Grade 1-7) and one school was a Senior Secondary (Grade 7-12). All schools were ranked according to South Africa's quintile system to qualify for the government's school feeding scheme, indicating the high levels of deprivation within the schools' local communities. The average number of pupils per school was 382 (range: ~180–552). The teacher to pupil ratio ranged roughly between 30 and 50 learners per teacher.

As indicated above, all schools fell into the lowest quintile of the South African schooling system and are therefore located in the most deprived locations of the country. Schools further varied in terms of basic infrastructure and support provided by DBE. Two schools were located more than one hour away from the next tarred road and had the lowest level of infrastructure support with not all classroom having built structures and only sporadic access to water and sanitation. None of the five schools had received any ICT equipment prior to the introduction of ICT4RED[40]. Consequently, none of the schools involved had teaching staff trained in ICT usage or policies and governance structures in place regarding the integration of ICTs in teaching and learning. In general, despite some variances between schools, it is accurate to describe all five schools as to belong to the most deprived educational institutions in the country; which was an explicit selection criterion for schools in the ICT4RED programme design (Herselman & Botha 2015).

Each school had successfully completed phase two of the programme and the interviewed teachers since owned their tablet devices having used them for over a year in their teaching. Within each school, I discussed with the principal and the chairperson of the ICT committee which teachers could be involved in the research as well as the logistics of my visits. The final sample consisted of 25 teachers of which all but two were females. All teachers were part of a teachers' union and all but one teacher were South African nationals. Only ten teachers were isiXhosa speaking residents of the local communities with most teachers being seconded from the Western Cape or Gauteng to their posts in the Eastern Cape[41].

Of the 25 teachers involved, only three were below the age of 30 years with the majority of teachers indicating to be between the age of 30–40 years (n=8) and 50–60 years (n=11). Three teachers were of age 60 and above. Teachers had on average 18 years of teaching experience; though only ten teachers had taught for more than five years at their current school. Nineteen teachers indicated that their formal teaching training lasted for two years or less indicating that the majority of teachers had obtained teaching diploma from dedicated teaching colleges rather than university-based formal teaching degrees, which require at least four years of studies. The most frequent subject expertise cited by teachers referred to english, isiXhosa, mathematics, natural sciences and life orientation. All teachers indicated to teach subjects that they were not trained for. Lastly, in terms of technologies use, none of the teachers owned a tablet device prior to joining the ICT4RED, but all teachers owned smart phones.

[40] Teachers, however, had access to personal mobile technologies including laptop PCs that they sometimes reported to have used for professional administrative purposes.

[41] Following completion of teacher training degrees, DBE assigns teachers to schools country-wide. Gauteng and Western Cape are South Africa's most developed provinces and host the largest number to teachers graduating annually. A large number of teachers based in Gauteng and the Western Cape is thus allocated to schools in other provinces, in particular schools that struggle to fill their teaching positions otherwise due to their rural location.

Research instruments

Individual in-depth interviews: I developed a semi-structured interview guide that was piloted during the 2014 research visits (Appendix 4.4). The guide focused on conversational topics to explore teachers' usage of the tablets in their professional and social lives, and what they valued about this usage. The interviews lasted 30 to 75 minutes and were conducted at the schools' facilities. I aimed to conduct at most two interviews per day, which I adhered to with the exception of one occasion on which three interviews were conducted.

Classroom observation schedule: I developed a semi-structured observation schedule that was piloted during the 2014 research visits (Appendix 4.5). The classroom observations lasted for the duration of the class facilitated by the teacher and concerned the teacher's pedagogical approach and technology use.

Focus group discussions: The focus group discussions took place during the training of trainers' sessions of the ICT4RED professional development course, which was held outside regular school hours on the weekends. The groups lasted for 30 minutes and I did not facilitate or participate in any discussions apart from providing the topic of the conversation: what do you value about the use of tablets; what don't you value?

In-depth interviews and focus groups were audio-recorded and transcribed using Dragon Dictate software for Mac.

Coding and analysis of data

The Capability Approach was applied as a conceptual lens to inform the coding and analysis of the collected data. However, I did not apply a specific framework linked to the CA such as the Choice Framework (Kleine 2013). Rather, I used the CA's analytical devices of functionings and capabilities as a lens through which to guide an inductive coding and thematic analysis of the data[42]. In this process of a CA-framed thematic analysis, I initially coded interview data for teachers' valued functionings using *In Vivo* codes (Saldaña 2013). These initial *In Vivo* codes (e.g. 'the tablet is always going with me') were then thematically grouped into descriptive themes with each theme being represented by a single *In Vivo* code (e.g. 'I like the tablet because it is mobile'). Following this iteration, the data was coded again using only the higher-level thematic *In Vivo* codes. This was required in order to assess overlap between the themes and to merge repetitive and similar codes.

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[42] This extends to associated concepts of opportunities, freedoms, choice, values, agency, and development.

After this second stage of coding, the remaining descriptive themes were configured into higher-level analytical themes to develop the final list of valued functionings expressed by teachers (e.g. 'to be mobile'). In a last step, these functionings were then organised into corresponding capabilities. Each capability was thus derived inductively from the teachers' valued functionings. This inductively produced capabilities then provided the foundation to develop an overall framework for teachers' use of mobile technologies as an educational tool. EPPI-reviewer software was used to facilitate the coding process and the thematic analysis. The data from the teacher observations was used to cross-reference the reported valued functionings expressed by the teachers.

4.3.4 Ethics in conducting the case study research

My case study research did take into account a range of ethical issues, which were fully outlined in a detailed ethics application (Online Appendix 3)[43]. Below, the key considerations are discussed.

My case study research required ethical approval at multiple layers. First, I sought and obtained approval from the UCL Institute of Education. However, as this research was conducted in South African schools, ethical approval was also required by the South African Department of Education, which controls researchers' access to engage in research on the formal education system. In addition, I also required ethical approval from the institution implementing the ICT4RED programme, the Council for Scientific and Industrial Research (CSIR). Ethical approval from each body was obtained. In addition, I informed the local teachers' unions about my research as well as education officials at the district and ward level. This level of scrutiny was required as education in South Africa, and in the Eastern Cape in particular, is a highly charged political arena. External researchers are often perceived as a threat by school administrators and teacher unions due to the often negative results of educational research studies. This is particular acute in the Eastern Cape in which the NGO Equal Education has successfully taken the provincial education department to court on a couple of occasions using research and M&E data to support their case. Without careful abiding to all formal structures at all levels of governance, the research could have presented a threat to the professional careers of the teachers and principals involved.

Participation in the research was voluntary and I sought free and informed consent from each research participant. Two teachers did not want to be interviewed when being chosen by the school principals, who then nominated a different teacher. Throughout the research

[43] Online appendix 3: https://africacentreforevidence.org/project-outputs-3/

period, I was particular concerned about the additional workload I was adding to teachers and the extent to which my research disrupted the regular schooling activities. I therefore ensured to closely co-ordinate all logistics with the school's principal and the involved teachers. All research visits were set around dates offered by the schools. A linked issue was that, due to the prominence of the programme, a number of research activities were engaging the ICT4RED schools already including an internal and external evaluation, on-going M&E, and a number of South African post-graduate projects. Research fatigue among the teachers and learners of these schools was since a serious threat. To mitigate this issue somewhat, I decide to focus my research in the schools involved in stage 2 of the programme, which unlike stage 1 and 3 schools were only subject to the external evaluation at the same time as my research and not to other research activities mentioned above.

I also grappled with the question of what level of anonymity to apply in my research. While all teacher- and school-level data presented in this thesis is fully anonymised, the research area and the ML4D programme under investigation is not. I took this decision for two reasons. First, the particular design of the ICT4RED programme and context in which it is applied is important in order to understand the data collected. It did not seem feasible to remove all design- and context-related information that could have potentially de-anonymised the research without removing vital information to contextualise the data. Second, ICT4RED is the educational technology flagship programme of DBE and DST. In a South African context, it is therefore not feasible to anonymise the programme due to its popularity and media coverage.

The research interaction between the research participants and myself as a researcher are subject to a range of power imbalances. Gender, age, ethnicity, and language all affected my positionality as a researcher. This is reinforced by the historical context of apartheid in South Africa. Throughout the research I was sensitised to my behaviour and interactions as a mid-twenty white male associated with a UK institution in a context in which most of the research participants where black African females in their forties. I was aided in this somewhat based on my previous experience of working in rural Eastern Cape on community development programmes for four years and my basic proficiency of isiXhosa. However, my positionality as a researcher is likely to have influenced the interactions and data collection to some extent.

Lastly, there is also a question whether desirability bias has influenced some of the teachers' responses. There is a curious absence of negative themes in my qualitative case study research and even when probed for what they did not value about using the tablets, teachers reported little feedback that could be seen as a criticism of the ICT4RED. I discuss this issue in more detail in appendix 7.1 linked to chapter 7.

4.3.5 Limitations of the qualitative case study

My qualitative case study research is subject to a range of limitations too. These stem from the representativeness of the identified case, the nature of the research process, and the analytical framework chosen. In terms of the representativeness of the identified case, there is a risk that the Information Communication and Technology for Rural Education Development (ICT4RED) programme does not reflect the average mobile learning programme in LMICs. The programme's design places a large emphasis on pedagogies rather than on the mobile technologies; it is focused on teachers and takes a systemic approach; and it is implemented at scale by the public sector. Each of these attributes suggest that the ICT4RED might present the case of a mobile learning programme in LMICs that subscribes to an innovate approach to teaching and learning with mobiles that does not present the norm. In addition, my research was only focused on teachers and not on learners involved in the ICT4RED and I further zoomed in on teachers partaking in phase 2 of the 3-phase programme.

In terms of the nature of the research process, my positionality as a white male researcher also is likely to influence and limit my case study's findings. There might be themes and narratives that research participants did not feel comfortable sharing with me and my presence might have been associated with the formal programme evaluation and implementation team as discussed in appendix 7.1. Limited research funds also set boundaries around the number of schools and teachers that I could access as well as the time spent in the Eastern Cape for fieldwork.

In terms of the analytical framework chosen for my case study, a key limitation of the CA is its perceived methodological or ethical individualism. A range of scholars hold that the CA is too focused on individuals and their functionings and capabilities and that this focus neglects structural issues such as power relations, social constraints on individual's choices, and group interactions and identities (e.g. Stewart & Deneulin 2002; Ibrahim 2006; Evans 2002). Sen does address these critiques to some extent, for example, taking into account adaptive preferences, different social environments (through conversion factors) and providing an evaluatory device that can highlight inequalities in opportunities and not just outcomes (the capability-functioning distinction).

However, there is consensus that CA remains incomplete in regard to theorizing how structural issues and power relations influence individual's and group's freedoms and agency (Robeyns 2005; Zheng 2009; Gigler 2015). In such instances the CA needs to be supplemented with additional conceptual tools or complementary theoretical frameworks. Examples of this refer to the use of critical theories (e.g. Zheng & Stahl 2011; Podova & Roberts 2017) and the development of the concept of collective capabilities (e.g. Ibrahim 2006; Stewart 2004). The proposed CA conception in my thesis is naturally subject to the same limitations and the qualitative case study and capabilities conception derived of it could be challenged as neglecting structural issues hindering effective and meaningful human development and agency. In chapter 9, I will propose Kullman & Lee's (2013) conception of 'liberation within' as a justification for my focus on individual's functioning and capabilities, but acknowledge that further conceptual and empirical work is required in this frontier issue of the CA.

A second often claimed limitation of the CA is that is does not provide practical advice on what to do in order to advance human's capabilities and agency (e.g. Robeyns 2005; Sen 2009b.) While accurate, this challenge somewhat misses the point of the CA, which is not intended as a normative framework or theory of development (Sen 2009b). The CA serves only a normative function insofar as to prescribe the space in which to evaluate development policies and interventions, that is capabilities and functionings. This sentiment is perhaps most succinctly captured by Robeyns's (2005: 94) explanation that "the capability approach is not a theory that can explain poverty, inequality or well-being; instead, it rather provides a tool and a framework within which to conceptualise and evaluate these phenomena".

In the context of my thesis it is thus important to acknowledge that my capabilities conception does not claim to provide practical guidance on the specific design and implementation of mobile learning programmes in LMICs. Further, I do not claim that the capabilities and valued beings and doings of teachers identified in my case study research are a unique product of the application of the CA or necessarily have to be expressed using its vocabulary. Rather, the unique contribution of the CA is its ability to "bring to the surface, systematically and coherently, a set of key concerns for scrutiny based on an explicit philosophical foundation" (Zheng 2009: 74). It is in this function that the CA enters the discourse on mobile learning's role and contribution in international development. In order to develop specific ML4D policy and programme recommendations and to guide decision-making, my capabilities conception of ML4D will have to be supplemented with additional explanatory theories.

Conclusion

This chapter has outlined and justified my applied research design and methodologies. In return it has discussed the design and conduct of the mixed-methods systematic review and the qualitative case study. The systematic review follows a mixed-methods approach in order to synthesise both quantitative and qualitative studies investigating the effects of ML4D interventions in practice. The review design therefore aims to provide empirical findings of what works, how and why for ML4D and to then plot these findings against a theory of chance for the use of mobiles to support education and development in LMICs. I apply meta-analysis and thematic synthesis as the method of synthesis to aggregate and configure the effects of ML4D programmes.

The qualitative case study follows as an instrumental case study design and generates qualitative data on teachers' perceptions on the use of mobiles in an educational context. It aims to assess the feasibility of applying the CA as a conceptual lens to frame ML4D. It uses the ICT4RED, a ML4D programme in rural South Africa, as a case to explore whether teaching with mobile technologies is perceived to support valued beings and doings and to enhance opportunities of educators. I use in-depth individual interviews, classroom observations, and focus group discussions as the main instruments for data collection.

The provided alternative conceptualisation of ML4D based on the CA is of conceptual nature. It draws from both empirical datasets. I first use the results of the mixed-methods systematic review to highlight gaps and contradictions in current conceptions of ML4D (chapters 5 and 6). I then use the results of the case study to explore the feasibility of an alternative conception of ML4D from the capabilities perspective (chapters 7 and 8). In a last step, I combine both these findings in a conceptual inquiry to propose a rethink of ML4D guided by the empirical evidence-base established by the systematic review research and the conceptual framework developed from the case study research (chapter 9).

Chapter 5. The aggregate effects of mobile technologies on education in LMICs

Introduction

This chapter presents the first set of findings from my mixed-methods systematic review. The systematic review set out to investigate the effects of mobile technologies' application by students and educators in Low- and Middle-Income Countries (LMICs) on learning outcomes, teaching practice, empowerment, and EMIS. Following a mixed-methods systematic review approach, the review combines quantitative and qualitative data on mobile technologies' impact using two distinct review modules (see chapter 4). This chapter only reports findings on the detailed aggregate effect of mobile technologies on observed educational outcomes, for example changes in learners' test scores, self-efficacy, and applied teaching strategies. The findings of the configurative review module on contexts and mechanisms that unpack the aggregate effects reported here will be illustrated in chapter 6.

This chapter is concerned with what works for mobile learning in LMICs, to what extent, and modified by what variables. First, I provide a descriptive map of the included research evidence on the use of mobile technologies to support education in LMICs. This map describes the characteristics of the available evidence-base. It comments on overall patterns in the included evidence on mobile learning for development (ML4D), for example what type of programmes have been evaluated, technologies used, educational approaches followed. This discussion includes an assessment of the trustworthiness of the available evidence-base. The objective of the descriptive map is to contextualise the subsequent meta-analysis of the best available research evidence against the broader features of the evidence-base, its overall trustworthiness, and relevance to the research question.

Second, this chapter discusses the findings of the statistical meta-analysis on mobile technologies' effects on educational outcomes in LMICs. This meta-analysis synthesises quantitative effect sizes derived from the included research evidence to estimate the overall pooled effect of mobile learning interventions. The conducted meta-analysis, in addition, interrogates this pooled effect using moderator and sensitivity analyses to illustrate the relative effects of key attributes of mobile learning such as the applied pedagogy, educational context, and existing use and perceptions of mobile technologies. I also assess the robustness of the meta-analysis findings to factors associated with the available evidence, in particular heterogeneity across mobile learning interventions and educational contexts, and the sensitivity of calculated effect sizes to research designs and outcome measures. The chapter ends with an overview of the key findings presented and a brief conclusion.

5.1 What research evidence do we have on mobile learning in LMICs? A descriptive map of the evidence

This systematic review employed exhaustive and reproducible methods to identify all available research evidence presenting an empirical account of what works, why, and how when using mobile technologies to support education in LMICs. Applying the inclusion criteria outlined in chapter 4, I first map the characteristics of the included research evidence. This serves to unpack the features of the available evidence-base and to identify descriptive patterns and structures for further analysis in the synthesis.

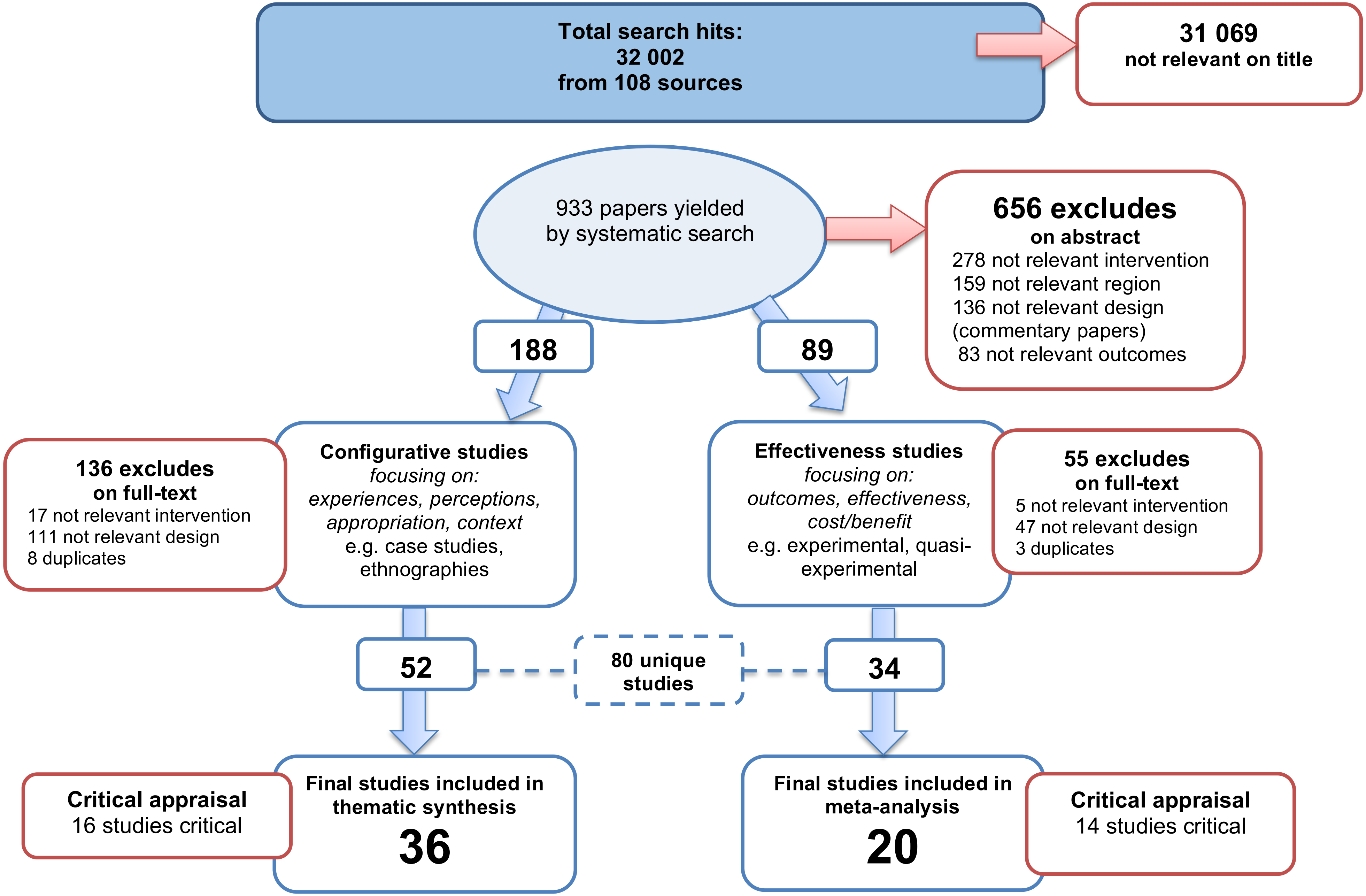
5.1.1 What research evidence did I identify? (systematic search results)

This section reports on the results of the exhaustive search for relevant research evidence. I designed a combined search strategy to identify quantitative and qualitative research studies. The search strategy was deliberately over-inclusive, that is the applied search techniques aimed to identify as much relevant research studies as possible, aiming to reduce the chance of missing any relevant studies. I ran searches from February to April 2014 and conducted a full search update between February to March 2016 (Appendix 4.1). Figure 5.1 below presents a detailed outline of the search results. The exhaustive search yielded a total of 32,002 hits from 108 unique sources. As anticipated the majority of search hits (31,069) was not relevant to the review topic and consequently excluded. As figure 5.1 shows, after the removal of these irrelevant hits, 933 papers were left for screening on abstracts and I excluded 656 further papers with reasons for exclusion listed below.

This left 277 studies that were accessed at full-text and screened against the detailed inclusion criteria. As a result, a total of 80 unique studies, reported in 99 papers, were included in the review (Appendix 5.1). These 80 studies included 52 configurative studies and 34 effectiveness studies. Six mixed-methods studies included both configurative and effectiveness studies. All identified studies were published in English even though search hits included Spanish and French citations[44]. The following descriptive analysis of the evidence-base draws on all 80 included studies. Appendix 5.2 provides an overview about the key characteristics of the included 80 studies.

[44] While I translated all citations at abstract level using Google Scholar, I did not have capacity to screen foreign language studies at full-text.

Figure 5.1 Search results



5.1.2 Socio-economic contexts within the available evidence-base

The identified evidence-base featured a wide geographic spread (Figure 5.2). A majority of studies was conducted in Asia (n=37), closely followed by Africa (n=34). Only eight studies focused on mobile learning in Latin America, and a sole study was conducted in Oceania. The review did not find any research on ML4D in a middle-income country in Europe. India (n=10), Taiwan (n=9), and South Africa (n=9) were the single most represented countries. Research from East Asia, due to the strong presence of the Asian Tigers group of countries, contributed almost a quarter of the studies (n=19). I therefore caution that there is heterogeneity across the socio-economic contexts in which the reviewed mobile learning interventions were applied. The setting of a ML4D mobile learning programme in urban Malaysia (Ismail 2013[45]), for example, will differ from a programme in rural Tanzania (Enge 2012). I analyse the sensitivity of the review findings to countries' economic status as low-/lower-middle income or upper-middle income in the moderator analysis in section 5.2.2.

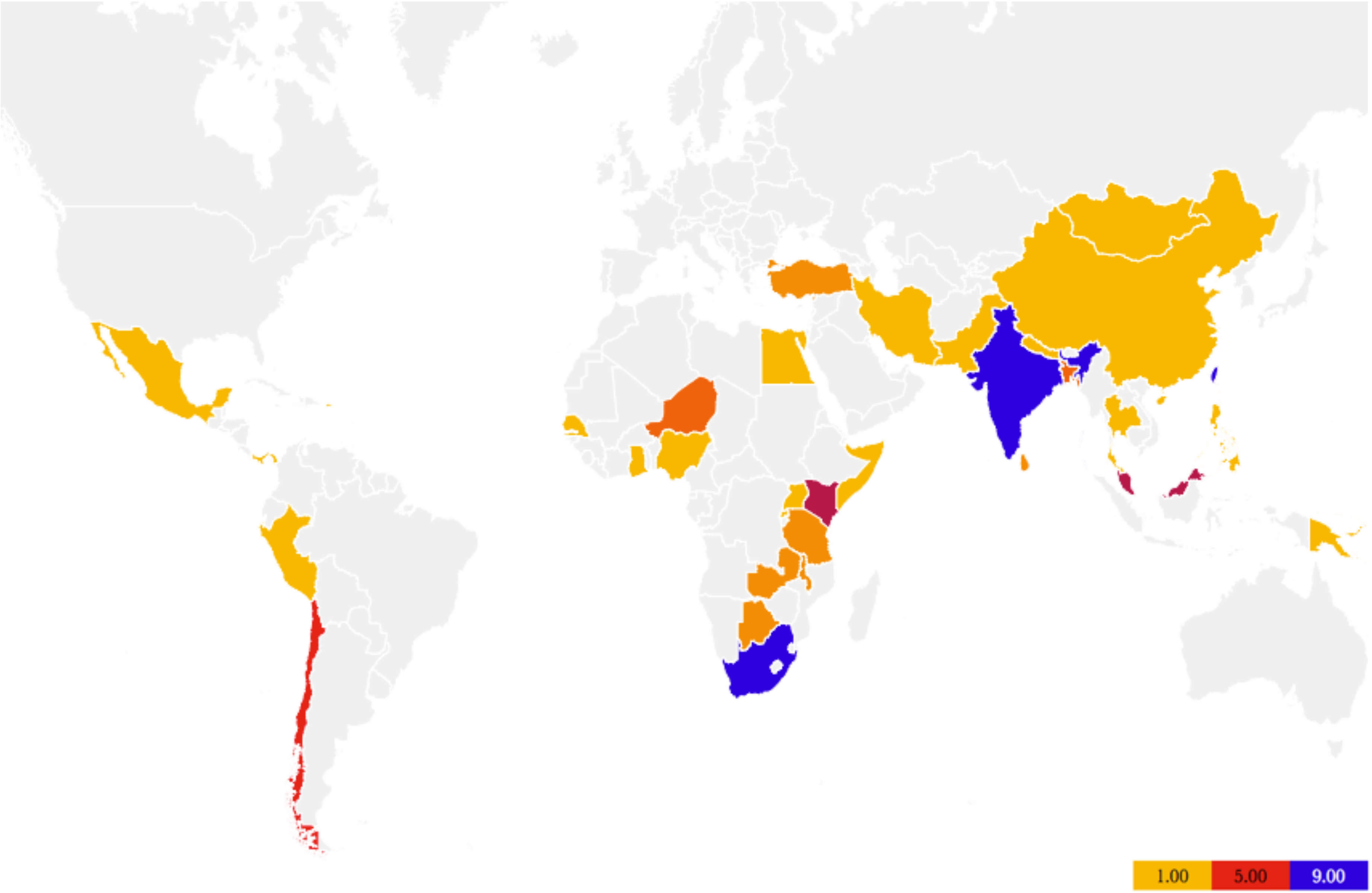
The majority of the reviewed interventions were conducted in urban areas (n=43) and only 17 ML4D programmes were implemented solely in rural areas. Twenty interventions reported mixed or peri-urban settings. More than two-thirds of programmes were conceived and driven by research interest rather than by policy actors or practitioner (n=55). National education institutions, on the other hand, only initiated eleven programmes, leaving government institutions in a clear minority compared to external entities—that is IGOs, NGOs, and corporates—who conceived 23 mobile learning interventions[46]. A vast majority of ML4D programmes were implemented in a formal educational setting (n=65). Only 15 studies assessed mobile learning in an informal educational environment (e.g. extension services, NGO-run literacy campaigns). In the sample of formal education, primary schools presented the most targeted level of schooling (n=32). They are followed by high schools (n=20) and universities (n=19). Of the university programmes only three studies featured research in a distance education context[47]. These overall school classifications, however, hid a clear pattern. ML4D in urban areas featured a significantly higher number of programmes conducted in high schools and universities (62% of the sample). The corresponding number in rural areas is a mere 18%. Rural ML4D programmes are predominately implemented in primary schools (36%) and informal education programmes

[45] When reporting on the systematic review findings, studies included in the review are only referred to by last name of the first author and year of publication.
[46] These numbers do not add up to 80 as some interventions were initiated through collaboration between different entities.
[47] The review identified a larger body of literature on mobile learning in distance education. Yet, most of these studies did not meet the methodological inclusion criteria.

run by NGOs and other non-state actors (27%). These patterns indicate that ML4D programmes by design follow existing structural inequalities in LMIC education systems (e.g. McCowan & Unterhalter, 2015; Motala et al 2013; Unterhalter 2015).

This unequal pattern further holds when assessing the existing resources and infrastructure ML4D programmes could draw from. Reliable access to electricity, stable network coverage, and safe storage facilities were reported in over three-quarter of the studies, which again hints at an implementation of mobile learning interventions in less resource-constrained educational contexts. Further, 42% of interventions were implemented using educators' and learners' own mobile devices. There was also evidence of an existent systematic use of ICTs in education in 23 interventions, all but one of which were conducted in urban areas.

Figure 5.2 Geographical location of included studies



Participants within the reviewed ML4D interventions similarly were unlikely to represent the most marginalised groups within communities or societies. A clear minority of programmes (n=7) targeted illiterate learners. Semi-literate learners—i.e. primary school learners in each instance—were a focus of 24 interventions, while the majority of 51 ML4D programmes targeted literate participants. Most studies were inclusive of gender and thus reported a balanced sample. Only four studies reported findings of female-only ML4D programmes (Balasubramanian 2010; Pimmer 2014 Velghe 2014; Zelezny-Green 2014) and in a single programme the use of mobile technologies was reserved for males (Nawi 2015). Participants' age correlated with the above-outlined schooling classifications[48]. Using technologies to support adult learning, a group for example often at a higher risk of illiteracy in LMICs (Nussey 2015, Maddox & Esposito 2011), was only reported in 11 studies. There was no experimental research reported on mobile learning programmes to support people with disabilities in LMICs.

5.1.3 Types of mobile learning interventions within the evidence-base

The identified 80 studies assessing the use of mobile technologies to support education in LMICs applied a diverse set of mobile learning programmes. The review identified 70 independent mobile learning programmes that aimed to improve educational outcomes in LMICs. The TeacherMate programme (e.g. Kim 2011), Worldreader (e.g. UNESCO 2014), Bridge International Academies (e.g. Enge 2011), as well as English in Action (e.g. Sohel 2012) each were applied in multiple interventions. I retrospectively assigned ML4D interventions into programme categories (Table 5.1). These categories thus iteratively emerged from the included studies and were formulated along stated intervention objectives. Categories were not mutually exclusive.

'Mobile-assisted language learning' (MALL) comprises the largest category in the identified ML4D programmes (n=31). MALL as a sub-set of mobile learning interventions applied mobile technologies with the explicit aim to improve language acquisition. In 20 programmes English as a foreign language was taught using mobile technologies. The remainder of programmes focused on literacy development in the learners' home language, predominantly Spanish (e.g. Zurita & Nussbaum 2004). Sixteen ML4D programmes were categorised as 'mobile assisted mathematics learning' (MAML). These programmes used mobile technologies explicitly to improve numeracy or more advanced mathematical

[48] Studies pre-dominantly reported the age of participants by the average national age for a certain grade. This hides the widespread problem (particularly rural areas) of learners accessing schools later in life or in disrupted patterns.

subjects. I assessed in the aggregative module whether MALL and MAML, given the approaches' popularity, are particular effective subgroups of ML4D interventions.

I classified 19 studies as exploring 'perceptions & adoption' of ML4D programmes. These studies were solely included in the configurative module as they explored the context of ML4D. This exploration of context, for example, could include a survey investigation whether teachers were willing to use mobile technologies as an educational tool. In nine of these studies factors of adoption in line with the technology acceptance model (Davis 1989; Venkatesh & Davis 2000; Venkatesh et al 2003) were analysed. A minority of only 10 studies were identified as 'teacher development'. Teacher development interventions used mobile technologies to primarily improve teachers' educational skills. Interestingly, none of these programmes were embedded in official teacher training courses. Mobile learning in teacher development was exclusively used as a form of on-job training and only in one instance linked to an accredited professional development course (Leach et al 2004). A specific sub-set of studies from East Asia (n=9) applied mobile technologies to facilitate contextualised learning, for example during field trips to national parks or heritage sites. Termed as 'experiential / inquiry-based' these studies presented a homogenous programme category. Alas, the external validity of this category is doubtful due to the complexity of the applied technologies. The studies nevertheless used and reported on rich mobile learning pedagogies in LMICs and I therefore categorised them as feasibility experiments and relevant for inclusion in the systematic review. The remaining categories referred to mHealth, agricultural extension, EMIS, and distance learning.

Table 5.1 Overview of mobile learning programme types

Types	*# of studies*
MALL	31
(English as a foreign language)	*(20)*
(Native language)	*(11)*
MAML	16
Perception & adoption	19
Teacher development	10
Experiential / inquiry-based	9
mHealth	3
Distance learning	3
Agricultural extension	2
EMIS	2

5.1.4 Mobile technologies used in mobile learning interventions

The reviewed mobile learning programmes applied an array of mobile technologies in order to support education in LMICs. Mobile phones, used in 66 programmes, were the dominant technology by a large margin. This dominance of phones as the most prevalent technology in ML4D programmes was independent of context. Mobile phones were the most applied technology in both rural and urban settings, foremost in each geographical sample and type of schooling, and featured as the technology of choice in each ML4D intervention category. Smart phones and basic/feature phones were used to the same extent (n=33/n=33). There was nevertheless an unsurprising trend to use more sophisticated phone models in more recent programmes. This is in line with the advancement in mobile technologies and the growing diffusion and affordability of more sophisticated devices.

Tablets and PDAs presented the second most applied technologies (n=14). Regarding PDAs, this finding was somewhat surprising as the technology itself is increasingly outdated and production and development of devices has been discontinued. The review did not record a use of PDAs in a mobile learning intervention post 2012. On the contrary, the use of tablets in mobile learning programmes was a recent trend. Most of these programmes have been conducted since 2013 (n=11) and of the included studies published in 2015 and 2016, 57% reported the use of tablet devices. All but three tablet-based mobile learning programmes were conducted in Africa. Additional mobile technologies identified in the review included gaming devices (n=4), mp3/iPod (n=2), and radios (n=1).

Mobile learning interventions further exploited a diverse range of mobile devices' unique affordances. Table 5.2 gives an overview of the main affordances used.

Table 5.2 Overview of mobile devices' technological affordances

Affordance	*# of studies*
Connectivity	57
Educational software	31
(Incl. educational games)	*(21)*
(Incl. apps)	*(11)*
Camera/video	29
SMS	18
GPS	14
e-books	11
Voice/Audio	9
Social networks	6
Mobility[49]	**n/a**

A large majority of programmes applied or intended to apply a 1:1 ratio of device ownership (n=69). This finding can be explained with the underlying ubiquity of in particular mobile phones in LMICs, which allowed 56 programmes to use mobile technologies that participants reported as having used before. In addition, where reported (n=20), over 90% of participants on average had a positive perception of the applied technologies at baseline. However, mobile learning programmes in rural areas were less likely to use participants' own devices and relied on providing mobile technologies as part of the intervention design.

5.1.5 The design of ML4D interventions

The reviewed ML4D interventions followed a range of different designs in order to support education in LMICs. A large majority of mobile learning interventions was learner-centred (n=68). Only 18 programmes focused primarily on teachers as the unit of implementation[50]. The same pattern held true for the assessed educational outcomes. While 51 studies measured changes in learning achievements, only 12 attempted to record changes in teaching practices. This finding reveals a bias of mobile learning programmes to bypass teachers, despite teachers serving as the principal agent in and gatekeeper to high quality education in LMICs (Hassler 2011; Leach 2005; Piper 2015; Rao 2014). While teachers usually were not excluded from the 68 learner-centred interventions (e.g. they could use a similar device), the interventions were designed around learners' needs and preferences

[49] The inherent mobility of devices presented an inclusion criterion in the review.
[50] Six studies reported on interventions that targeted learners and teachers simultaneously.

and aimed to primarily support this group rather than educators. Ten teacher-centred programmes placed a focus on teacher professional development (e.g. acquisition of more advanced teaching skills) (Leach 2005). Six teacher-centred interventions merely supplied mobile technologies as a support tool to allow for a more convenient teaching experience (e.g. Valderama 2010). Lastly, two studies investigated the potential of mobile monitoring to increase teachers' attendance (Aker 2015; Cilliers 2014).

The reviewed evidence identified a clear trend to embed ML4D programmes into a larger educational effort. That is, ML4D programmes were for most parts not standalone interventions in which the facilitation of mobile learning was the only educational activity. The large majority of interventions were embedded in formal education structures (n=65), and an additional seven programmes were implemented in conjunction with a comprehensive informal education programme, such as an NGO-led adult literacy campaign. Only eight reviewed interventions could be regarded as independent programmes (e.g. the Worldreader's mobile app). This observed design of ML4D interventions indicates that most interventions assumed a supplementary educational role. By itself, learning and teaching with mobiles, let alone the mere provision of devices, appeared to not present a viable intervention design in ML4D.

Technological components of ML4D interventions

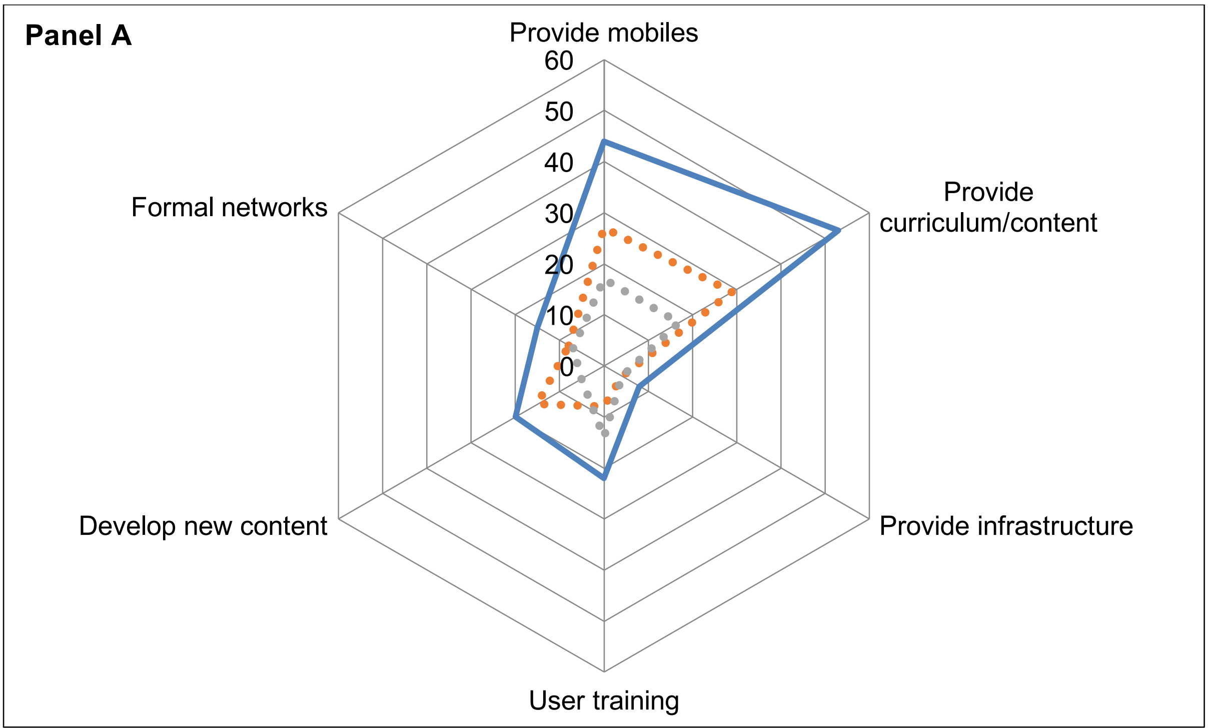
The review also assessed the detailed design characteristics of ML4D interventions by breaking down interventions according to their technological and educational programme components (Figure 5.3)[51]. On the technology side (panel A), the most applied component referred to the provision of digital curricula and educational content on mobile devices. A total of 66% of the interventions applied this programme component. Provision referred to making available pre-designed curricula or subject materials *without* input from the programme participants. This top-down mode of programme delivery presented the most applied intervention component. Only 55% of the ML4D interventions provided mobile technologies to the programme participants, which was the second most applied intervention component. The review did not identify a ML4D programme that supplied mobile devices as the only intervention component. This runs counter to famous examples of perceived technology-led learning as advocated by Sugata Mitra's Hole in the Wall project and subsequent development of minimally invasive education (Mitra & Vana 2001; Mitra 2003). The provision of mobile devices and digital content followed in most instances a combined programme approach. Less than a third of interventions offered training on device use to the

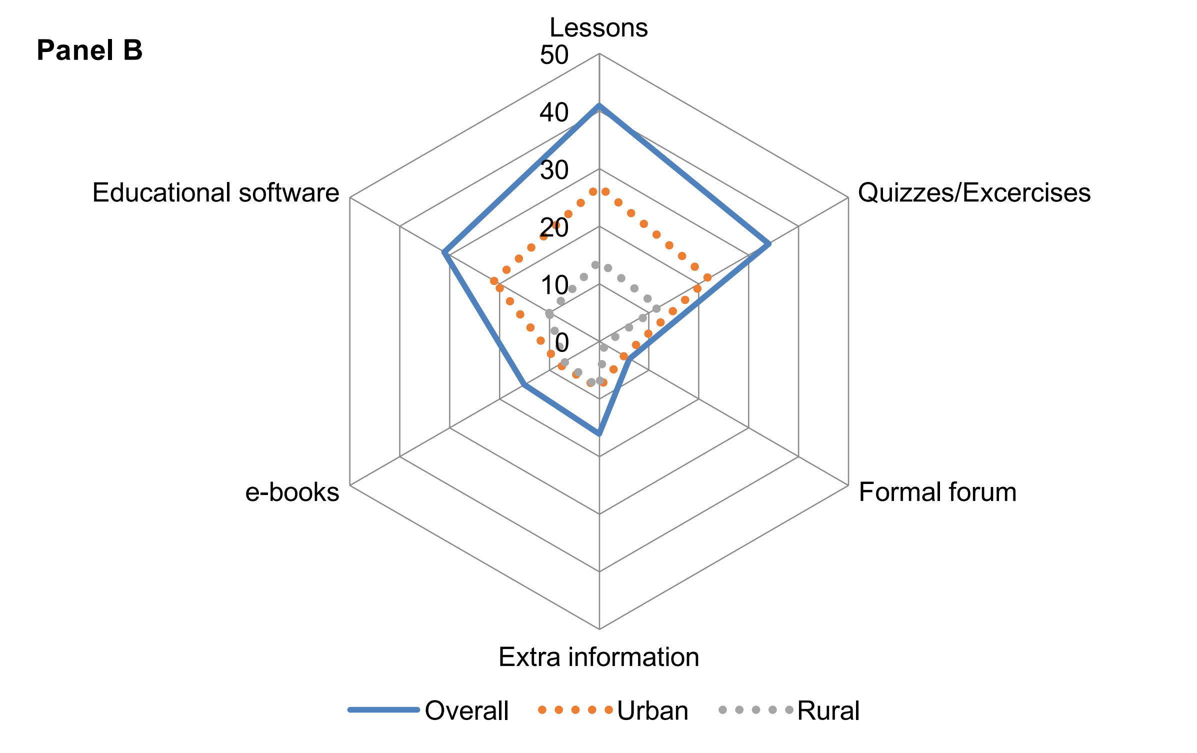
[51] Only the six most prominent components are reported below.

programme participants (n=22) and a similar number of programmes (n=20) developed tailored new educational content for the applied intervention.

The design of mobile learning interventions was dependent on the socio-economic context of the ML4D programme. Figure 5.3 compares the design patterns of intervention components in rural and urban areas. Keeping in mind that, overall, there were fewer interventions conducted in rural areas than in urban areas, the data shows that interventions conducted in rural contexts were more likely to provide mobile technologies as well as to engage in user training regarding the correct application of the device. This different programme approach seems to reflect existing inequalities in technology usage. Rural programmes were further less likely to develop new tailored content, an intervention component that requires more sophisticated user input. However, there was no difference in the provision of infrastructure as one might have suspected given rural areas' resource-constrained contexts.

Figure 5.3 Design characteristics of ML4D programmes (technological/educational)





Educational components of ML4D interventions

Panel B of figure 5.3 indicates the applied educational intervention components. Educational components refer to the educational input that the programme facilitated. It is important to recall that, as shown above, the majority of interventions were embedded into ongoing educational interventions and that the use of the mobile technology therefore was mainly supplementary to the existing educational events and actions. First, mobile-supported lessons were the most applied educational component (n=41). Of these, ML4D programmes most commonly provided structured lesson plans in which the technology use was incorporated (n=21). Direct lessons were facilitated using video technology (n=13), SMS (n=9), and audio/voice (n=5). Lessons represented a structured and targeted string of learning activities to meet a predefined learning objective. Second, mobile-facilitated quizzes and exercises equally presented a popular educational input in ML4D interventions and a total of 34 programmes made use of this input.

Third, educational software such as the TeacherMate (Kim 2012) or MobileMath (Voigt 2010) applications featured as a fast-growing educational component in the reviewed interventions (n=31). This component provided the most comprehensive educational environment with the ability to include for example lesson plans, exercises, and tutorial videos within one programme. Educational software components were, however, dependent on the availability of devices featuring more sophisticated operating systems. Fourth, in the most rudimentary approach, a number of ML4D programmes relied on supplying participants with additional educational information such as access to lexica or homework reminders (n=16). This component mainly increased the ability of participants to receive information of interest or relevance to their learning and teaching practice. Lastly, the use of e-readers or tablets to store e-books as an educational component replacing traditional text-books presented a minor intervention approach in the reviewed ML4D programmes (n=15).

As in the case of technological programme components, the review identified a structural impact of the socio-economic context on the design of educational components. The reviewed evidence, overall, indicated that the educational design of rural ML4D programmes subscribed to a less complex educational structure. Programmes components that required less pedagogical input (i.e. quizzes and exercises; extra information; and e-books), were overrepresented in rural ML4D interventions. Pedagogical rich components (i.e. educational software; and lessons) were, on the other hand, underrepresented in the rural programmes. Again, these findings provide evidence that mobile learning programmes in LMICs might fail to counter existing socio-economic inequalities in education systems.

5.1.6 Assumptions about how ML4D interventions facilitated educational change

The above data shows the diversity in the design of mobile learning interventions and the manner in which mobile technologies are used to support education in LMICs. In addition, the review investigated how the mobile learning interventions were positioned in their ability to influence educational change in LMICs. I therefore systematically coded the included research studies for data on the assumed educational change that the introduction of mobile technologies aimed to facilitate. Extracting data from the reported mobile learning interventions served to unpack what kind of changes in the educational environment (both teaching and learning related) were targeted in the interventions. This information then allowed comparisons as to whether these changes in learning and teaching through the use of mobile devices in fact referred to mobile learning's particular pedagogical strengths and contribution.

In this remit, I first assessed whether the mobility affordances of the technological devices were exploited in the interventions. A main attribute of mobile learning is the ability to allow learning in different contexts due to the mobility of the device. This feature allows the fluid interaction of learning events between formal and informal contexts to reinforce learning. Yet, despite this rationale only half of the applied ML4D interventions allowed an unrestricted use of the devices across contexts (n=32)[52]. That is, half of the programmes implemented restrictions to the use of devices in informal contexts. In most instances (n=27), this translated into a limitation to only apply the mobile technologies in the classroom. In case where no limitations to device use were applied, the most common usage was described as learning with mobiles 'anytime, anywhere' (n=32), 'at home' (n=14), and 'at work' (n=17). Mobile phone-based interventions were strongly correlated with an unrestricted usage, whereas programmes using PDAs or tablet devices were by a large majority limited to use in formal contexts. I assessed in the aggregative review module (section 5.2.2) the possible impact of these limitations in device usage on the effects of ML4D programmes.

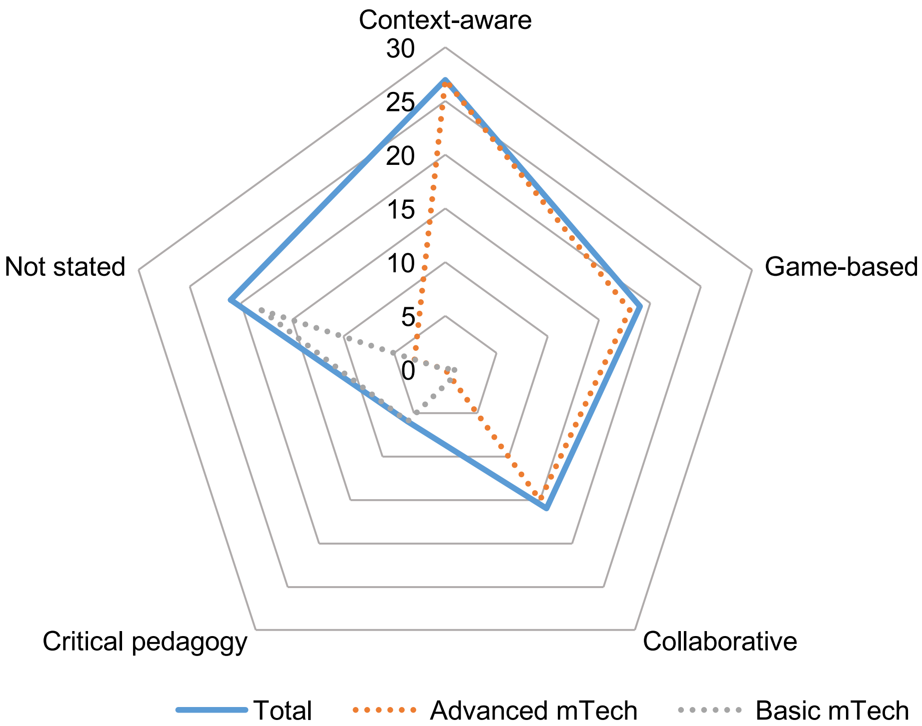
Reporting on the underlying pedagogies that informed the ML4D interventions, as well as how the programmes aimed to change teaching or learning was limited to information received at face value[53]. That is, I used the terms studies used to self-identify their applied pedagogies. Therefore, I only considered pedagogies that were *explicitly expressed* as such in the included studies and refrained from attempting to imply from the programme description what pedagogical approach might have informed its design. Facilitating more learner-centred educational approaches was a main change that was targeted through the introduction of mobile devices (n=52). Yet, more often than not, it was thereafter not evident how the applied intervention changed the existing educational situation to assume a more learner-centred character. For example, it was not clear how reading e-books and taking notes on a tablet device was inherently more learner-centred than reading and note-taking using traditional learning materials (e.g. Worldreader 2012). The review therefore identified a large discrepancy between stated educational approach and practical intervention design.

In addition to the overall theme of learner-centred pedagogies, a number of more focused educational strategies were stated in the identified ML4D programmes (Figure 4.4). The single most prominent pedagogy referred to context-aware learning (n=27) in which learners were assumed to gain a more relevant, personalised, and practical educational experience. This group included the most sophisticated mobile learning approaches such as a 'context-aware ubiquitous mobile learning system' (Chen & Li 2010) and 'RFID-supported immersive ubiquitous learning environment' (Liu 2009). Nineteen mobile learning interventions applied game-based learning strategies which went hand-in-hand with the design of educational

[52] The sample size is 61 studies as some studies did not implement a ML4D programme but assessed prevailing perceptions and contexts towards ML4D.
[53] I attempted to code studies as follows: prior educational approach, learner / teacher interaction, teacher skill level, teacher / pupil ratio. There was sufficient reliable information reported within the included studies to populate these codes consistently.

gaming devices or educational software. Game-based learning was mainly targeted at primary school children. Collaborative learning was stated by 16 ML4D programmes as the underlying pedagogical approach. These programmes designed group activities in which the mobile technology served as tool to ensure effective collaboration took place between learners. For instance, devices were used to enforce participation of each group member, preventing more advanced or assertive learners to take over the group's task. Lastly, six studies mentioned an explicit transformational agenda, for example critical pedagogies as developed by Freire (1972), to inform the ML4D programme design. Unfortunately, again, it was challenging to follow how the stated critical pedagogy objective was reflected in the intervention design (see also section 6.2.2 and 9.2.3 and 9.3.2).

Figure 5.4 Targeted pedagogies and mobile technologies applied



The systematic review of the included interventions established a clear correlation between types of mobile technologies and corresponding pedagogies. Out of the 21 studies that did not state any educational approach to inform the programme design, 18 used basic/feature mobile phones. Of the 27 studies with the most sophisticated mobile learning approach all used mobile devices with advanced computing and visualisation affordances such as smartphones or PDAs. Similarly, only a marginal number of game-based and collaborative learning ML4D interventions were conducted using basic/feature phones (n=2). Given the above-reported pattern that mobile learning interventions in rural areas applied more basic technologies (5.1.4 – 5.1.6), this therefore further translated into a lower likelihood of rich mobile learning pedagogies to underpin interventions in rural areas. This finding is also in line with the data presented above (5.1.5 – 5.1.6) that rural ML4D interventions followed a less complex programme design. In sum, there is thus further evidence of structural inequalities being reproduced by the choice of mobile technologies and applied educational approaches in ML4D interventions.

5.2 Meta-analysis findings: aggregate effects of ML4D interventions

I next present the findings of the statistical meta-analysis that synthesises the research evidence included in the aggregative review module. To recall, the aggregative review module aimed to answer the question of mobile learning's overall impact on learning outcomes, teaching practice, EMIS, and empowerment. Research evidence included was therefore required to make use of a rigorous study design able to evaluate the causal relationship between the provision of mobile learning interventions and the changes in the above-mentioned outcomes. The applied synthesis methods—i.e. meta-analysis—then aimed to aggregate the reported causal effects into one pooled numerical effect size reflecting the direction and magnitude of mobile learning's impact on educational outcomes in LMICs.

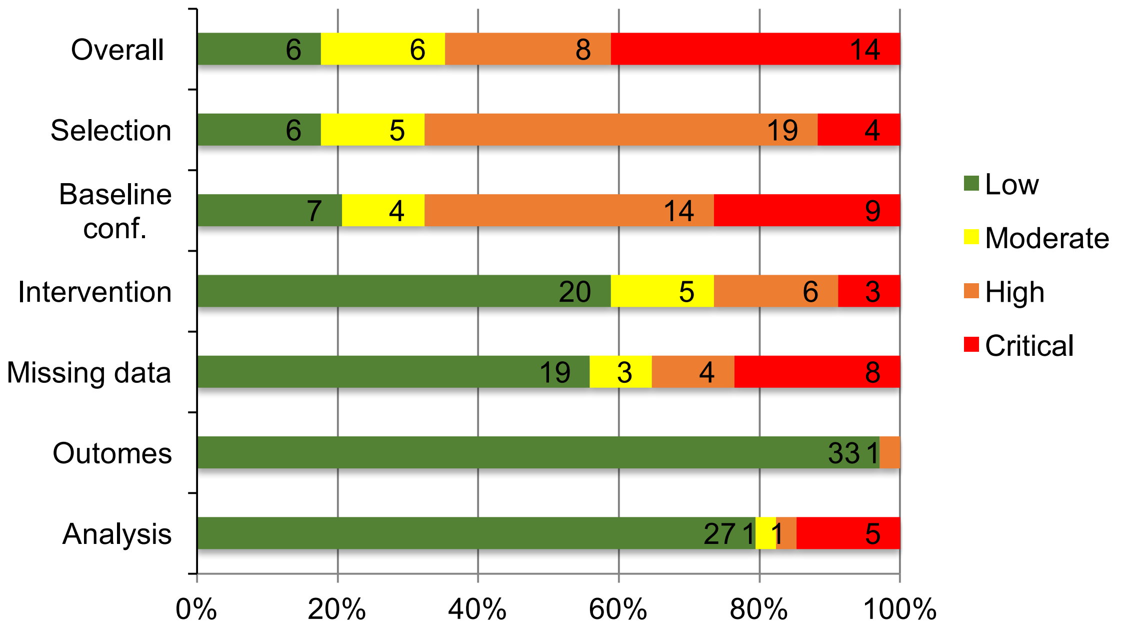
5.2.1 How trustworthy is the quantitative evidence (risk of bias assessment of studies)?

I included 34 rigorous impact evaluations of ML4D interventions in the aggregative review module that met the minimum methodological requirements. These studies were then subject to a detailed risk of bias assessment to establish the trustworthiness of the reported research results (Appendix 4.2). Fourteen studies were found to be of critical risk of bias and therefore excluded from the synthesis. Consequently, 20 studies were eligible to feed effect size data into the meta-analysis[54]. The detailed results of the risk of bias assessment are reported in figure 5.5. The assessment results indicated clearly that baseline confounding and missing data were the main causes to exclude studies from the synthesis based on a critical risk of bias. Baseline confounding resulted from an inadequate control for observable and unobservable characteristics between experimental groups. In critical-judged studies, I found clear information that experimental groups were inherently not comparable and that any findings reported in the study were at risk to result from the differences between groups rather than from the applied ML4D intervention. For example, in the evaluation of the Worldreader programme in Ghana (Worldreader 2012), baseline test scores between experimental groups were significantly different and intervention schools were handpicked by local officials whereas control schools were chosen at the convenience of the evaluation team. Missing data, most commonly caused by a loss of control units (e.g. schools) rather than the loss of data from individual pupils, presented a second major factor of critical risk of

[54] A detailed overview of these 20 studies reporting data on applied interventions-to-outcome configurations and effect size data is presented in Appendix 5.3.

bias ratings. Enge's (2012) evaluation of the Bridge International Academies, for instance, did not report data from more than half of their initial control schools at endline.

Figure 5.5 Overview of risk of bias assessment



The remaining 20 studies included in the aggregative synthesis were heterogeneous in trustworthiness. I judged six studies of low and moderate risk of bias respectively. The six low risk of bias studies presented five RCTs (Aker 2012; 2015; Cole 2012; He 2008; Pitchford 2014) and one rigorous matched quasi-experimental study (Kaleebu 2013). The studies were of considerable scale featuring an average sample size of 2514 participants (range: 88–5317) as well as an average period of follow-up of six months (range: 2–12).

5.2.2 Do mobile learning interventions improve learning outcomes in LMICs?

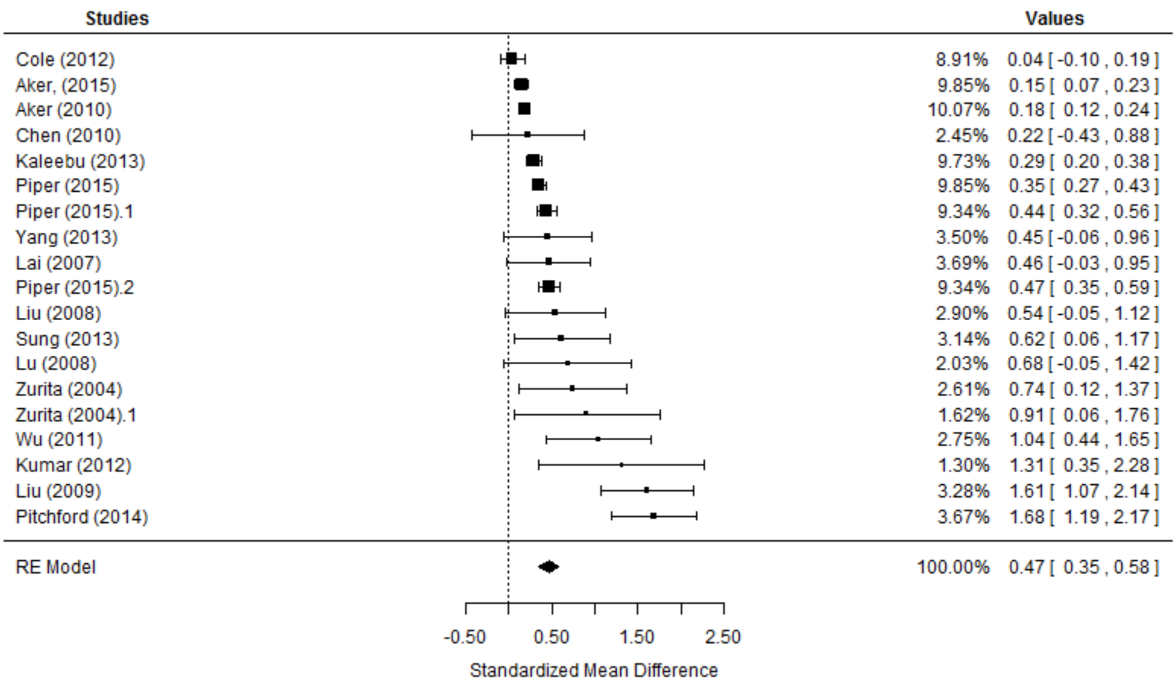
This section reports the overall impact of the educational use of mobile technologies in LMICs on learning outcomes. The reported meta-analysis (Figure 5.6) combines the learning outcomes of 19 individual mobile learning programmes reported in 17 studies[55]. The meta-analysis thereby comprises data from 17,909 participants involved in the included studies. Learning outcomes were measured in validated assessment tools such as the Early Grade Reading Assessment and tailored pre- and post-intervention tests. Eleven studies administered learning assessment as extra curricula tests, while six studies drew data from

[55] Piper and colleagues (2015) PRIMR intervention tested three different mobile learning programmes.

regular curricula tests. No study relied on administrative records of learners' test scores. The choice and application of the reported outcome measures was judged as a low risk of bias for each of the included studies in the meta-analysis. While intermediate learning outcomes such as student attendance and motivation were reported by individual studies, these intermediate outcomes were rarely measured consistently across both experimental groups and were therefore not included in the meta-analysis.

The meta-analysis of standardised mean differences indicates a positive and significant effect of mobile learning of 0.47 (0.35, 0.58) SMD on learning outcomes. This pooled effect size constitutes evidence of the impact of mobile learning interventions in LMICs. It expresses a clear and statistically significant increase in learning that can be attributed to the application of mobile technologies as an educational tool. The systematic review since presents evidence of the effectiveness of ML4D interventions as a means to increase learning outcomes in LMICs.

Figure 5.6 Forest plot: Average effect of mobile learning programmes on learning outcomes in LMICs



Heterogeneity: Q=127; df=18; p=1.68E-18; I^2=85.9%; tau^2=0.0349

The identified pooled effect size of 0.47 (0.35, 0.58) SMD can be considered a large effect size. Using the conversation formula outlined in appendix 4.3, the effect size translates into a 23.2% larger improvement in learning outcomes reported in the group of learners using mobile technologies as compared to learners not using mobiles. Comparing the established overall effect size of 0.47 SMD to related meta-analyses assessing the impact of educational interventions in LMICs, it emerges that mobile technologies seem to present a more effective approach to improve learning outcomes than other educational interventions. A meta-analysis by Petrosino and colleagues (2012), for example, estimated the overall impact of educational interventions at 0.14 (0.10, 0.23) SMD; albeit interventions to improve language learning score a higher effect size of 0.25 (0.19, 0.35) SMD. A meta-analysis of only RCTs on interventions that aimed to improve learning in primary schools in LMICs further found ICTs to be among the most promising interventions with a pooled effect of 0.15 SMD[56]. Finally, the most comprehensive systematic review and meta-analysis of interventions for improving learning outcomes LMICs identified structured pedagogy to have had the largest effect on education of 0.23 (0.13, 0.34) SMD (Snilstveit et al 2015). Snilstveit and peers' review also included 19 studies investigating the impact of computer-assisted learning which were found to feature an overall positive effect size of 0.07 (0.02, 0.11) SMD. The findings of my meta-analysis are since in line with the positive impact of ICTs on education in LMICs in general. Yet, I identified a larger effect size for mobile technologies and the mobile learning programmes which these technologies facilitate.

The identified pooled effect size of mobile learning interventions is statistically significant with a narrow confidence interval. It therefore presents robust evidence of the overall effectiveness of mobile learning as a tool to improve learning outcomes in LMICs. However, I caution to narrow down the question of mobile learning's impact to a single effect size and further analysis is required to understand and interpret this effect size. To being with, there is large heterogeneity within the conducted meta-analysis ($Q=172$, $p<0.05$; $i^2=85.9\%$).

A visual overview of the forest plot in figure 5.6 reveals that, while the combined impact of mobile learning is statistically significant, of the individual included studies only a minority of six studies features a narrow confidence interval, and over a quarter of the studies (n=6) cannot rule out the possibility that the study's findings are due to chance. However, this observation can be explained by the limited sample size of these studies, which include on average 34 learners per experimental group. Such small-scale studies are by design often underpowered for the purpose of statistical analysis (Thomas et al 2012; Borenstein et al 2013). Meta-analysis as a methodology is in particular designed to allow for a combination of samples and results from individual studies in order to increase the statically power of the overall analysis. I am since confident that the overall effect size, which is statistically

[56] There is no overlap in studies included between this meta-analysis and the reported studies.

significant and carries a narrow confidence interval, is a more accurate reflection of the magnitude of mobile learning's impact than the reported individual effects.

The high degree of heterogeneity reported in the meta-analysis was anticipated[57] and I therefore a priori identified a range of variables to that might explain the diversity in the identified effects. These sensitivity and moderator analyses presented below control that there were no systematic differences across the included studies that generate the variation in effect sizes. If systematic differences would prevail, the reported differences in effect sizes would not be related to the effectiveness of the applied interventions but rather to some external factors; in which case the calculated overall effect size would fail to present a true reflection of mobile learning's impact.

Assessing the quality of my meta-analysis: are the findings sensitive to heterogeneity in study design?

I first assessed whether the variance in effect sizes might be caused by factors related to the applied impact evaluation design. For example, a more rigorous impact evaluation design might systematically yield different effect sizes from a less robust design. I therefore investigated the sensitivity of the pooled effect estimate to a number of possible design variables (Table 5.3). It is, however, important to note that this table merely presents an observational overview to uncover possible sensitivities that I then formally assessed statistically as reported below.

[57] For example, Petrosino and colleagues' (2012) meta-analysis reports heterogeneity statistics of Q= 325.60, df=.24, p<.001; I^2=92.62, tau^2=.019.

Table 5.3 Sensitivity analyses

Variable	SMD	95% CI	Q	Tau^2	I^2	P-value	Sample
Mobile learning: all studies	0.465	0.348, 0.583	127	0.035	85.9%	0.0000	17
Study type:							
Randomised controlled trial	0.496	0.096, 0.896	39.4	0.107	94.9%	0.0000	5
Quasi-experimental design	0.661	0.390, 0.931	32.6	0.121	69.3%	0.0003	12
Risk of bias:							
Low risk of bias	0.359	0.137, 0.586	43.8	0.041	93.2%	0.0000	5
Moderate risk of bias	0.730	0.242, 1.220	14.0	0.219	71.4%	0.0074	6
High risk of bias	0.667	0.376, 0.959	3.01	0.000	0%	0.5560	6
Removal of outliers:							
Aker 2012	0.679	0.421, 0.937	77.4	0.174	84.5%	0.0000	16
+/- 0.5 SD from the mean	0.317	0.201, 0.432	60.5	0.015	76.8%	0.0000	13
Period of follow-up:							
above 1 month	0.422	0.210, 0.634	49.2	0.043	89.8%	0.0000	8
1 month or less	0.712	0.380, 1.040	16.9	0.131	58.6%	0.0179	9
Sample size:							
above n=100	0.183	0.071, 0.294	8.97	0.007	77.7%	0.0113	4
n=100 or less	0.833	0.515, 1.115	30.1	0.188	66.7%	0.0084	13

In the combined meta-analysis, I pooled studies of randomised controlled and quasi-experimental evaluation designs. The pooling of these study designs is a continuous debate within the systematic review community (Oakley 2000; Gough et al 2012; White & Phillips 2013) as quasi-experimental designs are often regarded as a less rigorous form of evaluation. In table 5.3 one can observe that RCTs and quasi-experimental studies indeed yield different pooled effect sizes with the RCTs reporting a smaller pooled effect. However, there was still considerable heterogeneity within the two sub-groups. Conducting a formal sub-group analysis (Online appendix 4)[58], I found that the different study designs could not explain the heterogeneity within the meta-analysis (Q=0.443, p= 0.51; heterogeneity explained: 0%). I therefore ruled out study design as an explanation for heterogeneity and the meta-analysis results are not sensitive to which impact evaluation design was applied.

In addition to study design, I also used the risk of bias ratings as an indicator of studies' rigour in the sensitivity analysis. I did not find any significant explanation for heterogeneity between low- and moderate-rated studies (Q=1.84, p=0.18; heterogeneity explained: 21%); between low- and high-rated studies (Q=2.72, p=0.10; heterogeneity explained: 15%); and between moderate- and high-rated studies (Q=0.05, p=0.83; heterogeneity explained: 0%). The pooling of studies with different risk of bias judgments since can neither explain the

[58] All formal sensitivity and moderator sub-group analyses reported in this section can be found in online appendix 4: https://africacentreforevidence.org/project-outputs-3/

identified heterogeneity.

As a next step, I analysed the sensitivity of the meta-analysis results to the removal of outliers. Following Borenstein and peers (2013), outliers are defined as studies diverting from the pooled effect size (0.47) by 0.5 standard deviations. This resulted in the exclusion of four studies from the analysis (Kumar 2012; Liu 2009; Pitchford 2014; Wu 2012). I found that the removal of outliers marginally reduces heterogeneity in the meta-analysis (Q=60.5; df=14; p<0.000; I^2=76.8%; tau^2=0.015). Using formal sub-group analysis, it emerged that the inclusion of these four outlying studies accounted for 57% of the prevailing heterogeneity (Q=53.5, p<0.05). However, as illustrated, the removal of outliers did only marginally reduce heterogeneity in the remaining sample of studies.

I also hypothesised that the period of follow-up could explain heterogeneity across the effect sizes in the meta-analysis. The duration between baseline and endline measurements seems to have had a small influence on heterogeneity (Q=2.56, p=0.11; heterogeneity explained: 58%). This finding, however, was not statistically significant. Lastly, I assessed whether the sample size of experiments can explain the variance in the identified effects. I found a significant impact of sample size on heterogeneity (Q=14.3, p=0.0001; heterogeneity explained: 61%). This finding explains that studies with a sample size above 100 participants have significantly smaller effect sizes than studies featuring a smaller sample.

Taken together, I identified two design related explanations for the large heterogeneity within the meta-analysis findings. The first explanation relates to sample size and to a lesser extent, secondly, to the period of follow-up. Both these factors relate to the degree of control researchers had over the implementation of the mobile intervention. Studies that were more closely supervised by the research team due to the smaller sample size and shorter periods of follow-up had significantly larger effect sizes. On the other side, more longitudinal studies with samples in the thousands (e.g. n=5014, Aker 2012) were under less control of the research teams. The degree of control arguably might have provided more room for immediate programme adaptation, targeting of inputs, supply of resources, etc. In contrast to study design and risk of bias, degree of control is a significant cause of heterogeneity. The larger the degree of control, the larger the impact of mobile learning programmes. Lastly, regardless of the controlled sensitivity variables, I highlight that the overall results of the analysis remain unchanged. In each analysis, the identified positive pooled effect size of mobile learning interventions remains robust and significant. I was unable to run a sensitivity analysis on the influence of the variance in outcomes measures applied in different studies as the included studies used a homogenous range of outcome measures judged at a low risk of bias.

Assessing the quality of my meta-analysis: are the findings moderated by characteristics of the applied mobile learning interventions and their contexts?

Aside from variables related to study design, variables related to the applied mobile learning interventions themselves and the context in which these were conducted could have systematically influenced the differences in effect sizes. The meta-analysis included 17 studies, which applied a variety of programme approaches, were implemented in diverse settings, used different technologies, and so forth. It was since expected that the true effects of the interventions would vary across these programme- and context-related variables. This assumption was confirmed by the large heterogeneity identified in the review. In the following, I assessed possible variables moderating the identified impact of learning and teaching with mobile technologies on learning outcomes. Using the same structure as in the sensitivity analysis, I first constructed a descriptive overview table of all possible moderator variables (Table 5.4), before engaging in formal sub-group analysis.

Table 5.4 Moderator analyses

Variable	SMD	95% CI	Q	Tau^2	I^2	P-value	Sample
Mobile learning: all studies	0.465	0.348, 0.583	127	0.035	85.9%	0.0000	17
Applied technology:							
Basic/feature phones	0.183	0.072, 0.294	8.97	0.007	77.7%	0.0011	4
Smart phones/PDAs	0.726	0.454, 0.999	17.2	0.089	47.5%	0.0464	11
Tablets	0.564	0.356, 0.772	29.1	0.035	89.7%	0.0000	2
1:1 model	0.571	0.386, 0.755	86.2	0.064	84.9%	0.0000	17
Shared ownership	n/a	no observations					
Socio-economic contexts:							
Urban	0.796	0.393, 1.200	29.0	0.254	75.9%	0.0001	9
Rural	0.200	0.068, 0.332	14.2	0.011	78.8%	0.0027	5
LICs[59]	0.224	0.177, 0.271	38.2	0.049	94.8%	0.0000	4
LMICs	0.585	-0.649, 1.820	6.57	0.687	84.8%	0.0104	3
UMICs	0.690	0.410, 0.969	15.6	0.087	48.7%	0.0485	10
Formal education	0.770	0.450, 1.090	59.5	0.228	81.5%	0.0000	14
Informal education	0.162	0.110, 0.214	3.08	0.060	67.5%	0.0792	3
Primary School	0.710	0.346, 1.070	35.0	0.192	80.0%	0.0000	9
High School	0.858	-0.010, 1.730	11.1	0.480	81.9%	0.0399	3
Tertiary	1.340	0.791, 1.910	1.88	0.075	46.8%	0.1700	2
Gender	n/a	no observations					
Prior level of education	n/a	no observations					
Intervention category:							
MALL	0.320	0.169, 0.417	16.0	0.013	62.5%	0.0137	7
MAML	0.214	0.156, 0.272	36.0	0.599	94.4%	0.0000	4
Perceptions & Adoption	n/a	no observations					
Teacher development	n/a	no observations					
Experiential / inquiry-based	0.661	0.316, 1.010	15.3	0.130	69.7%	0.0182	8
Teacher-centred	0.322	0.184, 0.481	27.5	0.020	89.1%	0.0000	3
Learner centred	0.663	0.411, 0.915	84.1	0.138	85.7%	0.0000	14
Pedagogy:							
Game-based	1.190	0.694, 1.700	6.12	0.130	51.0%	0.1060	4
Context-aware	0.490	0.257, 0.724	1.18	0.000	0%	0.9470	7
Collaborative	0.666	0.352, 0.980	0.58	0.000	0%	0.9010	4

[59] Note that Papua New Guinea has been re-classified as a LMIC. However, during the conduct of the primary study the country was classified as a LIC.

Socio-economic context as a moderating variable: The first set of possible moderating variables related to the different socio-economic contexts in which the mobile learning programmes were implemented. As indicated above, a majority of ML4D programmes were conducted in urban areas and these programmes tended to apply more complex educational approaches. The moderator analyses provide statistical evidence that this structural inequality translated into a difference in programme impact.

Urban mobile learning interventions had a larger effect size of 0.80 (0.39, 1.20) SMD as compared to programmes in a rural context (g=0.20; 0.07, 0.33). This difference in effect sizes was statistically significant (Q: 13.1, $p<0.05$). The more complex intervention approaches, e.g. multiple educational components and richer pedagogical models, since seemed to have influenced the effectiveness of mobile learning programmes in urban areas. Rural interventions mainly used an SMS-based approach to deliver short snapshots of information to participants (e.g. Cole 2012). While this was found to be effective to increase learning, the gained improvements are significantly smaller compared to more complex interventions in urban settings.

Next, I assessed whether the impact of mobile learning interventions was dependent on the economic development of the countries in which they were conducted. I applied the World Bank's classification of economies and allocated studies to low income, lower-middle income, and upper-middle income status. On observation, interventions in low income countries have a smaller combined effect size (g=0.22) than both lower-middle (g=0.59) and upper-middle income countries (g=0.69). Yet, this analysis was based on small sample sizes and upon statistical investigation I could not rule out that the differences in effect sizes between these three groups came as a result of chance (Q=0.86, p=0.35). Mobile learning interventions in upper-middle income countries shared the common characteristic of being evaluated under closely controlled conditions. I have already established that this level of control explains a large amount of heterogeneity. Three out of the four interventions in low income countries, on the other hand, were informal mobile learning programmes with large samples sizes and a longer period of follow-up. In the absence of statistical significance for between country classifications, I refer to these experimental design conditions as an explanation for the differences in effect sizes. The same logic extends to the difference in effect sizes between programmes in formal and informal educational settings. The limited number of studies in these samples negated a meaningful statistical analysis.

Lastly, I investigated the type of school in which the mobile learning programmes was implemented as a potential moderator. While the meta-analysis generated a small nominal difference between schooling types, this finding was not statistically significant (Q=0.10, p= 0.75). I since ruled out the hypothesis that mobile learning programmes in LMICs are particularly effective in certain types of schools. Rather, their impact on learning outcomes held true in each educational setting in which they have been implemented, that is informal education programmes (*g*=0.16), primary schools (*g*=0.71), high schools (*g*=0.86), and tertiary education (*g*=1.34). I could not assess gender or previous level of education as a possible moderator. None of the included studies did apply a gender specific focus and neither did studies report sufficient information on participants' level of education.

Applied technology as a moderating variable: I assumed that the mobile technologies applied in the mobile learning programmes might have an impact on the resulting programme effects. I therefore analysed the relative effectiveness of programmes using basic/feature phones, programmes using smart phone or PDAs, and programmes using tablet devices. On a glance, the meta-analysis results suggested that mobile learning programmes using more sophisticated mobile technologies have a larger effect size (*g*=0.73 for smartphones and *g*=0.56 for tablets vs. *g*=0.18 for basic/feature phones). This observation was validated by the statistical sub-group analysis, which showed the differences in effect sizes to be statistically significant (Q: 13.1, $p<0.05$ for smartphones vs. basic phones; Q: 11.8, $p<0.05$ for tablets vs. basic phones). More sophisticated mobile devices, for example in terms of computing power and visualisation, generated systematically larger effect sizes. I was unable to assess the relative effectiveness of mobile learning programmes using a 1:1 model and shared models of device ownership due to the absence of quantitative evidence on the latter. I neither was able to use previous exposure to or perception of the applied technologies as a moderator. This information was not sufficiently reported in the included sample of studies.

Mobile learning intervention category as a moderator: I also investigated whether specific types of mobile learning programmes might be more effective in improving learning outcomes in LMICs. In this, I relied on the above-outlined ML4D intervention categories. Alas, the review did not identify any quantitative evidence on teacher development programmes or reliable numerical measures on changes in perception and adoption of mobile learning. I found a nominal difference between mobile learning programmes aiming to improve language learning (*g*=0.32) and programmes targeting mathematical ability (*g*=0.21). Yet, upon statistical sub-group analysis this difference was not significant (Q=0.94, p=0.33). Mobile learning programmes that facilitated experiential / inquiry-based learning, for example examining a local ecosystem, showed a larger effect size than both MALL and MAML (*g*=0.66). This difference was statistically significant and mobile learning since seems to have been particular effective when using technology to contextualise learning experiences and allowing learners to explore content independently ($Q=3.92$, $p<0.05$).

This last finding underlined mobile learning's rationale as an innovative educational approach, which allows for a more relevant and practical learning experience through combination of different learning contexts. If this potential is fully exploited, as in the case of experiential / inquiry-based learning programmes, which specifically designed the learning experience around the combination of learner contexts (e.g. factual information about an ecosystem on mobile devices that are made accessible at the same time when learners experience this ecosystem in practice), then mobile learning in LMICs was found to produce larger knowledge gains. Finally, I was unable to assess whether learner-centred mobile learning programmes were more effective than teacher-centred interventions. Only three interventions targeted teachers as the main recipients of the mobile learning programme (Aker 2015; Kaleebu 2013; Piper 2015). The limited number of studies in this sample negated a meaningful statistical comparison with the learner-centred group of studies that featured a sample of 14 studies.

Mobile learning pedagogy as a moderator: The last potential moderator I analysed referred to the specific pedagogies which underlined the application of mobile devices in educational settings in LMICs. Of the different underlying pedagogies described in section 5.1.3, only three types prevailed in the included studies for meta-analysis (game-based n=4; context-aware n=7; collaborative n=4). A key finding in this moderator analysis was that pedagogy served as an effective moderating variable that highly reduced heterogeneity across the studies combined in each sub-group. Each of the three pedagogy-related sub-groups presented a homogenous sample (see table 5.4). I therefore conducted a more detailed narrative analysis for each of the sub-groups which is provided in appendix 5.4.

Each of the individual mobile learning pedagogies had a higher combined effect size than the overall average effect of ML4D programmes. That is, there is observational evidence that following an explicit pedagogy is in its own right a variable that increases the impact of using mobile technologies in education in LMICs. The formal statistical sub-group analysis confirms this hypothesis ($Q=13.7$; $p<0.05$). However, it is important to caution that studies using explicit pedagogical approaches applied more controlled evaluation designs in which the researchers oversaw the implementation of the innovative teaching and learning strategies enabled by the use of mobile devices. These findings therefore can only be interpreted as an indication of the importance of applying formal pedagogies supported and enabled by mobile learning. In addition, all but one of these pedagogical-rich studies have been conducted in UMICs; and, likewise, all but a single mobile learning intervention using explicit game-based, collaborative, or context-aware pedagogies have been conducted in urban areas.

Lastly, the meta-analysis results also indicated nominal differences between the combined effect sizes of different mobile learning pedagogies themselves. Using formal sub-group analysis, I found that the relative effectiveness of game-based mobile learning as compared to collaborative and context-aware pedagogies was statistically significant ($Q=6.13$, $p<0.05$; $Q=6.24$, $p<0.05$). The identified difference between collaborative mobile learning approaches and context-aware mobile learning, however, was not significant ($Q=0.77$, $p=0.38$). Based on a limited sample of evidence, the meta-analysis thus presented game-based mobile learning as the most effective approach to learning and teaching with mobile technologies in LMICs.

5.2.3 Do mobile learning interventions improve teaching practice in LMICs?

This section reports the overall impact of the use of mobile technologies in LMICs to change teaching practices in LMICs. Only four studies included in the meta-analysis attempted to measure a change in teaching practice using quantitative instruments. In three studies, this referred to observation of teachers facilitating lessons using mobile technologies and recording instances of applied teaching strategies, pedagogies, and teacher-learner interaction (Kaleebu 2013; Rosas 2002; Zurita & Nussbaum 2004). Unfortunately, only Kaleebu and peers' outcome measure was included in the synthesis as the remaining two studies only assessed teaching practices in the intervention group and not in the control group. A single study set out to investigate whether teachers' efforts had increased following the provision of mobile technologies (Aker 2012). As a result, there were only two studies eligible to contribute effect size data on changes in teaching practice into the meta-analysis. Unfortunately, neither study reported sufficient statistical information to calculate effect sizes and I am therefore limited to reporting the studies' outcomes in narrative form.

Aker (2012) investigated whether the provision of SMS quizzes and lessons supplementary to an existing adult literacy programme in Niger can increase learning outcomes. Teachers as well as adult learners were provided with basic phones and an increase in teachers' efforts given the provision of the phone was hypothesised as a possible mechanism to explain increases in learning. While the study established the latter, it ruled out a change in teachers' efforts as a contributing factor. Following the provision of basic phones, teachers did not conduct significantly more or longer lessons as compared to teachers who received no phones.

On the other hand, in their 2013 evaluation of the SMS story programme in Papua New Guinea, Kaleebu established a significant effect of the mobile learning programme on teaching practice. SMS story provided teachers over two academic terms with a total of 100 daily text-message stories and 100 related text-message lessons. Aiming to support the instruction of students' reading abilities, teachers received tailored stories to read together with students as well as lesson plans on how to integrate and assess these stories in their daily teaching. Random visits to intervention and control schools showed that teachers in the intervention group were actively engaging with the content sent to them as text-messages and that there was a large change in the reported use of teaching strategies promoted by SMS story lesson plans. Overall, teachers using SMS story were found to be more engaged and to facilitate lessons in a more interactive and learner-centred fashion. These results were based on a proxy indicator consisting of classroom activities such as writing stories on chalkboards, reading stories to children, encouraging children to read from chalkboards, and listening to children reading to teachers one-on-one.

I also investigated the prevalence and effects of intermediate outcomes indicating potential changes in teaching practice. For this analysis, I consulted the entire sample of 20 studies included in the meta-analysis. However, there was insufficient information on intermediate outcomes related to a potential subsequent change in teaching practice to conduct a meta-analysis or narrative synthesis. Intermediate teaching practice outcomes mentioned but not investigated as part of the experimental design of studies referred to changes in teacher motivation, teacher training, perception and ease of use technology, and teacher confidence in learners' future performance. These outcomes were assessed using qualitative research methods and are therefore included in the configurative review module.

In sum, the review identified insufficient evidence to assess the aggregative impact of mobile technologies on teaching practice in LMICs. As a result, it can neither confirm nor refute the hypothesis that the use of mobile devices might alter teaching strategies and approaches. I will present further evidence on this question in the configurative review module in chapter 6.

5.2.4 Do mobile learning interventions improve EMIS in LMICs?

This section reports the overall impact of the use of mobile technologies in LMICs to support the collection and monitoring of educational information and outcomes. Only two studies included in the meta-analysis investigated the effects of mobile technologies on EMIS (Aker 2015; Cilliers 2014). Both studies assessed the impact of using mobile phones to monitor and increase teacher attendance. Aker's (2015) RCT was judged at a low risk of bias, while Cilliers's (2014) RCT was subject to a high risk of bias rating. Unfortunately, I was not able to calculate effect sizes for either study due to an absence of variance statistics being reported in the studies in reference to teacher attendance data. I am thus restricted to provide a brief narrative of the studies' results.

Cilliers's (2014) RCT in Uganda assessed the impact of different local monitoring schemes on teacher attendance. Headmasters as well as parents of pupils were provided with mobile phones to use a standardised SMS system to monitor teacher attendance at their schools. In two arms of the trial, teachers received a bonus for regular attendance based on the monitoring data. The study found mixed evidence of the effectiveness of mobile monitoring. Out of three different intervention designs only the mobile monitoring conducted by head teachers coupled with bonus payments increased teachers' attendance by 11%. There was no significant effect in the other two intervention designs. What is more, the quality of reporting using mobile phones was less reliable than in-person monitoring. Both, parents and head teachers, underreported teacher absenteeism by 14 to 18% despite the anonymous and rapid mobile tool to report attendance.

Aker's (2015) RTC presented strong evidence that mobile monitoring can increase teacher attendance. The authors further found that the increase in attendance led to a subsequent significant increase in learning outcomes of 7.5% (g=0.15; 0.07, 0.23). Adult literacy teachers received weekly phone calls by programme officers to inquire about their record of conducted lessons in the past week. There was no bonus or penalty tied to teachers' attendance and number of lessons taught. Teacher information was verified by calling adult learners part of the literacy programme. The regular phone calls led to a marginal increase of attendance: on average, teachers attended 1.27 additional days over six months. The authors therefore concluded that teacher attendance alone cannot explain the increase in learning outcomes. Rather, improved educational performance was driven by an increase in teacher motivation following the correspondence with programme officers, which was perceived by teachers as a recognition of the importance of their work. The same survey data also revealed that while motivation increased, the weekly calls did not influence teachers' self-reported pressure, and perceived competence or choice. The mobile monitoring thus assumed a different role than theorised, being greeted by teachers as a form of motivation rather than supervision. This finding, if replicated in other studies, would question they very assumptions about the root causes for teacher absenteeism in resource-constrained settings and the role of mobile monitoring in decreasing such absenteeism.

In sum, based on the systematic review evidence, it was not possible to arrive at an aggregate answer to the question of mobile technologies' effects on EMIS in LMICs. There is currently not enough rigorous experimental research evidence to answer this question. Evidence from two RCTs indicated positive effects of mobile monitoring on teachers' attendance, but the two monitoring programmes used different intervention designs and the mechanisms at play varied greatly. I am aware of two additional trials of mobile monitoring interventions in LMICs. However, the full research report of a World Bank funded RCT that has been concluded in December 2015 in Haiti is not yet in the public domain (Adelmann et al 2015)[60]. In addition, past and ongoing impact evaluations of the Bridge International Academies in Kenya and Liberia have collected regular data on teacher attendance via tablet devices. These data were used in combination with other factors to determine teacher pay. Unfortunately, the NGO has not made this data or the evaluations publicly available. Given the recent publication dates of the included studies as well as the indication of large-scale ongoing studies, it seems reasonable to suspect that the evidence-base on mobile monitoring in LMICs will increase in size in the near future allowing for a more meaningful synthesis.

5.2.5 Do mobile learning interventions increase empowerment in LMICs?

This section reports the aggregate effects of learning and teaching with mobile devices on empowerment in LMICs. In total, only three studies included in the meta-analysis collected outcome data on empowerment (Aker 2012; 2015; Pitchford 2014). However, in two studies the applied outcome measure of empowerment was of critical risk of bias and could therefore not be used in the synthesis. Pitchford (2014) asked 9-11 year-old learners in Malawi a 10-item survey investigating among other how many children the respondents intend to have and what they assumed their own future income to be (Pitchford 2014: 16). This data was assumed to yield insights on learners' ambition and empowerment. In addition

[60] Preliminary analysis has been disseminated through a World Bank seminar and policy brief: http://documents.worldbank.org/curated/en/2015/12/25781533/haiti-can-smartphones-make-schools-better

to the unrealistic assumptions underlying this outcome indicator, the control questions in the survey revealed that over half of the learners had not understood the survey questions. Pitchford's (2014) reported findings on learner empowerment in Malawi were thus excluded from the synthesis.

The second empowerment outcome measure excluded from the synthesis was reported by Aker (2012). As part of the adult literacy intervention in Niger reported above (5.2.3), the researchers attempted to measure the level of interest of adult learners in education; with level of interest being treated as an indicator of empowerment. Level of interest in education in return was assessed counting adult learners' use of a toll call hotline to express "their support for the adult education program" (Aker 2012: 114). In addition to the lengthy logic model linking collected data to empowerment outcomes, the research team was unable to collect information of the control groups' level of interest in education negating any conclusions on the attribution of the observed effect to the applied mobile learning intervention.

However, in their 2015 follow-up study of the 2012 RCT, Aker (2015) applied a more trustworthy outcome measure of empowerment consistently across both experimental groups. This study is therefore the only piece of evidence contributing empowerment outcome data to the synthesis. Following weekly phone calls to adult learners to allow them to report their teacher's attendance, learners' self-reported changes in empowerment were assessed through Rosenberg Self-Esteem Scale and the General Self-Efficacy Scale. Only findings on self-efficacy were statistically significant indicating a positive effect of the weekly calls on learners' perceived ability to increase their knowledge. This overall effect however did hide important variances in the reported data. Self-efficacy only increased in intervention communities in which learning outcomes increased too. Study areas in which learning was not enhanced reported the opposite effect on efficacy: that is, adult learners reported to have less control over the ability to increase their knowledge. The increase in self-efficacy, framed as empowerment in the study, is thus more likely to be a result of the increase in learning outcome (literacy gains in this case) than a result of the weekly phone calls per se. This is an important observation as it would suggest that if mobile learning is able to increase learning outcomes in disadvantaged settings, these increases in knowledge might support perceived empowerment too. The meta-analysis on learning outcomes reported in section 5.2.2 did indeed suggest that mobile learning is able to increase learning outcomes. However, only a minority of the mobile learning interventions included in the meta-analysis were conducted in disadvantaged rural settings comparable to the context of Aker's (2015) assessment of empowerment outcomes in rural Niger. In sum, I can only conclude, based on the systematic review evidence, that there is an insufficient amount of research to allow for an overall assessment of mobile learning's effects on empowerment in LMICs.

5.2.6 Are mobile learning interventions a cost-effective approach to support education in LMICs?

The meta-analysis has produced rigorous statistical evidence that learning and teaching with mobile technologies in LMICs improved learners' test scores by 23.2% (*g*=0.47). In the context of meta-analyses of other educational interventions in LMICs this is a large effect size. However, mobile technologies—as all education interventions—require an investment in inputs. I therefore also extracted information on the cost-effectiveness of ML4D programmes. Information on input costs and rates of returns were only provided in six studies. While reported information was too heterogeneous to conduct a statistical cost-effectiveness analysis, the individual studies' cost-benefit findings presented in table 5.5 below revealed two patterns.

Table 5.5 Overview of cost-effectiveness calculations

Study	Intervention	Cost-effectiveness calculations	Finding
Aker 2012	SMS-supported adult literacy campaign	Additional costs of adding SMS module to intervention / additional number of learners reaching level A1 proficiency	'for an additional US$6.50 per student, 4% more students were able to reach Level 1'.
Aker 2015	Mobile teacher monitoring of adult literacy campaign	US$ saved from in person monitoring per village / SD learning gains	'per-village savings are $6.5, as compared with average gains of .20 SD in learning'.
Cole 2012	Mobile-phone based agricultural extension	Comparison of aggregated input cost for mobile and human extension service per farmer	'the cost of the intervention is quite low: monthly cost of approximately USD $1.13 per farmer; the "all-in" costs for physical extension were about $8.50 per farmer'.
He 2012	PDA-supported	Aggregation of input costs	'measured by academic

	foreign language learning: Mobile device with interactive vocab features & quizzes	for PicTalk machine / Standard deviation change in learning per child	gains, PicTalk's cost per child per tenth standard deviation is $7.87 (external) and $3.11 (teacher). While the unadjusted per pupil cost is high, the gains in average score are commensurate with costs'.
Kaleebu 2013	SMS messages to teachers to inspire interactive and learner-centred teaching	Listing of input costs	'the estimated cost of delivering the text messages and subsequent reading improvement is approximately $0.63 per child.'
Piper 2015	Tablet with pedagogical materials provided to: a) Teacher assistants b) Teachers c) e-readers with pre-loaded books provided to learners	Effect for each treatment group / per-pupil per-subject unit cost of each of the mobile tools	a) $100 leads to 7.8 students reaching full reading fluency b) $100 leads to 4.3 more students reaching full reading fluency c) $100 leads to 0.5 more students reaching full reading fluency

First, table 5.5 indicates that all four mobile phone-based interventions were highly cost-effective. Either using SMS or voice calls as a method to facilitate the intervention, the programmes had low input costs while still reporting increases in learning outcomes. Despite this encouraging findings, I caution that the meta-analysis findings suggested that these type of interventions have a significantly smaller effect on learning outcomes than more complex and pedagogy-rich mobile learning programmes. The evidence map further suggested that SMS-based interventions are primary targeted at rural, resource-constrained settings. So, while the reported interventions seem to be cost-effective, their educational impact is significantly smaller than other mobile learning interventions—an important consideration when interpreting these cost-effectiveness findings.

Second, table 5.5 also highlights that in formal educational settings investments into technologies for learners (i.e. PDAs and e-readers) are less cost-effective than investments into technologies for teachers. The provision of phones to teachers in Papua New Guinea (Kaleebu 2013) and tablets in Kenya (Piper 2015) led to large increases in students' learning at a low input cost. While 1:1 technology provision to students, too, increased learning outcomes, the financial investments required to achieve a similar increase in learning are significantly higher. Piper's (2015) trials illustrate this finding in particular: US$100 invested in tablets for teachers led to 4 to 8 students achieving full reading fluency depending on the programme design. The same $100 invested into e-readers for students, however, only led to 0.5 learners achieving full reading fluency.

In sum, there was some indication in the evidence-base that mobile technologies present a cost-effective tool to support education in LMICs. Mobile phone-based interventions using SMS as a delivery tool as well as teacher-centred interventions reported effective cost-benefit ratios. Major investments in 1:1 models of technology delivery to students, on the other hand, were not found to be cost-effective. One needs to keep in mind though that the reported pooled effect of mobile learning was higher than the average pooled effects of educational interventions in LMICs reported in the literature, which supports the assumption that mobile technology investments can be cost-effective. However, this assumption needs to be balanced against the observation that most mobile learning programmes were by and large add-ons to existing educational efforts. That is, the technology provision built on the existing educational infrastructure (e.g. school buildings, trained teachers) and mobile learning programmes were able to exploit this established educational environment. A simple technology input cost vs. learning gains calculation therefore overlooks the initial educational investments providing a space in which mobile learning interventions can be implemented.

Conclusion

This chapter has presented the findings of my systematic review research on the aggregate effect of mobile learning on educational outcomes in LMICs. I first mapped the empirical evidence-base of research studies investigating the use of mobile technologies in LMICs to support education. Thereafter I used statistical meta-analysis to synthesise the reported numerical effects of mobile learning's impact to answer the question of what works for mobile learning in LMICs.

Starting with the descriptive map of the evidence, a diverse picture of ML4D interventions emerged. I found that most ML4D programmes were implemented in a formal educational setting and did not present independent programmes. The mere provision of mobile technologies seemed not to present a feasible programme approach to support education in LMICs. Mobile technologies assumed a supplementary role to existing educational interventions. Mobile phones were by large the dominant device applied and most ML4D interventions actively exploited the specific technological affordances of mobile technologies. Yet, the potential of mobile technologies to facilitate teaching and learning across contexts was hindered in half of the programmes due to deliberate limitations to device use in informal contexts.

The reviewed mobile learning interventions in LMICs aimed to facilitate a more learner-centred educational approach and targeted this objective through programme designs catering for and centred on learners' needs and preferences. The use of mobile technologies to support or target teachers was secondary. There was a built-in bias in the reviewed evidence to bypass teachers and other educational stakeholders in favour of targeting learners as the main users and beneficiaries of mobile learning. The most prominent ML4D approach applied MALL as a tool to support literacy or foreign language acquisition. Game-based, context-aware, and collaborative learning strategies expressed the most common pedagogical underpinnings of ML4D interventions. Underlying pedagogies were, however, dependent on the applied technologies. Less sophisticated mobile devices, such as basic/feature phones, used less advanced teaching and learning strategies, whereas PDAs, smartphones, and tablets featured richer pedagogical models.

In the context of international development, it appeared that the reviewed mobile learning interventions overlooked the most disadvantaged groups in society. The interventions further were shaped by—rather than aimed to counter—existing structural inequalities within education systems in LMICs. In particular, there was evidence of inequalities between rural and urban educational settings being reproduced in the educational design of ML4D programmes. Mobile learning interventions in rural areas subscribed to a less complex educational structure. Social transformation and empowerment was assessed by a minor number of programmes. Development indicators, for example official poverty lines, were not included in outcome measures of ML4D programmes.

The reported meta-analysis provided rigorous evidence of mobile learning's aggregate impact on education outcomes in LMICs. The meta-analysis established that the use of mobile technologies to support learning and teaching had a significant positive effect on student attainment. Synthesising the effects of 17 different mobile learning interventions comprising data from 17,909 participants, the meta-analysis found that there was an overall improvement of 28% in test scores between learners supported by mobile technologies and learners without access to technology. This positive and significant pooled effect of mobile learning interventions held true across contexts and various sensitivity and moderator analyses. Table 5.6 provides an overview of the key meta-analysis findings in the context of this thesis.

Table 5.6 Overview of meta-analysis results

Outcome	Standardised mean effect (*g*) N of effect sizes in parentheses	Percentage improvement in treatment over control
Main:		
Learning outcomes	0.47 (17)	23%
Teaching practice	Insufficient quantitative evidence	n/a
Empowerment	Insufficient quantitative evidence	n/a
EMIS	Insufficient quantitative evidence	n/a
Supplementary:		
Language	0.32 (7)	16%
Math	0.21 (4)	10%
Knowledge gains	0.66 (8)	32%
Significant moderators	*Difference in standardised mean effect*	*Number of studies*
Urban context	+0.59	9
Rural context	larger *g* in urban areas	5
Basic/feature phones	+0.54	4
Smart phones/PDAs	larger *g* for smart phones & PDAs	11
Experiential learning	+0.34	8
MALL & MAML	larger *g* for experiential learning	10
Game-based	+0.53	4
Collaborative & Context-aware	larger *g* for game-based learning	11

In addition to presenting evidence of the positive aggregative effect of mobile learning on student attainment, the meta-analysis also identified a number of variables that were associated with a larger impact of mobile learning on learning outcomes in LMICs. I found that mobile learning interventions were significantly more effective in urban than in rural areas and explained this effect due to the more complex educational and technological intervention design of urban programmes. I also established that programmes using more sophisticated technologies, which had the ability to generate richer mobile learning experiences, had a significantly larger effect size. Drawing conclusion from these two points, the meta-analysis findings suggest that pedagogies matter in the design of mobile learning interventions in LMICs. The mere delivery of content, e.g. through daily text messages (Aker 2012; Cole 2010; Kaleebu 2013) on mobile devices was significantly less effective in improving learning in LMICs. Interventions using mobile technologies to design context-aware, game-based, and collaborative learning experiences, on the other hand, were found to be more beneficial in improving learning. I did not identify conclusive evidence on the other outcomes of interest in this systematic review. The evidence-base on mobile learning's aggregate impact on teaching practice, EMIS, and empowerment was too thin at the time of conducting this review. As a result, I can neither support nor refute the hypothesis that mobile learning is an effective tool to improve these three outcomes.

This chapter has provided evidence of mobile learning's educational potential in LMICs. The chapter was concerned with the aggregate effect of mobile learning programmes and has established that these programmes are effective to increase learning outcomes. During this investigation of ML4D's overall impact, however, a small number of important mechanisms and contexts that mitigate mobile technologies' educational and developmental potential were discovered. For example, the applied pedagogies presented a key mechanism to support mobile learning's impact and the context of reproducing structural inequalities in the design of mobile learning interventions questioned its developmental agenda.

These findings suggest that investigating mobile learning's aggregate effect alone provides an incomplete answer to the assessment of mobile learning's relevance and usefulness in LMICs. In addition to what works in ML4D, an investigation into how and why teaching and learning with mobile devices led (or led not) to education and development outcomes is required. Chapter 6 will therefore next investigate a configurative synthesis of mechanisms and contexts at play when using mobiles as an educational tool in LMICs. This synthesis will also examine whether and how the educational gains reported in the aggregative synthesis of mobile learning's effects can be linked to development outcomes. The question of whether mobile learning can be positioned to support poverty reduction, reduce inequality, and support a transformation in livelihoods cannot be answered based on the conducted aggregative review module. In this remit, the findings reported in this chapter will serve as the basis of a theory of change for ML4D, which will be fully developed using the findings of the thematic synthesis on contexts and mechanisms to zoom in on mobile learning's link to questions of development.

Chapter 6. Configuring a theory of change for the use of mobile technologies to support education in LMICs

Introduction

This chapter presents the second set of findings from my mixed-methods systematic review. It further combines both sets of review findings to develop a detailed theory of change for how the use of mobile technologies is assumed to support education in Low- and Middle-Income Countries (LMICs). This theory of change is thereafter juxtaposed with the prevailing conceptualisation and positioning of using mobile technologies as an educational tool in LMICs by international development and mobile vendor organisations. Through this juxtaposition, the chapter highlights gaps and contradictions between the understanding and positioning of mobile learning for development (ML4D) and the empirical evidence-base investigating the effects of teaching and learning with mobiles on educational actors.

The second set of systematic review findings refer to the thematic synthesis conducted as part of the configurative review module. Based on themes derived from qualitative research evidence, the results of the thematic synthesis establish contexts and mechanisms that unpack the aggregate effects of mobile technologies reported in the meta-analysis. For example, these contexts and mechanisms illustrate how technologies are perceived, how learning and teaching practices might (or might not) change, and what components of mobile learning interventions support effective educational processes.

Following the presentation of the thematic synthesis findings, I merge these with the findings of the meta-analysis to construct a theory of change for ML4D interventions. This theory of change outlines how mobile technologies are assumed to support education, and subsequently development outcomes, in LMICs according to the empirical research studies included in the systematic review. The theory of change illustrates a range of such pathways linking the educational use of mobile technologies to development outcomes[61]. The systematic review findings of the effects of ML4D interventions and the contexts and mechanisms configuring these effects are then plotted against this theory of change.

[61] Development outcomes here refer to the definitions of development reported in the primary research studies.

In a last step, I juxtapose this theory of change for ML4D and the presented systematic review findings with the prevailing understanding and positioning of ML4D. This comparison aims to illustrate what assumptions about the effects of using mobile technologies as an educational tool in LMICs are supported by the empirical evidence and where there are gaps and contradictions between the evidence-base of ML4D's effects and technologies' perceived potential. These gaps and contradictions are then used to underline the case for applying the Capability Approach (CA) as a conceptual lens to explore the educational and developmental potential of ML4D interventions. The chapter concludes with a brief summary of the reported findings.

6.1 Thematic synthesis: contexts and mechanisms configuring the impact of ML4D interventions

The thematic synthesis explored the contexts and mechanisms that mitigate or reinforce the impact of using mobile technologies as an educational tool in LMICs. I therefore synthesised qualitative research studies that investigated the application of ML4D programmes in order to be able to unpack how and why teaching and learning with mobile devices led (or did not lead) to education and development outcomes. In this, I extracted the research findings of the qualitative primary studies, coded these findings for common descriptive themes, and then configured the descriptive themes into higher-level analytical themes. The coding framework targeted the identification of themes around contexts and mechanisms. As outlined in chapter 4, I define context as 'variables exogenous to the ML4D intervention that influence its impact' and mechanism as 'changes caused by the use of mobile technologies that influence its impact'. The identification of themes followed largely an inductive coding process with a small number of a priori defined deductive codes (Online appendix 1). To recall, in order to be included in the systematic review, qualitative research studies had to meet minimum criteria related to the transparent reporting of research methodology, data collection, and data analysis.

6.1.1 An overview of the included qualitative evidence

A total of 52 studies were included in the configurative review module. The majority of studies (n=27) applied a case study design, followed by ethnographies (n=4). Participatory rural appraisal and action research were each used in only a single study. In 19 studies, the research design was described in terms of the methods of data collection such as 'in-depth interviews' or 'qualitative survey'. In general, individual interviews were the most common method of data collection (n=31) followed by observations (n=22) and survey methods (n=13) (e.g. of perceptions towards the use of mobile technologies). Ten studies used focus groups to collect qualitative data, while six studies used data collected by the applied mobile devices themselves (e.g. chat protocols, call logs). Regarding methods of data analysis, where explicitly stated, thematic analysis was the most common form of analysis (n=19) followed by content analysis (n=7), grounded theory analysis (n=4), and discourse analysis (n=2). Where interviews were conducted, the average reported number of interviews was eight (range: 3–32). Data collection predominately took place while teachers and learners were still engaged in the use of mobile technologies (n=24).

Similar to the aggregative module, studies focused on learners' experiences with mobiles (n=36) rather than teachers' use of mobiles (n=16). This pattern further reflects in the type of ML4D interventions investigated by the qualitative studies: only eight ML4D programmes focused on teacher development. The majority of qualitative studies explored the perceptions of educational actors regarding the use of mobile technologies and their subsequent adoption (or non-adoption) (n=19). MALL and MAML were the subject of investigation in respectively 16 and 10 studies. Again, the most common device used in mobile learning programmes is the mobile phone (n=44) followed by some margin by tablets (n=8) and PDAs (n=6).

In terms of outcomes, the included studies mainly focused on qualitative changes in learning outcomes (n=38). These outcomes differed from the quantitative studies by having a stronger focus on the type of learning experiences and changes in learning practice. A total of 10 studies investigated qualitative changes in teaching outcomes. These followed a similar pattern with an emphasis in changes in teaching experiences and teaching practice. Only four studies explicitly tried to link the event of mobile learning to ideas of empowerment. These focused on adult literacy learning drawing on Freire's Critical Pedagogy and Sen's Capability Approach as well as gender empowerment outcomes (Andersson 2010; Balasubramanian 2010; Velghe 2014; Kumar 2010).

The studies included in configurative module had a stronger emphasis on intermediate outcomes than includes in the aggregative module. The majority of the qualitative studies provided rich information on the perceptions of teachers and learners on using mobiles as an educational tool. In terms of intermediate outcomes this targeted the following in particular: mobiles' pedagogical contribution (n=22); ease of use (n=20); perceived near/long-term usefulness (n=16); and technology acceptance (n=12). Reoccurring outcome measures in terms of what factors support integrating devices into educational practice referred to the importance of local content (n=7); device ownership (n=6); and teacher training (n=5).

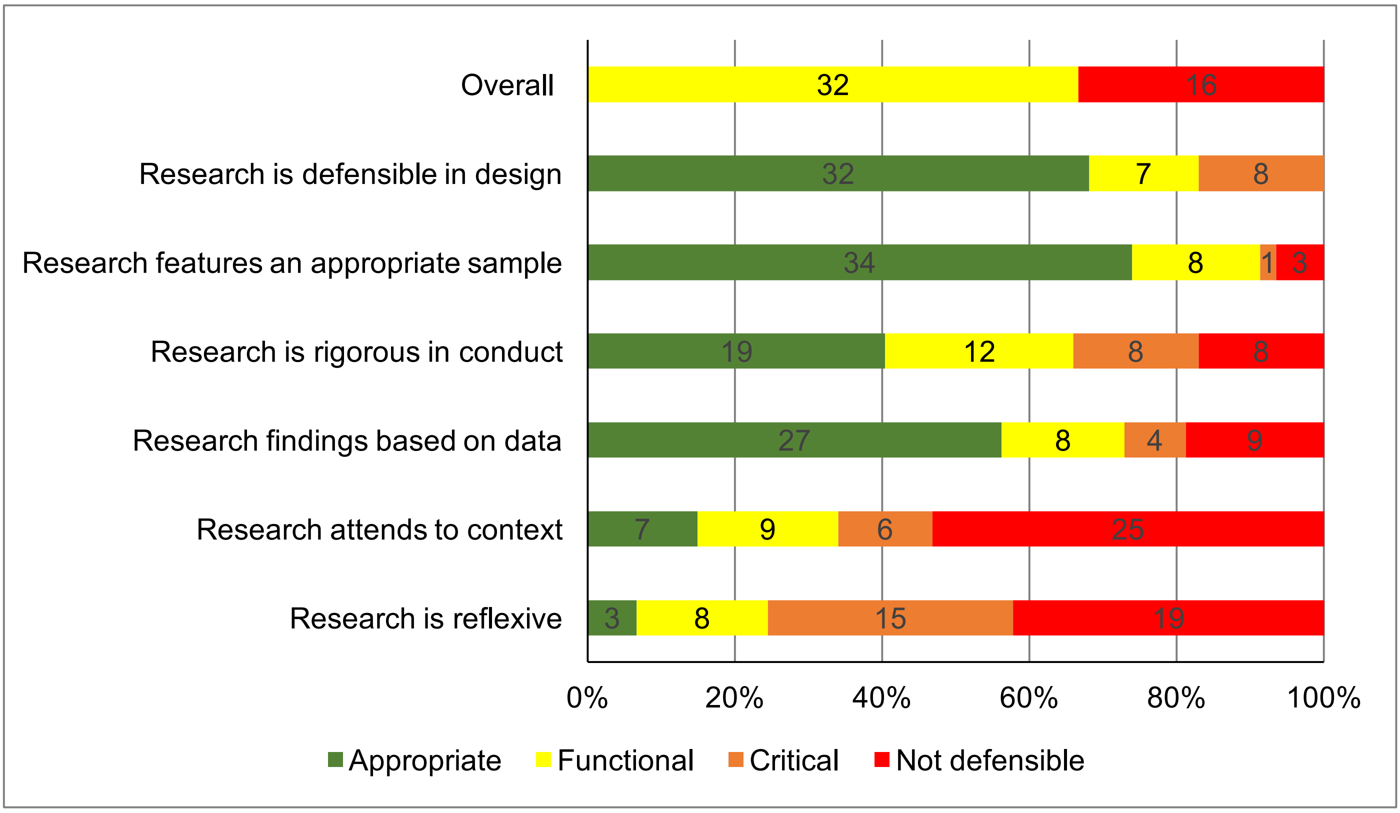
6.1.2 How trustworthy is the qualitative evidence (critical appraisal of studies)?

As in the aggregative review module, I conducted a critical appraisal of the included research studies to ensure that primary findings used in the synthesis were trustworthy. This appraisal, however, followed different criteria more suitable for qualitative research (see Chapter 4, section 4.2.4) formalised in a detailed critical appraisal tool (Appendix 4.2). Figure 6.1 below illustrates the results of my critical appraisal of the qualitative research studies. Of 52 studies, 16 studies were subject to critical flaws undermining the trustworthiness of the research findings, which were consequently not included in the thematic synthesis. As figure 6.1 indicates, the main reasons for exclusion from the synthesis following the critical appraisal were that the link between research findings and presented primary data was not evident (n=9) and that the research process was not reflecting sufficient quality and care (n=8)[62]. Challenges in terms of linking reported data to stated research findings and conclusions, for example referred to UNESCO's (2014) 'Reading in the mobile area' study. Despite not having collected data or conducted an analysis on the gender breakdown in the reading patterns of the Worldreader app, the study claims to identify such gendered patterns in the high downloads of romantic novels, citing an inherent preference of females for romantic fiction in Africa (UNESCO 2014: 55). The second main factor of exclusion referred to evident challenges in the technical conduct of the research itself. To illustrate, Worldreader's evaluation of its Project LEAP in Kenya was conducted by the NGO's own research manager. The report illustrates that the sample of respondents was changed during the study; that respondents were asked to estimate frequency of device use by individuals 12 months post the event; and that respondents were financially dependent on the occupation provided by Worldreader—the organisation leading the evaluation.

Following the exclusion of the 16 studies of a critical risk of bias, only 36 studies were eligible to contribute data to the thematic synthesis. That is, coding for descriptive and analytical themes was only conducted on the research findings of these 36 studies. No scaled critical appraisal was applied.

[62] To recall, the critical appraisal questions related to 'research attends to context' and 'research is reflective' were not used to include or exclude primary studies. However, research appraised highly for being reflective of shortcomings in other appraisal areas could overrule the study's exclusion from the synthesis—though I did not identify any cases in this regard (Appendix 4.2).

Figure 6.1 Overview of critical appraisal: qualitative research



6.1.3 Thematic synthesis findings: What mechanisms and contexts mitigate and reinforce the effects of ML4D interventions?

This section reports the results of my thematic synthesis. The analysis and synthesis of the findings of each of the 36 included studies resulted in 16 analytical themes, which consist of 69 descriptive themes (Appendix 6.1). The analytical themes are separated into mechanisms for change and context themes. Taken together, these analytical themes unpack the identified effects on mobile technologies and investigate how and why these effects might (or might not) manifest. I first discuss the identified mechanisms for change before turning to the context themes.

Mechanisms for change: how and why do ML4D interventions work?
In the thematic synthesis, I identify ten mechanisms for change that present insights into what types of changes and processes are triggered through the application of mobile technologies as an educational tool in LMICs. These mechanisms to some extent unpack how the causal effects identified in the meta-analysis might be generated, but the thematic synthesis further highlights changes in teachers' and learners' behaviours that were not

identified in the quantitative impact evaluations on which the meta-analysis is based. So, some of the mechanisms for change below directly link to the findings of the meta-analysis, such as the mechanisms around pedagogies, which was identified in the meta-analysis too. Others, however, were not identified in the quantitative studies included in the meta-analysis, such as mechanism 4: teaching experience. These types of mechanisms for change illustrate the effects of using mobile technologies as an educational tool in LMICs that were not investigated and identified in the impact evaluation evidence.

The process of identifying these mechanisms for change in the thematic synthesis is outlined in detail in chapter 4, section 4.2.4 and appendix 6.2. In brief, for each included qualitative study, I coded the study findings according to reoccurring descriptive themes. For example, studies reported that learners described studying with mobiles as more interactive or more personal. Such findings were then coded in a descriptive manner as ‘interactive learning’ and ‘personalised learning’. Column 1, in table 6.1 illustrative these descriptive themes. Having identified descriptive themes, I then configured these themes into higher-level analytical themes by investigating synergies, contrasts, and complementaries across descriptive themes. These analytical themes thus go beyond the actual findings reported in the included primary research and present the unit of analysis on which the results of my thematic synthesis are based. For example, the mentioned descriptive themes were configured together with three other descriptive themes into the analytical theme around mechanism 1: pedagogy and practice (Table 6.1).

The analytical themes were formed around mechanisms for change and context themes, which provided the overall framework to organise the descriptive themes. Behind each reported mechanism for change and context theme, there is thus a set of descriptive themes linked to the primary research findings in the included studies. It is important to keep in mind that while some analytical themes were based on a larger number of descriptive themes and primary research findings, I do not weight the analytical themes in their contribution to the synthesis. That is, none of my analytical themes (i.e. none of my mechanisms for change or context themes) is regarded as ‘richer’ than the others in their contribution to the synthesis. Lastly, analytical themes are not mutually exclusive and are based on overlapping descriptive themes as much as on the overlapping results of the included primary studies.

Table 6.1 provides a summary of the ten identified mechanisms for change and how they were constructed[63]. The identified mechanisms for change can be broadly divided in three

[63] The full list of analytical and descriptive themes is provided in Appendix 6.1.

categories. First, mechanisms around changes in the way teaching and learning is experienced and practiced following the introduction of mobile technologies. This category presents the majority of mechanisms including mechanisms 1 to 5: pedagogy & practice; learner experience; teaching practice; teaching experience; and relationships & interactions. Second, mechanisms giving rise to a different set of socio-economic changes not identified in the meta-analysis. This category comprises mechanisms 7 to 10: social capital; economic capital; self-efficacy; and empowerment. Third, a strong and reoccurring mechanism around of the centrality of teacher training, mechanism 6.

Table 6.1 Summary of mechanism themes

Reported descriptive themes based on primary studies' findings	Mechanisms for change at play when teaching and learning with mobiles
• interactive and collaborative learning • authentic educational approach • personalised and targeted learning • increased access to information • variety in teaching and learning activities	**Mechanism 1: Pedagogy & practice** Mobile learning in LMICs can change the way education is practiced, leading to a number of more learner-centred educational approaches.
• education is engaging and enjoyable • personalised and independent • enhance the relevance of educational experience • more open educational experience	**Mechanism 2: Learner experience** Mobile learning in LMICs can change the way education is experienced by learners facilitating a more engaging, relevant, and open educational experience.
• a more learner-centred approach • increased subject knowledge • opportunities for collaboration, peer-support, and social learning • reinforce or trigger existing practices rather than establishing new practices	**Mechanism 3: Teaching practice** Mobile technologies can support pedagogical and non-pedagogical changes in teaching.
• teaching as more enjoyable and less stressful • more efficient and better organised • more connected and, in rural areas,	**Mechanism 4: Teaching experience** Mobile devices can facilitate the act of teaching leading to a better perception of,

less isolated • more recognised and valued	and satisfaction with, the profession (in return increasing the motivation to teach).
• a role of facilitating knowledge • *shift not intrinsically connected to the use of technology* • control is reason for adoption • some students did not agree with a shift away from teacher power • tech use as exercise of power	**Mechanism 5: Relationships & interactions** The educational use of mobile technology can change the relationships and interactions between students and teachers.
• training to be in control of technology use • training to focus on pedagogy and subject expertise • collaboration and peer-support	**Mechanism 6: Teacher training** Teacher training is key to ensure technology adoption and its pedagogical use during teaching.
• large social spill-over effects • ability to connect • collaboration and peer-to-peer support • social standing • experience pride	**Mechanism 7: Social capital** The educational use of mobile technology can support the accumulation of social capital.
• direct economic benefits of IT skills • access to online job postings • support rural community development • intrinsic economic motivation	**Mechanism 8: Economic capital** The educational use of mobile technology can support the accumulation of economic capital.
• improved self-perceptions (pride) • self-efficacy and aspiration • community & peer recognition/status • technology use as exercise of power	**Mechanism 9: Self-efficacy** Mastery of technology can be a large motivation for learning with technology as source of pride, confidence, self-efficiency.
• critical pedagogy • women empowerment • co-construction of knowledge	**Mechanism 10: Empowerment** A theme of using mobile technologies to support empowerment ran through a sub-set of studies, but was not focused on the particular role of mobile learning in this process.

Mechanisms for change: teaching and learning experiences and practices

The thematic synthesis generated a large variety of themes around how learners and teachers perceived education to have changed following the introduction of mobile technologies. These themes centred around the perception that mobile technologies' affordances can support the application of more learner-centred pedagogies. Qualitative evidence highlighted the ability of teachers and learners to exploit technologies' affordances such as connectivity, gamification, information sharing and visualisation to engage in more interactive and collaborative educational approaches (e.g. Hassler et al 2011; Kim 2012; Masperi & Hollow 2008). In addition, these affordances paired with others such as the portability of devices, camera and GPS, and multimedia features were linked to more authentic and situated learning experiences (e.g. Ekanayake 2013; Liu et al 2009). For example, adult literacy programmes in South Africa and India tailored mobile content depending on the domestic context of women in which they were assumed to access the educational content (Velghe 2014; Balasubramanian 2010).

Changes in educational practice also were linked to an enhanced ability to target and personalise educational lessons to the learners. An emerging sub-theme here referred to the ability to use mobile technologies to match educational content to learners' ability and rates of progression. This tracking and matching approach has been found effective in a number of impact evaluations (e.g. Chen et al 2010; Duflo 2015), but was only explicitly mentioned as a perceived contribution of mobile technologies in three studies included in the synthesis. An increased access to information facilitated by mobile technologies presented a further major change to educational practice. This was the most reoccurring descriptive theme identified in 25 studies. Teachers and learners both reported the value of having constant access to a wider range of information allowing them to extend learning beyond provided learning resources (e.g. Cole & Fernando 2012; Witt et al 2016). Taken together, these reported changes to educational practices were perceived to give rise to more interaction between teachers and learners, and between learners themselves; allow for more independent learner inquiries; and more contextualised and authentic learning experiences—each of which was assumed to support a more learned-centred educational approach.

A range of descriptive themes highlighted the perceived benefits students reported following the use of mobile technologies as an educational tool. Learners indicated a range of beneficial changes to their educational experiences including more engaging and enjoyable tasks and lessons in which, for example, 'I don't want to stop, I forget that I am learning' (Turtianined 2010). Increased personalisation and independence in the learning process again were identified, as were an enhanced relevance and openness of the educational experience supporting more participation and interaction in lessons. These themes do overlap with the mechanism theme of learned-centred pedagogies[64].

Teachers, too, reported a more positive educational experiences as a mechanism through which mobile technologies support educational processes (e.g. Leach et al 2005; Onguko et al 2013). This includes a change to a more learner-centred pedagogy, but the thematic synthesis also identified a range of more pragmatic reasons. For example, teachers often reported that the use of technology made it easier to control the classroom as there was less need to lecture students because the devices kept them occupied and motivated (e.g. Sahni et al 2008). Similar pragmatic advantages include for instance: less paper work, easier marking of student papers, and ready-to-go educational content. A reoccurring benefit of using mobile technologies for teachers further referred to their ability to enhance their subject knowledge. Teachers often reported teaching subjects they had not studied for and perceived the mobile devices as a helpful tool to increase their subject expertise (e.g. Sohel & Kirkwood 2012; Wennersten & Qureshy 2012).

The reviewed primary studies reported that teachers valued the mobile devices in particular for the opportunity to collaborate, connect with peers, and engage in social learning. The ability to be connected to a wider community of educators and to be able to network and communicate with one another was a reoccurring theme (e.g. Onguko et al 2013; Sahni 2008). Teachers reported to feel less isolated, in particular in rural schools, and to feel more up-to-date (e.g. Ekanayake 2013). Collaboration with teachers in comparable contexts also served as a source for new teaching content and approaches. In sum, the thematic synthesis generated a range of themes linked to teachers' practices and experiences, not all of which were linked to pedagogical changes. An equally important mechanism associated with the use of mobile devices was that the devices can facilitate the act of teaching, which can lead to a better perception of, and satisfaction with, the profession by the teacher themselves.

Investigating the linkages between the mechanism themes around teachers' and learners' practices, there is a repeated emphasis on how the use of mobile technologies in LMICs can change the relationships and interactions between students and teachers. A range of studies provide rich evidence that the more learner-centred pedagogies can shift the educator's positon to assume the role of facilitating knowledge rather than being the holder and

[64] I provide a more critical interrogation of these findings in the discussion of the combined systematic review findings in section 6.2.2.

transmitter of knowledge (e.g. Anderson 2010; EIA 2011; Sohel & Kirkwood 2012; Sahni 2008; Hassler et al 2011). This shift is linked to teaching strategies that allow for more participation, learner-led activities, and more interaction and communication, which comes at the expense of less frontal teaching and content delivery. However, this theme was not unanimous. First, as eluded to above, teachers did not necessarily adopt more learner-centred teaching strategies for the pedagogical benefit, but for more pragmatic reasons (e.g. Kim et al 2011; Sahni 2008). Second, in a sub-set of studies, communities and students in different LMICs objected to this shift demanding the teacher to remain firmly in control of the educational process (e.g. Anderson 2010; Sohel & Kirkwood 2012). Third, there is also evidence that both teachers and learners employ mobile technologies as a tool to exercise power rather than to diffuse power relationships. Examples of this are teachers threatening to withhold devices to learners if they do not obey the teacher, or learners using the technology to dominate group work (e.g. Ale & Chib 2011; Kumar et al 2010). Fourth, in the above cited studies providing findings that support the mechanism ‘Relationships and interactions’, the reported shift is not necessarily linked to the application of the mobile devices. That is, the applied pedagogies do not depend on the use of mobile technologies and I would caution to draw a direct causal link between the observed changes and the provision of mobile technologies.

In summary, these five mechanisms unpack some of the positive learning effects identified in the meta-analysis. The application of mobile technologies as an educational tool in LMICs seems to be able to support a more learner-centred educational approach leading to more engaging and interactive learning experiences. These changes to educational practices, however, can also be non-pedagogical and teachers in particular applied the mobile devices to support a range of pragmatic changes to ease their teaching practices and experiences. More positive and engaging educational experiences as well as more learner-centred practices then might be able to explain the observed gains in educational outcomes. However, to be clear, these findings do not claim that there is a direct causal link between the provision of mobile technology and the observed pedagogical changes. The thematic synthesis is based on qualitative evidence and does not test hypotheses. Rather, the synthesis provides a structure on the diverse and rich *educational experiences and practices reported* in the primary evidence. *The thematic synthesis does not cover the question of attribution.*

The thematic synthesis findings I present are based on the body of evidence and need to be contextualised as such. For example, it would be presumptuous to claim that the identified themes around educational changes can be positioned to constitute mobile learning, following the pedagogical definition by Kearney and peers' framework (Kearney et al 2010) presented in chapter 2, section 2.1.3. While across the themes, all of Kearney and peers' attributes of mobile learning are covered—that is, authenticity, collaboration, and personalisation—only a small minority of primary studies in fact apply all three attributes (Kim et al 2011; Pimmer et al 2014; Zurita & Nussbaum 2004). The assumptions and challenges this raises are discussed in detail in chapter 9, section 9.3.2.

Mechanisms for change: teacher training

The importance of teacher training in the adoption and application of mobile technologies emerged as a central mechanism in the thematic synthesis. A large body of quality evidence (n=12) highlighted different dimensions in which teacher training influences the educational changes associated with technology use (e.g. Kafyulilo 2012; Voigt & Matthee 2010). A first dimension referred to the need for teachers to be in control of the technology adoption. That is, teachers expressed a need to be proficient in the use of the mobile devices before students gained access to them. In a number of case studies, teachers actively blocked the application of mobile devices in the classroom if they did not feel in control of them (Ale 2011; Kafyulilo 2012). This findings positions teacher training as a main mechanism to support the effective use of mobile technologies. In the body of qualitative evidence that investigated such teacher training, reported findings emphasised for the training to focus on practical teaching strategies in which the technology can be embedded rather than to focus on training for ICT skills (e.g. Ekanayake 2013; Leach 2005). Within different training approaches, collaboration and peer-to-peer learning were mentioned as useful training strategies. The Digital Education Enhancement Project and the Digital StudyHall Project programmes, for example, used videos, secondment visits, and train-the-trainer strategies to let teachers observe and learn from other teachers in similar educational contexts on how to integrate mobile technologies into their teaching strategies (Leach 2005; Sahni 2008).

Mechanisms for change: socio-economic changes

My thematic synthesis identifies four mechanisms for change that describe how the use of mobiles in an educational setting is perceived to support socio-economic changes in the lives of teachers and learners. These mechanisms are based on qualitative evidence and therefore do not aim to indicate causal effects. Two sets of mechanism for change explored how the application of mobile devices might be linked to an accumulation of social and economic capital.

In terms of social capital, a consistent theme referred to large social spill-over effects of the introduction of mobile technologies. Both, teachers and learners, were reported to share the devices and their educational uses in cases where device use was not limited to the educational setting (e.g. Voigt & Matthe 2008; Hassler 2011). Social capital could also be enhanced through using the mobile devices to connect with friends, colleagues, and relatives, which was highly valued for social reasons in particular among teachers. This also related to the ability to collaborate with and learn from other teachers, a theme discussed above already. Lastly, social capital was reportedly affected by a shift in perceptions around teachers and the educational system. The possession and mastery of mobile technologies was associated with an increased social standing of teachers. Likewise, being part of a ML4D programme including the provision of mobile devices was a matter of pride for parents and community members enhancing educational perceptions and motivation. This theme is discussed in more detail under contexts.

In terms of economic capital, four themes described how mobile devices could support economic outcomes for learners and teachers. Each of these four themes describes mechanisms bypassing the educational system. First, teachers and learners perceived the possibility to derive a direct economic benefit from their acquisition of IT skills. This related to assumptions of better employment opportunities and the ability to take part in the information society (e.g. Masperi & Hollow 2008; Ekanayake 2013). Searching for employment using mobile devices was repeatedly reported as a benefit of being able to use mobile technologies. Qualitative evidence of ML4D programmes in rural areas further identified beliefs across teachers, parents, and community members that the provision of mobile technologies could support the development of the local community and slow the urban migration of youth (e.g. Leach 2005; Sahni 2008). Lastly, a small but consistent body of evidence on adult literacy programmes unpacked an intrinsic economic rationale to be able to use mobile devices. Adult learners in Niger, South Africa, and India reported that being able to write SMS rather than having to make phone calls would increase their business activities and profit (e.g. Aker 2012; Balasubramanian 2010; Velghe 2014). Similarly, they would be able to use their phone to access business related information.

The final two mechanisms for change centre around the application of mobile devices to contribute to what could broadly be understood as processes of empowerment. There was a contrast in the identified qualitative studies between the richness of evidence underlying more granular personal changes in self-efficacy and locus of control and more formal assessments of empowerment on a more collective scale. For the latter, only a small number of qualitative studies reported linkages between the use of mobile technologies and a formal or collective process of empowerment (n=4). For example, despite the general theme that access to information can empower communities and people, my thematic synthesis identified marginal evidence that pedagogies were built around this access, for example in a Freirean sense of Critical Pedagogy. Only Andersson (2010) and Balasubramanian (2010) aimed to empower communities and disadvantaged groups through the use of explicit pedagogies involving mobile devices. The same finding emerged in relation to gender empowerment. There were only three studies included in the thematic synthesis which set out the collect empirical data on how gender empowerment could be affected by learning and teaching on mobile devices. Likewise, while there were repeated suggestions in the literature that mobile devices can support a co-construction of knowledge, there were few empirical examples of this mechanism to be found in the included qualitative evidence. Instances of learners or teachers using mobiles to generate their own content were only reported in two studies (Pimmer et al 2012; 2014).

In contrast, I identify a range of themes related to changes in learners' and teachers' self-efficacy. Mastering technology usage and applying mobiles as an educational tool emerged as a source of pride, confidence, and improved self-perceptions. Related themes were identified in 13 studies. Teachers in particular considered themselves to be more 'advanced' and 'ready for the 21st century' leading to an increased professional standing (Leach 2005; Ekanayake 2013). These feeling were reinforced by community and learner perceptions of teachers, who in return reported to feel more valued as professionals and community leaders. Being able to master and teach with technologies thus became a source of pride and recognition for educators—a more granular shift in self-efficacy and agency. The same mechanism was observed for students, but based on a smaller body of evidence (n=5). All in all, however, claims to mobile learning's empowering attributes—in particular linked to empowerment through access to information—need to be cautioned. I do not find a large supportive body of evidence in the thematic synthesis or in the meta-analysis to fuel this narrative. Rather, the evidence-base seems to suggest that more individual and granular changes in teachers and learners' self-efficacy and social capital might be a mechanism through which mobile learning can link to ideas of empowerment and increased agency.

Context themes: how and why do ML4D interventions work?

The thematic synthesis further generated six context themes that unpack conditions, attributes, characteristics and other variables exogenous to the mobile learning programmes that were associated with the observed effects of technology usage. These context themes identify conditions that can facilitate or block the perceived educational and developmental impact of mobile learning programmes. Table 6.2 presents a summary of the six identified context themes as well as the descriptive themes that informed them[65].

Table 6.2 Summary of context themes

Reported descriptive themes based on primary studies' findings	Contexts influences the teaching and learning with mobiles
• ubiquity & familiarity with mobiles • convenience & blend in daily routines • produce new and support existing forms of communication • affordability of devices	**Context 1: Positive perceptions** Mobile devices' particular affordances can nurture a general positive perception of mobile technologies among educational stakeholders in LMICs.
• ease of use • interface design and space for personalisation of devices • technical queries relate to issues with hardware	**Context 2: Feasibility** Mobile devices are technically able to serve as educational tools in LMICs.
• respect and recognition from peers and function as peer educators • pride of participation and higher perceptions of teachers and schools • teachers feel more professional and valued • teachers express higher opinions of students	**Context 3: Technology as a social and professional status symbol** Mobile devices are intrinsically associated with status and professionalism leading to higher perceptions of schools / teachers who possess the devices.
• user training and teacher training • integrated in the existing curriculum • power issues on domination • intrinsic economic motivation	**Context 4: Factors of adoption** While mobile technology as an educational tool is acceptable to teachers, learners, and parents in LMICs, supporting factors have to be in place to nurture its adoption as an educational tool.

[65] The full list of analytical and descriptive themes is provided in Appendix 6.1. Context themes were identified following the same process as for the mechanism themes.

• teachers report a range of mobile and contextualised technology usages • students rarely are allowed to use mobile technologies unsupervised during formal educational activities • teachers and parents are reluctant to allow the possession of devices outside school hours	**Context 5: Informal use limited for learners** The mobile and contextualised use of technologies is determined and limited by formal education actors and social structures.
• teacher transfers • frequent strikes • absenteeism • caveat on time spent with devices	**Context 6: Systemic challenges** A range of systemic issues negatively affected the implementation of ML4D programmes in LMICs.

The six context themes include four themes linked to intrinsic attributes of mobile technologies and how they are perceived by educational actors in LMICs. These refer to contexts 1 to 4: positive perception; feasibility; technology as a social and professional status symbol; and factors of adoption. In essence, these four contexts explain how and why mobile technologies can experience rapid adoption as an educational tool. The themes also present the background to the mechanisms related to enhanced self-efficacy and social capital. The remaining two context themes refer to two key barriers to mobile technologies' impact on education in LMICs: informal use limited for learners and systemic challenges, contexts 5 and 6. To keep in mind, a range of contexts have already been included in the meta-analysis as moderator variables, for example socio-economic settings, and are therefore not discussed again in the thematic synthesis.

Contexts: adoption of mobile technologies as an educational tool

A key question in my thematic synthesis was how and why mobile technologies find adoption as educational tools in LMICs. Often reports about the use of mobiles in schools reference strong resistance among teachers and parents, ranging to outright bans of mobile devices in some instances (Trucano 2015; DBE 2015; Beland & Murphy 2015). I therefore explicitly coded the qualitative studies included in the thematic synthesis for any factors explaining uptake or rejection of mobile technologies in educational contexts. This led to four analytical themes explained below, but also established a strong and consistent finding that, on aggregate, the qualitative evidence reported barely any instances of non-adoption or rejection of mobiles. Of 30 studies providing qualitative data on the adoption of mobile technologies, only two studies (Ismael 2012; Kafyulilo 2012) reported a rejection of mobile devices by educational actors in LMICs, teachers in both cases. The empirical evidence-base thus suggest little support for popular narratives of the rejection of mobiles in education in LMICs.

Three main contextual themes might explain the adoption of mobiles. A first contextual theme focuses around pre-existing positive perceptions towards mobile technologies in general by teachers, learners, and parents in LMICs. A range of mobile devices' particular affordances seem to nurture these perceptions. For example, parents and teachers repeatedly referred to the ubiquity of and familiarity with mobiles (e.g. Liu et al 2010; Ale & Chib 2011). The technologies were not perceived as a foreign educational input but rather as an artefact that parents and teachers felt familiar with and used in their daily interactions themselves. The latter was emphasised regarding the ability to use mobiles to stay in contact and communicate with students and teachers (e.g. Jantjies & Joy 2014).

A second linked contextual themes highlighted that there was little reservation across teachers, learners, and parents regarding the technical feasibility of using mobile technologies for educational purposes. A reoccurring theme identified in 27 studies referred to the ease of use of mobiles. Learners and teachers were already familiar with mobiles and how to operate them, leaving few reservations among these groups that this use can be adapted in an educational context. Design aspects supporting such adaptation referred to the interface design of the educational application as well as the ability to personalise devices, for example through covers and individual log-ins (e.g. Leach 2005; Hassler 2011). Reported barriers to the use of mobiles mainly were caused by problems with the hardware of devices, such as battery life, screen size, memory storage, and breakage due to wear and tear. Overall, however, there was little qualitative evidence refuting the technical feasibility of using mobiles to support education in LMICs.

A third contextual theme highlighted the intrinsic association of mobile technologies with professionalism and success in LMICs. That is, ownership of mobile devices was seen as a social and professional status symbol. This theme was consistently found across the included qualitative studies (n=21) independent of the setting in which the mobile technologies were applied. Given mobile technologies role as status symbols, ownership and mastery of the devices therefore generated a range of social and professional benefits. Teachers in particular reported to feel more valued; both, in terms of being provided with devices akin to other government employees or 'office workers' (Leach 2005; Masperi 2008), and in terms of how local communities and learners perceived them. A common theme referred to ‘they [learners and community members] see us as professionals now’. Teachers thus reported to feel more respected and recognised as professionals, which was linked to enhanced self-perceptions and job satisfaction.

Further, the social and professional benefits of using mobile devices were not limited to teachers only. They likewise extended to learners and schools. For example, both teachers and parents expected students to perform better in school if mobile devices were used as teaching and learning aids. Parents in particular reported a preference to send their children to ‘technology schools’ (e.g. Masperi 2008; Voigt & Matthe 2012). As a result of the intrinsic high professional associations of mobiles, a virtuous circle of positive perceptions can be in place. This reinforced the adoption of technologies and, too, supported important social spill-over effects of device ownership.

Finally, despite these three context themes supportive of mobile technologies adoption, the thematic synthesis also identified a range of other supporting factors that influence the adoption of mobiles as an educational tool. Teacher training as already mentioned presented a key theme, but so did user training for learners. The latter was not so much focused on device literacy but rather on the responsible use of mobiles in an educational setting (e.g. Turtiainen et al 2010). The integration of the mobile learning programmes into the existing curriculum presented a second major factor of adoption (e.g. Kim et al 2011; Wennerstein 2012). Mobile learning content that did not follow the current curriculum and/or did not fit local contexts, such as local English accents, was often rejected (e.g. Masperi 2008; Wennerstein 2012). A linked theme again referred to teachers’ need to be in control of the educational use of the technology. For instance, learner-centred and interactive teaching strategies in which the teacher is still in charge of the learning process (e.g. group work and presentations aided by mobile devices) found stronger adoption than strategies in which the teacher can be challenged or does not set the learning objective. In sum, the thematic synthesis therefore identified three contextual themes that support an intrinsic acceptance and adoption of the technology, but these are mitigated by specific educational contexts and needs.

Contexts: barriers to mobile technologies’ impact on education in LMICs

In the thematic synthesis, I identify two context themes that provide rich evidence on factors mitigating the effects of teaching and learning with mobiles in LMICs. These two barriers are present across different settings and are likely to be faced by most ML4D interventions. First, in the large majority (n=20) of the mobile learning programmes included in the thematic synthesis[66], the mobile and contextualised use of technologies is determined and limited by formal educational actors and social structures. That is, teachers and parents set strict boundaries around learners' use of mobile devices if they have the power to do so. This can lead to large restrictions on the learners' abilities to exploit the mobility of the devices and potential mobility of the learning experience. While teachers themselves report to value the ability to access learning materials 'anytime, anywhere' (e.g. Ekanayake 2013; Shohel & Kirkwood 2012), they rarely permit or encourage their students to use mobile technologies unsupervised during formal educational activities. Where such unsupervised mobile learning events occur, they are explicitly built into the mobile learning intervention design (e.g. Kumar 2010; Ekanayake 2013).

Teachers cite fear of theft and loss of devices as well as concerns that learners would not focus on the educational task as reasons for limiting device usage to formal classroom settings (e.g. Voigt & Matthe 2008; Kim 2011). For parents, fears of a financial loss of having to replace the devices in case of damages or thefts as well as fears over children accessing illicit online materials were the main reasons for rejecting an unsupervised use of the devices. Given the results of the meta-analysis and the thematic synthesis on mechanisms, in which rich mobile learning pedagogies that facilitated more learner-centred and contextualised learning approaches led to larger educational outcomes, this limitation to a mobile use of the devices across contexts presents a major barrier. Many attributes and benefits of mobile learning remain unlocked if the devices can only be used in a formal classroom setting.

A second contextual key barrier identified in the thematic synthesis refers to systemic challenges within the wider education system. Almost half of the studies included in the thematic synthesis (n=16) mentioned systemic obstacles that affected the ML4D intervention. The most frequent cited obstacles to effective programme implementation were teacher transfers (n=9), teacher strikes (n=8), and teacher absenteeism (n=8)—underlying the centrality of teachers to the use of mobile technologies (as well as the education system in general). None of the mobile learning programmes subject to these systemic challenges was able to use the technologies to circumvent these challenges. This finding highlights the extent to which programmes were embedded into the existing education systems and therefore subject to the system's functioning. There was an absence of empirical research evidence on ML4D interventions that attempted to influence systemic issues within

[66] But, interestingly, of the 20 studies included in the meta-analysis only five apply such restrictions. This is linked to the larger degree of control that researchers had over the intervention design in most of the impact evaluations included in the aggregative review module.

education systems in LMICs. In the light of this absence, the context of the existing education system is a major determinant of the ability to engage mobile technologies as an educational tool in LMICs.

Non-themes: deductive themes for which no evidence was identified

In the thematic synthesis, I also set out to explore a number of deductive descriptive themes that were specified a priori based on common themes in the literature on ML4D. Here, I briefly report on some of the deductive themes for which I did not identify any systematic empirical evidence in the included qualitative evidence. I refer to such themes as 'non-themes' and an exhaustive account of them is provided in Appendix 6.1. To be clear, I do not claim that the absence of evidence on these themes implies an evidence of absence. For various reasons the available research evidence might not have focused or reported empirical data on these themes.

In total, there were 12 themes for which I found no empirical data in the included studies. Most notably among the non-themes linked to contexts was that I did not identify any systematic empirical evidence that different groups or actors are able to exploit or access mobile devices differently in formal education. I explicitly attempted to code the included studies for gender-specific usage of technologies; age-related difference in use; and socio-economic and ethnic-related differences. In mobile learning programmes in formal education structures neither of the above themes were reported. This differs from mobile learning programmes in informal education programmes. Here, I do find that gender emerges as a determinant of access to devices. However, this is based on a small number of studies (n=3) and is linked to mobile learning programmes that have an explicit focus on gender empowerment in general. Across the body of evidence available, therefore, little data reported differences in access and usage of mobile technologies.

There was also no systematic empirical evidence to indicate that mobile technology presents a mechanism to access otherwise inaccessible education services, that is the use of mobile devices as a substitute for formal educational structures. Only two studies linked to adult learning in informal contexts (Balasubramanian et al 2010; Velghe 2014) used mobiles as a formal replacement for education services. This links to the non-theme of systemic change mentioned above already. There was no systematic empirical evidence on mobile learning's effects on systemic change in education in LMICs. This finding might be partly related to the scale of most mobile learning programmes assessed in the thematic synthesis, which usually were focused on single schools. It further reflects, however, a lack of engagement with structural and systemic issues in the design of most ML4D programmes included in the synthesis. For example, I did not identify any studies on ML4D programmes focused on leadership in or management of education systems in LMICs. Systemic change, it seems, was not within the scope and objective of the evaluated programmes.

6.2 A theory of change for ML4D drawing on my mixed-methods synthesis

Following the meta-analysis as a method of synthesis in the aggregative review module and the thematic synthesis as a method of synthesis in the configurative module, I next combine both syntheses findings in a mixed-methods synthesis. In this, I merge both sets of synthesis findings to construct of theory of change of how the educational use of mobile technologies in LMICs can be linked to education as well as development outcomes[67]. This theory of change thus reflects all the synthesised quantitative and qualitative research evidence on the empirical effects of using mobile technologies as an educational tool in LMICs. It thereby provides my answer to the question whether the empirical and conceptual claims to mobile learning contribution to development are warranted (c.f. chapter 2, sections 2.2–2.3)?

6.2.1 Developing a theory of change for ML4D interventions

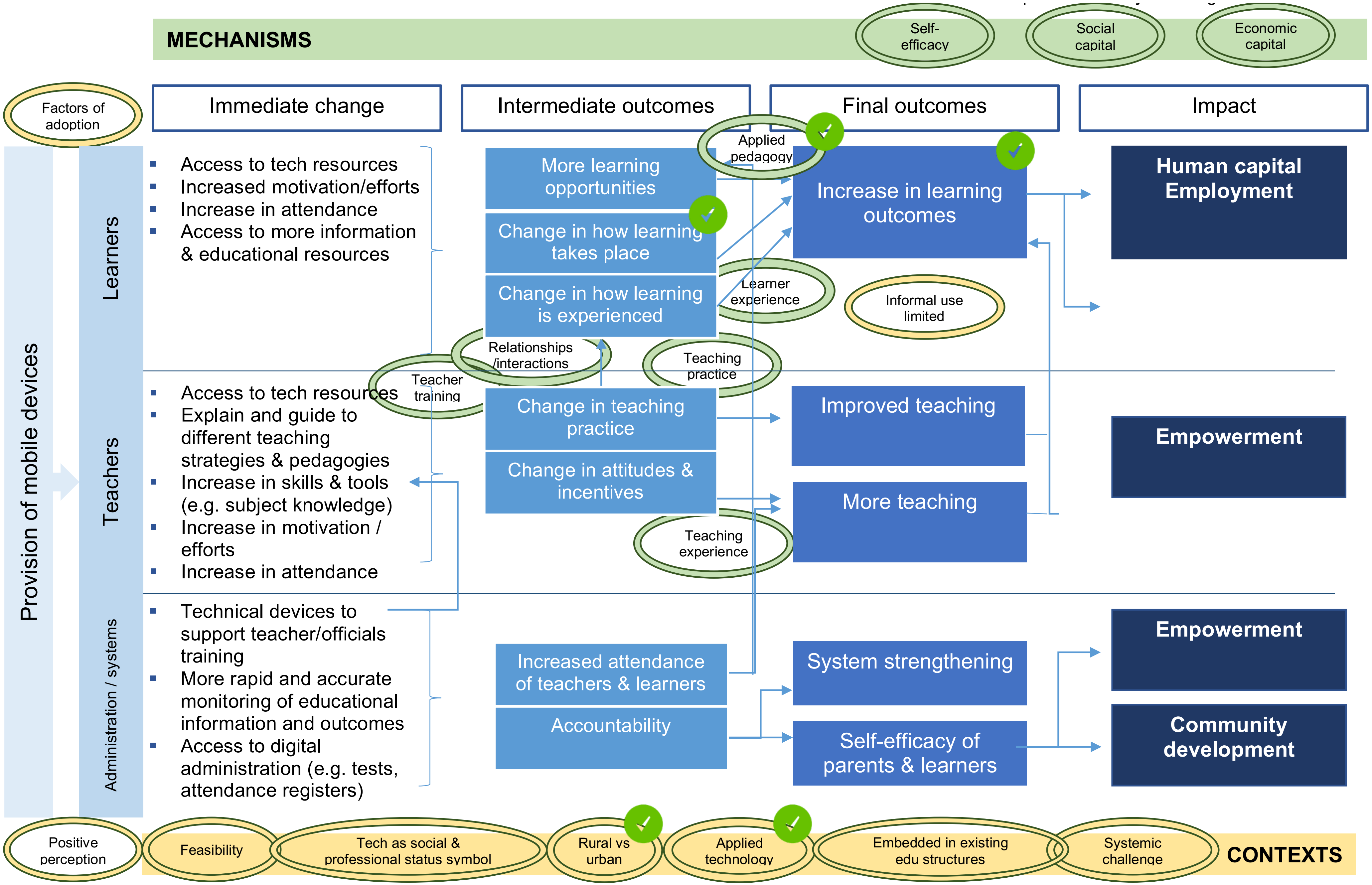
The constructed theory of change is provided in Figure 6.2. From left to right, it follows the changes in educational settings in LMICs post the provision of mobile technologies as educational tools. It therefore tracks the immediate changes, intermediate outcomes, final outcomes, and impacts of the mobile learning programmes. In this, the theory of change aims to assess to what extent the empirical systematic review evidence supports a link between the application of the mobile learning programmes (far left) and the impacts on development (far right). In other words, it aims to assess the empirical and conceptual validity of the '*for*' in Mobile Learning '*for*' Development. Development here refers to the concept of development reported in the synthesised primary literature on which the theory of change is based.

The theory of change tracks three conceptual pathways starting from the provision of mobile devices: devices targeted at (1) learners, (2) teachers, and (3) administrators. These three conceptual pathways directly reflect the ML4D intervention designs reported in the 70 interventions included in my systematic review. Intervention pathways are not mutually exclusive and overlap multiple times within the theory of change. Blue arrows on the theory of change indicate direction of effect or influence. For example, a change in how learning takes place (intermediate outcome) influences increases in learning outcomes (final outcome). Green tick boxes indicate that the empirical results of the meta-analysis confirm the presence of an outcome. The mechanisms for change identified in the thematic

[67] It is important to keep in mind that the theory of change is based on the included primary research studies and its pathways and links to development outcomes thus reflect the assumptions of the primary literature and how these studies have conceptualised development.

synthesis are plotted around the theory of change in green boxes, while the context themes are represented by yellow boxes. Taken together, the theory of change thus combines all my empirical systematic review results and visualises the interplay and connection between different sets of findings and their relation to the applied ML4D interventions.

Figure 6.2 A theory of change for ML4D



To provide an illustration of how the theory of change diagram can be interpreted: starting at the provision of mobile devices to, say, learners, this can result in an immediate new access to technological resources as well as new access to educational resources. Such access could result into more learning opportunities, or changes to how learning is taking place or is experienced. This, though, depends on changes in teaching practices, which in return are dependent on a range of mechanisms being in place. At this point, the meta-analysis only provides causal evidence for changes in learning to take place dependent on the applied pedagogy. The intermediate outcomes for the learners then might translate into actual increases in learning outcomes, again dependent on a range of mechanisms. The meta-analysis confirms that such increases in learning outcomes are observed in most mobile learning programmes. Alas, while targeted in the mobile learning programme design, there is currently no empirically verified link between changes in learning outcomes and impacts on human capital, employment, and economic growth—the impacts mentioned in the ML4D literature. Finally, each of these linkages is influenced by the context themes at the bottom of the theory of change.

As introduced, the main question is then whether the theory of change supports the assumption that mobile learning programmes can be linked to development outcomes as stated in the literature on ML4D? In the next section I am applying the developed theory of change to answer this question. I will discuss the systematic review results that the theory of change reflects and the implications of this review of ML4D evidence-base for the conceptual and empirical claims on mobile learning's role and contribution to international development.

6.2.2 Putting the theory of change to work: assessing Mobile Learning 'for' Development?

The findings of my mixed-methods systematic reject a link between using mobile technologies as an educational tool in LMICs and development outcomes as assumed in the literature on ML4D. Having systematically reviewed and synthesised both quantitative and qualitative studies investigating the effects mobile learning programmes in LMICs, I provide four linked sets of findings to support my argument that, in its current application, *mobile learning programmes cannot claim to support development outcomes*. First, I will highlight the evidence gaps on my theory of change related to development outcomes. Second, I will illustrate that current observed positive educational effects are not sufficient to claim a meaningful change in educational outcomes. Third, I will highlight that the design of mobile learning interventions is subject to two structural biases, which undermine the positioning of the intervention to target development outcomes. Fourth, I will unpack how the current conception of development outcomes itself hinders the linkage between mobile learning and development outcomes.

The missing link: an evidence gap on development outcomes

The developed theory of change highlights an evidence gap on development outcomes. Looking at the impact column on Figure 6.2, I find an absence of evidence supporting empirical links between the observed education and social outcomes and impacts on development. The included mobile learning interventions applied three pathways in order to influence development impact. The first assumed that increases in learners' educational attainment could result in an increase in human capital, which then would enhance their employment prospects. Income-based or livelihood-based poverty and development outcomes were not targeted or measured in the included interventions. This pathway was the most popular narrative with 22 studies explicitly referencing it. However, as indicated on the theory of change, I did not identify any quantitative or qualitative evidence in either synthesis supporting it.

The second pathway assumed that an increase in learners' educational outcomes might be linked to empowerment outcomes. For example, for girl learners enhanced education might have a more intrinsic value of increasing their ability to take control over their lives. Again, however, neither of my two syntheses identified systematic evidence supporting this pathway. In addition, only a small set of studies across both review modules (n=8) explicitly referenced this pathway to development. The same applies to the third assumed link between the provision of mobile technologies in educational settings and potential development outcomes: using mobile technologies to empower learners and parents to monitor and enforce educational processes and standards. This pathway was only referenced in three studies, with none of the studies reporting supporting empirical evidence. There was no pathway reported between providing teachers with mobile devices and assumed development outcomes.

In sum, a simple record of the available empirical evidence clearly indicates an absence of evidence between providing mobile technologies as an educational tool in LMICs and impacts on socio-economic development as assumed in the literature. Again, I caution that an absence of evidence does not refute the assumption that such an impact could potentially take place. The current empirical evidence included in my systematic review, however, suggests that claims to mobile learning's impacts on development are currently not based on the available research evidence.

The size and nature of mobile learning's educational impacts

My theory of change for ML4D plots the positive results of the meta-analysis along a range of educational outcomes. Given the positive overall effect size of 0.47 SMD (23.2% change over the control group) on learning outcomes, one might argue that this impact translates into meaningful changes into learners' abilities and subsequent development outcomes[68]. It is therefore crucial to contextualise this identified effect of a 23.2% change in educational attainment in order to be able to interpret whether it indeed reflects a transformational potential of teaching and learning with mobiles. A key question here is the baseline of the effect as well as the functionality of the gained educational outcomes. To assess both questions, I will focus on the seven studies of the lowest risk of bias, which too present the largest impact evaluations in the meta-analysis and drive 97% of the pooled effect (Aker 2012; 2015; Cole & Fernando 2012; He 2008; Kaleebu 2013; Piper 2015; Pitchford 2014). A narrative summary of all seven studies is presented in Appendix 6.3 for transparency.

Five out of the seven studies focus on mobile learning programmes to increase literacy outcomes (Aker 2012; 2015; He 2008; Kaleebu 2013; Piper 2015)[69]. In three studies the programme design included SMS-based lessons and exercises (Aker 2012; 2015; Kaleebu 2013), while Piper applied a range of tablet-supported mobile learning strategies, and He used the PicTalk machine learning device. All mobile learning programs lasted between 6 and 24 months and all five programmes report positive effects on literacy outcomes. However, upon closer examination these positive literacy effects cannot be regarded as transformational learning outcomes that enable learners to enhance their human development. In fact, in none of the five experiments does a majority of learners experience meaningful shifts towards functional literacy.

In Kaleebu's (2012) impact evaluation, 20% of the children part of a 7-months mobile learning intervention still score an outright zero on endline literacy tests and the mean score on a scale of 0–10 has increased from 3.7–5.6. Likewise, in Aker's (2012) study of a mobile learning programme in Niger roughly 40% of participants improve their literacy levels from A0 to A1 after a two-year programme. In her 2015 experiment, a similar finding emerged with participants experiencing roughly a 20% change (0.15 SD) in reading abilities with a

[68] This would further assume that education outcomes in LMICs equate development outcomes. However, I would argue that education cannot be equated with development per se, and rather presents an integral component of and driver for development. For example, education outcomes are a *subset* of the HDI and other multi-dimensional poverty indexes. Therefore, education, and learning outcomes in particular, should not be equated with development outcomes.

[69] He et al (2008) and Piper et al (2015) in fact focus on literacy and maths outcomes, but I report their results on literacy outcomes here only.

baseline mean value of 3.4 on a 12-point test score. Piper's (2015) 10-months tablet programme in Kenya led to a slightly more positive but still marginal effect. Post intervention, 13.5% of pupils were able to attain the 65 correct words-per-minute benchmark threshold established by the Kenyan Ministry of Education Science and Technology. Broken down per $100 invested, this translates into an average number of 0.5 students reaching full reading fluency post intervention[70]. Lastly, in He's (2008) two-year implementation of the PicTalk programme, baseline data collection on English literacy scores using a standardised assessment had to be discontinued due to an insufficient number of students understanding the assessment. The authors then resort to using students' recognition of English words as an indicator of literacy. Unfortunately, baseline mean results for this outcome measure are not reported, but it seems reasonable to assume that the ~30% change (0.25 SD) commenced from low word recognition rates.

The observed positive educational impact of mobile learning programme in LMICs therefore can barely be regarded as to constitute transformational changes and to support learners' educational functionings significantly. To be sure, I do not refute the results of the meta-analysis which provided rigorous of evidence of a strong and consistent effect on learning outcomes. Mobile learning does indeed increase learning outcomes in LMICs. However, contextualising the observed impacts highlights that the positioning and interpretation of these positive effects need to be cautioned. The empirical evidence does not suggest that the generated learning gains support structural or transformational changes in learners' abilities. Rather, the observed effects—as the applied mobile learning interventions themselves—are firmly embedded in the overall structure of education systems in LMICs. In contexts where these systems are unequal or underperforming, the introduction of mobile technologies as educational tools cannot claim to positively influence the properties and outcomes of these systems.

Mobile learning for whom?

For mobile learning in LMICs to claim potential to support development outcomes, it is important to consider who has access to and is partaking in the mobile learning programmes. Based on the combined systematic review findings, two structural biases in who is included in mobile learning programmes undermine the positioning of the mobile learning interventions to target development outcomes. First, the reviewed ML4D interventions overlooked the most disadvantaged groups in society; and, further, the

[70] I am unable to provide similar cost breakdown for the remaining studies, due to an absence of reliable empirical data on cost and/or cost-effectiveness.

interventions were shaped by—rather than aimed to counter—existing structural inequalities within education systems in LMICs. Mobile learning programmes in LMICs clustered largely around urban areas and socio-economic indicators suggest that more affluent schools are targeted as hosts for mobile learning programmes in formal education. For example, flagship ML4D programmes such as Worldreader or Mobile Math each focus on learners in more affluent schools with a pre-existing track record of providing high-quality education (Worldreader 2012; Roberts & Vänskä 2011).

Of the small amount of mobile learning programmes that targeted education in rural areas, the vast majority applies less sophisticated mobile technologies (largely basic and feature phones) and less complex programme designs (largely mere information dissemination). As a result, mobile learning interventions that included more disadvantaged populations are not as pedagogical rich as their counterparts in more affluent and developed contexts. This directly translates into observed programme effects, which are smaller in rural areas, due to the moderating effect of the applied pedagogies on learning outcomes. This in-built inequality in programme design also affected the few mobile learning programmes that explicitly targeted social transformation and empowerment of disadvantaged populations (e.g. Andersson & Hatakka 2010; Balasubramanian 2010). These programs exclusively made use of basic and feature phones limiting the mobile learning design to applying SMS-based learning and information sharing exercises. In short, mobile learning programmes in more disadvantaged contexts generally applied the least advanced technologies and intervention designs. This finding challenges the positioning of mobile learning as a tool to support inclusive development for all groups in society.

The second structural inequality in mobile learning intervention design is the exclusion of teachers and communities. As indicated in the systemic review findings and reflected in the theory of change, the large majority of mobile learning programmes assumed learners as the population of interests. Supporting teachers or communities through the use of mobiles is a marginal programme component. In fact, the theory of change does not even plot a link between provision of technologies to teachers and development outcomes. And, as explained above, the link between providing mobiles as a monitoring tool to community members to empower them to enforce educational standards and processes was based on only three studies.

It is unclear why these key educational stakeholders are marginalised within the current mobile learning programmes in LMICs[71]. Though, the implications of this marginalisation are evident. It results in a strong human capital narrative to development. That is, if mobile technologies can support learners to obtain higher educational outcomes, this then translates into increases in human capital and subsequent socio-economic development. It is this narrative that strongly dominates the literature on which the theory of change was developed. However, as illustrated above, there is little empirical evidence supporting this narrative. In the context of this absence of evidence, the marginalisation of teachers and communities in mobile learning intervention design requires attention. It seems current mobile learning programme overlook a key link between technologies' affordances, educational changes, and potential improvements in livelihoods.

What counts as development in ML4D?

The available evidence-base on mobile learning and development seems to apply a narrow interpretation of what constitutes development[72]. The main understanding of development is linked to ideas around human capital and subsequent increased employment prospects and productivity. This narrative of human capital and economic growth as development is prevalent across much of the wider ICT4D literature of which the mobile learning literature is a subset—so this finding does not particular surprise (Castells & Himanen 2014; Unwin 2009). In ICT4D, however, there have been strong critiques of this human capital narrative, which I would argue apply similarly to ML4D (Kleine et al 2009; Zheng 2009; Oesterlaaken 2012; Gigler 2015).

The strong focus on human capital as a driver of development has led mobile learning programmes to overlook alternative pathways to development. It further has shaped a linear intervention design, focused on increasing learning outcomes in formal education. It is not so much that the human capital pathway per se is problematic; rather it is its dominance within the applied programme designs which crowds out alternative pathways to, and understandings of, development. I already have illustrated this in reference to the marginalisation of teachers and communities within the reviewed interventions. But, it is apparent within the positioning of empowerment processes and outcomes in the included studies too.

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[71] Though I provide potential reasons for this in Chapter 2, section 2.3.3.

[72] Here, I directly critique the existing definitions and understandings of the concept of 'development' within the reviewed ML4D literature. This highlights the discrepancy between my personal definition of development following Sen and the definitions of development that my systematic review of ML4D literature empirically assessed.

The small amount of evidence on the link between the educational use of mobile technologies and empowerment outcomes applies a linear link between increases in learning outcomes and processes of empowerment that mirrors the positioning of learning outcomes and increases in human capital. Within the body of evidence on empowerment, studies assume and investigate a direct relationship between increases in literacy test scores and empowerment measures such control over one's life and changes in gender norms. This appears to reflect a naïve view of empowerment processes and outcomes. Empowerment is exclusively positioned as the direct consequence of enhanced literacy abilities. This shapes directly how these mobile learning programmes are designed with no provision made for the political and cultural processes reported as crucial in the literature on empowerment in development (e.g. Aslop & Heinsohn 2005; Kabeer 2010).

It appears then that current conception of empowerment as development in ML4D is too narrow and still subject to a linear focus on increases in learning outcomes as a key mechanism. The systematic review presents a range of different mechanisms linked to personal empowerment that could enrich the link between the provision of mobile technologies and concepts of empowerment; but these mechanisms are currently not integrated into mobile learning programme designs and largely emerge from qualitative studies of teachers and learners' perceptions on using devices. These refer in particular to the mechanism themes of self-efficacy, social and economic capital, and the context theme of technology as a status symbol. All of these systematic review findings point towards more granular and personalised changes and benefits that users of mobiles can derive from the devices' integrations in their social and professional lives. These changes are mainly linked to non-education outcomes such as feeling valued and respected or being able to enhance one's standing in the community. These mechanisms and outcomes seem to be closer connected to the affordances of mobile technologies that led to mobiles' adoption in LMICs in the first place, for example, connectivity, communication, and mobility. It therefore seems that an enhanced conception of what constitutes 'development' in ML4D might allow for a range of additional pathways to emerge that can link the provision of mobiles in educational settings to socio-economic outcomes. In other words, the definitions of development within the reviewed primary research are too narrow to capture the diversity of pathways and mechanisms between the use of mobile technologies, education, and human development and well-being.

In sum, my mixed-methods synthesis and theory of change finds no evidence that supports the positioning of mobile learning as a tool for socio-economic development in LMICs. *Development outcomes claimed in the ML4D literature such as poverty reduction, reduction* *in inequality, and transformations in livelihoods cannot be empirically linked to the applied mobile learning programmes.* Further, observed positive effects in learning outcomes, on their own, do not translate in meaningful changes in educational functionings. Structural inequalities within mobile learning intervention design and a narrow conception of development as an increase in human capital also hinder mobile learning's potential to support development outcomes.

Empirically, it is therefore challenging to position mobile learning as a development intervention—let alone to claim a mobile revolution to be taking place in education in LMICs (UNESCO 2014). Some promising areas of where links between mobile learning and development could occur remain under explored. This refers to teachers' use of mobile technologies; changes in self-efficacy and personal and professional development; changes in social capital; and community-based monitoring.

6.3 What have we learnt from the evidence-base? Discussion of systematic review findings

My mixed-methods systematic review presents empirical evidence on the effects of using mobile technologies as an educational tool in LMICs. I next integrate the findings of the review into ongoing debates and discourses on ML4D. This aims to highlight gaps and overlaps between the systematic review findings and the wider literature. It also aims to flag potential implications for current and alternative conceptions of mobile learning as a development intervention.

6.3.1 A mobile revolution? Claims to ML4D's impact

As referenced in Chapter 2, section 2.2 the discourse on the impact of using mobile technologies to support education in LMICs features a strong assumption that mobiles can fundamentally alter education outcomes and achievements. This discourse is shaped in particular by international development organisations and mobile vendors and is perhaps best captured by UNESCO's proclamation of a mobile reading revolution:

> "There are strong indications that the benefits of mobile reading are long-lasting and far-reaching, with the potential to improve literacy, increase education opportunities and change people's lives for the better. A *revolution in reading* is upon us thanks to the massive proliferation of mobile technology [in LMICs] (…)" (UNESCO 2014: 83, emphasis added).

However, the UNESCO is not the sole organisation using research findings attributing large transformational impacts to mobile learning in LMICs in order to advocate for an increased investment in educational mobile technologies. The GSMA, for example, too claims that "a revolution is coming" based on the power of mobile to change education in LMICs (GSMA 2012a: 11). In support, the organisation references research from India in which mobile phone-based educational games allegedly raised learning outcomes by 60%. Likewise, the World Economic Forum states in the aptly titled 'accelerating the adoption of mLearning' report that "(m)obile learning represents an opportunity to systemically redefine the way that individuals and communities can contribute to society" (WEF 2012: 3). This report is based on qualitative research conducted by the GSMA in which youth in LMICs were interviewed regarding their perceptions on mobile learning. This qualitative study claims that "mLearning has a crucial role to play in improving the education and life prospects of young people in emerging markets [LMICs]" to then conclude with a call for "mobile industry, international development community and governments to collaborate and create services that will have a profound, lifelong impact on the lives of young people” (GSMA 2012b: 4).

My systematic review findings refute these claims and provide reliable evidence that such wide-ranging claims to mobile learning’s impact on education and development in LMICs are not warranted. The UNESCO (2014) and GSMA (2012b) studies were in fact excluded from the systematic review due to being of a critical risk of bias. For example, the underlying empirical data in the UNESCO study announcing a reading revolution finds that smart phone users in a range of African countries were logged into the Worldreader application on average for one minute (male sample) to seven minutes (female sample) per day. Further, the cited research findings on mobile learning from India in the GSMA (2012a) report are misrepresented. The study, He and peers (2008), is included in my systematic review but suggests a change in outcomes of between 0.25-0.35 standard deviations, which is based on a very low baseline level of literacy. To arrive at the 60% figure, the report authors of the GSMA report seem to have used the upper-bound confidence interval of a sub-group outcome in year two of the study.

In contrast, the findings of my systematic review seem to echo a range of existing reviews and academic studies. Wagner and peers’ (2014) Mobiles for Reading landscape review finds a “lack of solid evidence of [mobiles] effectiveness” (2014: 9), which overlaps with the findings of my own review on development outcomes. The 2016 Word Development Report equally bemoans a lack of reliable evidence on the question of mobile technologies’ impact on education and development in LMICs (World Bank 2016: 146). The same conclusion is reached by Tamin and colleagues (2015) in a review of large-scale, government-supported educational tablet initiatives in which the authors conclude that “the majority of these initiatives have been driven by the tablet hype rather than by educational frameworks or research-based evidence” (Tamin et al 2015: 2).

Tamin and peers (2015) findings are particular interesting as they explicitly reference the discrepancy between the excitement around mobile technologies as educational and developmental tools and the empirical track record of such initiatives. This conflict is perhaps most evident in the ITU’s (2015) m-Powering Development Initiative report. In it, the ITU’s working group on mobile learning commences with the common claim among mobile vendors to mobile learning’s immense potential to change education: “Mobile devices have the potential to contribute significantly to education and learning across the world”, only for the report to then immediately concede that, “(h)owever, uncertainty persists as to their precise impact, and how best they can be used to contribute positively to education and learning” (ITU 2015: 12). Further in the paragraph it is then acknowledged that there is “far too little rigorous evaluation and M&E of mobile learning programmes", but this does not stop the authors from highlighting the "widespread recognition of the potential of m-Learning to improve the delivery of education and skills acquisition" (ibid).

The ITU's position might be best described as a 'faith-based' view of educational technologies' impact (Trucano 2015) in which mobile learning interventions 'ought to work' due to the investments made (c.f. Traxler 2013a). It seems not unreasonable for mobile vendors to assume such a position given their vested interest. However, their use of research evidence to claim support to the vast potential of mobile learning on education and development in LMICs is not warranted. My systematic review, as other related reviews, provides consistent and reliable evidence that such an interpretation of the available evidence-base is not accurate.

6.3.2 The limitations of access to technologies

The findings of my systematic review also have implications on ongoing debates on how to position access to technologies in relation to what users of technologies can actually do with them. These debates reflect similar concerns in the field of ICT4D, which outline how the translation of access to technologies into meaningful and effective use towards development outcomes is often challenged in LMICs (e.g. Gigler 2015; Kleine 2011; Zheng 2009). My systematic review findings challenge two perspectives of access to mobile technologies and their link to development outcomes: first, the techno-centric assumption that a mere access to mobile technologies can establish significant education and development outcomes; and second, the assumption that a mere access to content and information on the devices presents a meaningful education or empowerment intervention.

The techno-centric position assumes a close link between the provision of technologies and subsequent education and development outcomes (Unwin 2009; Traxler 2015). There is little need for further intervention aside from providing the technological devices to users. Prominent examples of this approach in relation to technology and education in LMICs are Sugata Mitra's Hole in the Wall project and subsequent development of minimally invasive education; the OLPC project; and the Solar Classroom in a Box project (Mitra & Vana 2001; Mitra 2003; Annay & Winters 2007; Solar Classroom 2017). In these educational technology interventions, the technology is commonly the only input provided and becomes essentially synonymous with the educational input of the intervention. For example, children are supposed to use the Hole in the Wall computers to teach themselves, an educational approach similar to the OLPC project through later iterations of the project do use the laptop computers in a formal education context too. In my systematic review I found no empirical evidence supporting the effectiveness of a techno-centric approach to ML4D. There was not a single ML4D programme that supplied mobile devices to educational actors as the only intervention component.

This finding suggest that the mere provision of mobile devices is simply not a feasible intervention approach for mobile learning programmes in LMICs. Partly this can be explained by the fact that most educational actors do already have access to mobile technologies and that therefore interventions rather do design for the educational use and application of the technologies. Only a little bit more than half (55%) of all mobile learning programmes included in the systematic review actually had to provide the mobile devices as part of the intervention design. Another explanation might be linked to a general shift away from a focus on inputs and outputs in the education sector in LMICs in general. Following the large investment into access to education as part of the MDGs, recent efforts along the EFA and SDGs place a much stronger emphasis on the outcome and quality of education (Unterhalter et al 2015; WEF 2016). This is also reflected in recent disinvestments of large-spaced mobile learning programmes in LMICs. Since 2015, national-scale tablet programmes in Turkey, Kenya, and Thailand, which focus largely on the supply of technologies to teachers and learners, have been cancelled by governments.

Another manner in which access to technologies is commonly linked to education and development outcomes is to assume that access to mobile devices equates with access to educational content; and/or that access to information on mobiles equates with empowerment outcomes. Such perceptions are often expressed by evoking the metaphor of mobile technologies as “education you can hold in your hand” (WEF 2012: 4). Or, in Melinda Gates’ words: “If every woman has a smartphone, imagine all the empowered people” (Gates 2016). Again, my systematic review refutes this positioning of technology access. Both, the meta-analysis and the thematic synthesis illustrate clearly the importance of the underlying pedagogies in order to exploit the technological affordances of mobiles for educational purposes. A range of sub-group analyses and mechanisms focus on the particular types of pedagogical approaches and how they can change teaching and learning practices to support educational outcomes in LMICs. In short, the review findings point to the centrality of what the different educational strategies supported by mobiles allow teachers and learners to do; the findings do not point towards a mere provision of educational content on mobiles which learners can then access independently or, in the case of teachers, to pre-existing educational content being stored on devices, which teachers can then use as ready-to-go materials for their lessons. The same applies to empowerment outcomes, which cannot be reduced to a mere access to information or learning opportunities (see section 6.1.3 and 6.2.2).

A conception that assumes the access to educational content or information on mobile devices to present mobile learning links back to very early definitions of mobile learning as learning that takes place ‘anytime, anywhere’ (e.g. Quinn 2000; Kukulska-Hulme et al 2005; Traxler 2005). Current pedagogical definitions of mobile learning do not focus technological access or utilisation, but on the types of learning practices that can emerge from the interplay between technology usage and other educational inputs; and how these learning practices benefit from different types of mobile affordances (Wali et al 2008; Sharples et al 2007; Kearney et al 2010). This is informed by a socio-cultural view of learning and education and positions mobile learning firmly within this educational school of thought (Winters et al 2017; Pachler 2009).

From an educational perspective then, there is consensus that access to educational content on mobiles does not constitute mobile learning as it lacks an underlying pedagogy or theory of learning. The continued positioning of such access to content to constitute an effective educational and developmental intervention in LMICs is thus in contradiction to both educational theory and the empirical evidence reported in my systematic review. In the words of Winters (2015: 10) “the provision of content on mobile phone is neither pedagogically nor technically innovative (…) and positions mobile learning in a place where research was more than 10 years ago”. The findings of the systematic review underline that mobile technology interventions need to draw on the full pedagogical value of mobile learning in order to unlock their educational and developmental potential.

6.3.3 Appropriate technologies?

My systematic review findings also pertain to ongoing debates as to what types of mobile technologies are most relevant and useful to support education in LMICs. A common narrative here advocates for what could be loosely termed ‘appropriate’ technologies to be used. This refers to the application of simple and affordable mobile technologies that are preferable already in use by people and communities (Trucano 2015; Trace 2016; Smith et al 2011; Balasubramanian 2010). It links to a wider academic school of thought based on Schumacher’s (1973) intermediate technology concept, which is not discussed here. A prominent and much cited example for the use of simple and affordable mobile devices refers to Jensen’s (2007) paper on how fishermen in India used their cellphones to access market information in real time in order to determine at which harbours to sell their daily catch.

ML4D programmes have often subscribed to this narrative, which has resulted in programme designs that make predominately use of simple technologies such as radio devices and basic and features phones. For example, of the ML4D programmes included in the systematic review, all but two programmes implemented in conjunction with an NGO or other types of development organisations made use of basic and features phone. The idea that mobile technologies already in use by people and communities in LMICs are most suited as a tool for mobile learning programmes thus seems to enjoy much currency.

However, in the wider literature on ML4D this view is not unchallenged. Unwin (2015: 15) for example laments that "'second-hand' technologies still continue to be passed-down to people living in poorer contexts". He assumes such technologies to hold back the potential of mobile learning programmes in LMICs as their technological features limit the interaction between people and technologies, and further do not reflect people's own choices in what devices to pursue. Winters (2016; 2017) adds to this critique highlighting that the use of less sophisticated devices necessarily limits the types of affordances that can be used to support learning and teaching practices. As a result, the range of pedagogies supported by mobile devices becomes limited. This observation is shared by Buckner and Kim (2013), who, following ten years of experimentation with different mobile learning intervention designs in LMICs, conclude that in order to integrating technology and pedagogy, sophisticated mobile devices with sufficient technological affordances are required.

The findings of my systematic review challenge the narrative of appropriate technologies to some extent. While not formally testing the impacts of different ML4D interventions against one another, there is observational evidence to the limitations of using simple and affordable technologies. Pedagogically-rich mobile learning programmes are found to yield larger effects, and too are associated with a range of mechanisms that enhance their relevance and usefulness to programme participants. However, these pedagogically rich mobile learning programmes are linked to the use of more sophisticated mobile devices, smart phones and tablets in particular. Mobile learning programmes using less complex programme designs were found to have a smaller effect. What is more, these less complex programmes—both technologically and pedagogically—were predominantly applied in rural areas and in more disadvantaged educational settings. This correlates with the link between NGOs and development agencies as ML4D programme implementers and the of use simpler technologies.

Therefore, there seems to be a paradox for advocates of appropriate technologies in ML4D programmes. Simple technologies such as basic/feature phones are positioned as technologies of choice by disadvantaged communities and on these grounds argued as the most relevant technologies to support mobile learning programmes targeting social transformation and empowerment (e.g. Balasubramania et al 2010; Andersson et al 2010; Trace 2016; Smith et al 2011). But, it is the very simplicity of these devices that constraints their educational and transformational potential as they allow for the mere dissemination of information or educational content. This model of content and information provision has already been shown to present an insufficient approach to ML4D. In sum, there is a contradiction between the necessarily limited pedagogies that basic/feature phones can transmit and their assumed transformational impact by development practitioners. From an educational perspective Rochelle (2003) urged mobile learning practitioners to “identify those simple things that technology does extremely and uniquely well, and to understand the social practices by which those new affordances become powerful educational interventions” (Rochelle 2003: 9). It seems that ML4D practitioners could pay closer attention to this advice. Applying mobile devices that have a wider range of affordances are likely to do a larger variety of things extremely and uniquely well, and therefore seem to present a more powerful education and development intervention.

6.3.4 Education as a broken service?

The last conversation that my systematic review finding relates to is whether the provision of mobile technologies and design of mobile learning programmes can be regarded as an endogenous or exogenous part to the formal education system. As discussed in chapter 2, section 2.3.3, there is a trend that technology provision deliberately bypasses the formal education systems and sets up parallel structures to it. Such a strategy is justified on the grounds that the current education system is regarded as weak and that its actors and processes are more likely to constrain the perceived potential of mobile technologies than to support it. Mobile learning programmes such as Solar Classroom in a box or the tablet iteration of the OLPC in Ethiopia (Talbot 2012) are examples of the setting up of such parallel structures in practice. Support for this narrative also comes from mobile vendors with the GSMA for example underling that “(m)obile technology’s power to transform education is difficult to overstate, given the importance and impact of learning that takes place outside a traditional classroom environment.” (GSMA 2012a: 4). This positioning might not surprise as a device- and content-focused understanding of ML4D provides a market opportunity for mobile vendors.

The systematic review findings strongly suggest that mobile learning programmes in LMICs operate within, and not outside the formal education system. What is more, the large majority of the reviewed ML4D interventions are in fact supplementary to existing educational structures and interventions. The mobile learning interventions in LMICs included in the systematic review are embedded within existing educational structures—either structures in the formal education system or existing informal education structures such as NGO literacy programmes.

The review suggests a number of reasons and mechanisms as to why this embeddedness in formal educational structures might be observed. It appears that most of the factors driving the adoption and effects of ML4D programmes are depended on inputs that only formal educational structures can provide. First and foremost, this refers to the centrality of teachers and pedagogies in the effective use of mobile technologies to support education in LMICs. My systematic review has provided ample evidence for the importance of both factors. Currently only formal educational systems in LMICs can provide both at scale. Likewise, more effective mobile learning programmes relied on complex technological and educational programme designs. These designs require supporting infrastructure to be in place such as internet connectivity, reliable electricity, provision and maintenance of devices at scale, etc. The same can be said about the established factors of adoption, for example integration of technology into existing curricula, user training, and peer-to-peer support, all of which are provided by formal education structures at scale. In sum, my systematic review findings indicate that mobile learning interventions are firmly embedded in the overall structure of education systems in LMICs. The framing of mobile learning as a parallel structure to the formal education system does not seem to be based on empirical research evidence.

However, mobile learning's embeddedness into formal education systems also infers that programmes will be subject to the negatives properties of the systems. In contexts where these systems are unequal or underperforming, ML4D is likely to reproduce rather than challenge these properties. This provides a challenge to my critique of the techno-centric positioning of mobile learning as exogenous to the formal education systems. A strong rationale for a techno-centric ML4D approach is that existing education systems suffer from a range of structural inequalities that disadvantage certain groups of learners. For example, girl learners in patriarchal societies might be systematically excluded from formal education or the language of teaching might exclude certain ethnic groups. By being positioned within existing education structures, ML4D programmes are unlikely to address existing inequalities and might actually sustain marginalisation. The systematic review findings support the assumption that this is indeed the case with current ML4D programmes.

The argument as to whether ML4D can or should be positioned as working within or outside formal education structures will be developed in full in chapter 9, section 9.3.1. To conclude the caveats around positioning mobile learning closely within existing education structures derived from my systematic review findings, two remarks need to be highlighted. First, as much as the majority of ML4D programmes were embedded within existing education systems, there was barely any evidence that these programmes aimed to strengthen the functioning of these systems. For example, mobile learning programmes rarely targeted structural support to sustain education systems such as supporting teacher training and professional development; EMIS; stakeholder engagement; and education management and leadership. Second, a very low number of ML4D programmes was driven by LMICs governments and education departments (n=4). The vast majority of programmes was driven by research interest, NGOs, and development agencies. It is challenging to claim a strong positioning of ML4D within formal education structures if decision-makers of these structures do not drive mobile leaning programmes.

Conclusion

This chapter has presented the second set of systematic review findings based on the thematic synthesis and provided a theory of change for ML4D combining both sets of systematic review findings. In the thematic synthesis, I identify a range of mechanisms and contexts that unpack how the provisioning of mobile technologies might influence education and development outcomes in LMICs. The identified mechanisms provide rich evidence on the changes in teaching and learning practices that can explain the observed positive educational effects of mobile learning programmes in LMICs. They too point to a wider range of socio-economic changes that educational actors might derive from the provisioning of mobile technologies. In terms of contexts, the thematic synthesis indicates that the acceptability and uptake of mobile technologies as an educational tool is aided by intrinsic positive perceptions about the technologies. However, factors within the education system also play an important role in the uptake and implementation of mobile learning programmes. This refers in particular to the role of teachers and teacher training in ML4D interventions.

I then combine the thematic synthesis and meta-analysis findings in a mixed-methods synthesis to construct a theory of change for ML4D. This theory of change aims to assess to what extent the provision of mobile technologies in LMICs can be linked to education and development outcomes. Based on the empirical evidence in both review modules, I show that there is currently no supporting evidence on the impact of mobile learning programmes on development outcomes in LMICs. In addition to this evidence gap, observed positive educational outcomes cannot be attributed transformational impact on education in LMICs. Structural inequalities within mobile learning intervention design and a narrow conception of development as an increase in human capital also hinder mobile learning's potential to support development outcomes. I therefore conclude that mobile learning cannot be positioned as development intervention based on current evidence and show how this finding runs counter to popular narratives on ML4D.

The findings of my mixed-methods systematic review suggests that a rethink of the positioning and conceptualisation of ML4D is required. While the absence of evidence on development outcomes cannot be equated with an evidence of absence, it seems justified to probe deeper into how else one might conceptualise the provision of mobile technologies in LMICs in relation to education and development. A more in-depth investigation into the perceived transformational potential of mobile learning on education in LMICs and how and why this change might lead to subsequent socio-economic changes is called for. In this, I propose the Capability Approach (CA) as a conceptual lens through which to redefine how learning and teaching with mobiles might be linked to education and development in LMICs.

The CA has guided alternative conceptions of development outcomes in related research fields; and in particular unpacked similar techno-centric assumptions about access and use of technologies in relation to development. However, despite its wide application in development studies and ICT4D, empirical work on the CA in relation to mobile leaning in LMICs is scant. My review only identified three studies that explicitly referenced the CA, neither of which used it as a conceptual or analytical framework for data collection and analysis. Yet, a number of my systematic review findings indicate sufficient conceptual scope for the CA to guide a rethink of ML4D. For example, my thematic synthesis identified a range of themes around valued opportunities that teachers explored independently following the provision of mobile devices. In current conceptions of ML4D as laid out in my theory of change, there is however little scope for such pathways to development, which are dominated by a human capital approach to understand and assess education and development outcomes. From a capabilities perspective an investigation and conceptualisation of the use mobile technologies in educational settings in LMICs could pay more attention to what opportunities mobiles allow users to explore and how these are linked to individual changes in well-being, agency and human development. I therefore next present the findings of my qualitative case study of a ML4D programme in South Africa in which I applied the CA as a conceptual lens to investigate the transformational potential of mobile learning on education and development.

PART II:

DEVELOPING A CAPABILITIES CONCEPTUALISATION OF MOBILE LEARNING'S CONTRIBUTION TO DEVELOPMENT

Chapter 7. Using mobile technologies to expand teachers' capabilities: A qualitative case study of a mobile learning programme in rural South Africa

Introduction

This chapter presents the results of my qualitative case study investigating a South African mobile learning programme from the perspective of the Capability Approach (CA). The case study set out to explore how teachers in the Information Communication Technology for Rural Education Development (ICT4RED) programme in rural South Africa accessed and used mobile technologies in their social and professional contexts. I investigated whether the provision of personal tablet devices to teachers as part of the ICT4RED programme altered their valued capabilities and functionings. That is, I am interested in teachers' own views on whether and how their educational use of mobile technologies allowed them to explore valued beings and doings. And, if so, how these valued functionings support teachers' opportunities to live a life they had reasoned to value. To guide this investigation, I collected a range of qualitative data including in-depth interviews, focus groups, and classroom observations on teachers' perceptions and use of tablet devices in a rural education context.

The objective of this qualitative case study is to apply the CA as a conceptual lens through which to analyse the usage of mobile technologies in educational contexts in Low- and Middle-Income Countries (LMICs). Through the case study, I aim to operationalise the CA as tool to frame the outcomes of mobile learning for development (ML4D) programmes. I am therefore interested in whether the CA with its conception of development as freedom (Sen 1999) and its focus on the effective opportunities or freedoms of individuals to transform access to resources—mobile technologies in this case—into valued beings and doings provides a useful framework to unpack the role and contribution of mobile learning to development[73]. This chapter zooms into my empirical investigation on whether the CA can indeed be applied as a conceptual tool to analyse the effects of ML4D interventions and what types of outcomes emerge from such an application. In further chapters, I will discuss

[73] This implies applying my preferred definition of development based on Sen (1999) from this point onwards in the thesis.

in more detail an analytical framework of ML4D interventions based on the CA that I derived of the case study findings (chapter 8) and what the implications of applying a capabilities perspective to the educational use of mobiles in LMICs has on the overall positioning of ML4D (chapter 9).

This chapter is structured as follows. I first provide a brief justification for the application of the CA based on the systematic review findings. This enhances the more substantial justification provided in chapter 3. I next briefly contextualise my qualitative research and applied research methodology before presenting the results of my case study research. These results are categorised according to the four overall capability dimensions emerging from my data. The chapter concludes with a brief summary of the reported findings.

7.1 Overlap between the systematic review findings and the CA

Chapter 3 provided a detailed conceptual justification for the application of the CA as a conceptual lens to analyse the application of mobile technologies as an educational tool in LMICs. This justification pointed to a range of conceptual overlaps with research bodies related to ML4D in which the CA has already been applied. It also pointed to a range of gaps between existing CA frameworks and the nature of mobile learning interventions in LMICs, which negated an off-the-shelf use of existing CA frameworks. In addition to this justification based on the existing literature, the findings of my mixed-methods systematic review present further support to the feasibility and usefulness of investigating ML4D from a capabilities perspective. I touch on these review findings briefly below.

My systematic review identified a range of gaps and contradictions between the evidence-base on ML4D and the perceived potential and subsequent positioning of mobile learning as a development intervention (chapter 6, section 6.2–6.3). It seems that some of the gaps between mobile learning's assumed transformational potential and its empirical track-record can be explored and framed using the CA as a conceptual lens. This relates in particular to the evidence gap of ML4D programmes on development outcomes.

The systematic review identified a lack of evidence of ML4D on development outcomes such as poverty indicators. It also highlighted a human capital perspective on both education and development as a dominant thought throughout the theory of change of ML4D interventions. At the same time, it illustrated a range of mechanisms, which emphasised the importance of using mobiles to support more granular changes linked to self-growth and attainment (e.g. self-efficacy, job satisfaction, social status). From a capabilities perspective, the emphasis on the theory of change for human capital approaches to education and development would be challenged. If we investigate the effects of teaching and learning with mobiles in terms of the valued opportunities they create for individuals, an instrumental view of education linked to skills is too narrow. Likewise, an enhancement in the levels of skills and productivity of the population would not be equated with development.

Consequently, contextualising my review findings from a capabilities perspective suggests that the findings might not indicate a lack of development outcomes per se; but rather that education and development outcomes are too narrowly defined. Applying a capabilities lens with its focus on individual well-being and agency would place a greater emphasis on individual's own appropriation of the mobile devices and the functionings she obtained from this appropriation. This would open-up the theory of change to require a more substantial engagement with the mechanisms for change around self-efficacy and social status. It would further challenge the lack of engagement with the intrinsic value of education and some of the technological affordances of mobiles linked to non-educational technology usage. For example, while my review cannot link the observed learning effects to development outcomes as they do not present a significant change in educational abilities, a capability analysis would question whether this does not overlook other opportunities and functionings that learners might have derived from the programme. That is, a capability analysis would require a more substantial engagement of ML4D interventions with the interlinkages between educational, social, and economic outcomes. The systematic review findings show clearly that there is scope for such an analysis given the limited causal pathways between the provision of mobile technologies, their educational use, and development outcomes currently reported in practice in the ML4D literature.

Another major barrier identified in the systematic review affecting mobile learning's transformational potential in LMICs referred to the reproduction of structural inequalities. Mobile learning programme designs were found to discriminate against more disadvantaged groups in society. This programme design flaw could be alleviated by the application of the CA to conceptualise ML4D. In a capabilities conception, the emphasis in intervention design would shift from the provision of resources (i.e. mobile technologies here) to the conversion factors of individuals to apply these resources to an effective use to further their own valued being and doings. A capabilities lens would thus have highlighted the discrepancy between the conversation factors of more disadvantaged groups, the technology and programme design provided, and the assumed transformation impacts. If the equality of opportunities becomes the lens of analysis and programme objective in ML4D interventions, different design features would have been warranted to counter-balance the different abilities of users to apply the technologies to further their valued beings and doings. Arguably, designing ML4D for the equality of opportunity could have enhanced the development potential of interventions and addressed—rather than reproduced—these observed structural inequalities.

This argument then links back to the discussion on the limitations of access to technologies and the limitations of appropriate technologies. The former has already been sufficiently covered in chapter 2 and 6 and the systematic review findings add empirical support to the CA's critiques of techno-centric approaches to ML4D. In reference to the latter, applying a capabilities perspective to the use of technologies would question the inherent assumption that technologies already widely in use by the target population of ML4D programmes present the most relevant devices. If technologies are being assessed in their ability to support individuals to enhance their set of opportunities to live a life they have reason to value, limiting ML4D interventions to technologies already in use consequently limits the sets of opportunities that can be achieved. A CA investigation of ML4D programmes requires to move towards equality of opportunity and choice, and to ask what mobile devices allow one to do. This seems to shift the emphasis away from the already existent access and use of technologies to what types of other usages and roles technologies could support if applied to enhance effective opportunities and capabilities[74].

In sum, the systematic review findings therefore provide additional support that the CA presents an effective tool to guide an in-depth investigation into the perceived transformational potential of mobile learning in LMICs.

[74] I discuss the potential risks of the CA's strong focus on individuals in chapter 4, section 4.3.5 and chapter 9, section 9.3.1.

7.2 Contextualising the case study research

Before presenting the result of my qualitative case study of a ML4D programme in rural South Africa, I comment briefly on a few aspects related to the research design and process not covered in chapter 4. This aims to provide additional context on how I arrived at the presented results and how they might be understood.

The vast majority of qualitative data used in the analysis presented here was collected between January and March 2015. During this period, I accompanied 25 teachers involved in the ICT4RED mobile learning programme during their daily teaching activities and conducted in-depth interviews with each teacher. I also attended a series of professional development workshops part of the ICT4RED intervention which involved the same teachers; graduation ceremonies of different phases of the programme; as well as policy meetings and policy roundtables related to the programme. These events extended from June 2014 to October 2016. Most of the teachers interviewed and shadowed in the 2015 data collection became ‘ICT champions’ following the completion of phase 2 of the ICT4RED programme and subsequently served as trainers of trainers for the programme in phase 3 in 2016. I therefore continued to interact with the majority of research participants post the initial data collection. However, the results and analysis presented here are exclusively based on the data collected until March 2015. In my later engagement with the ICT4RED programme and the teachers involved, I did not assume the role of a researcher. Through a separate research project[75], I was subsequently advising programme staff and the government departments funding the programme on how to use the overall programme’s research results to inform the revision of a white paper on e-education in South Africa. My role in and interaction with the ICT4RED programme had thus changed to an extent where it did not seem appropriate to regard myself as an external researcher.

In my case study research of the ICT4RED programme I exclusively collect data from the teachers involved in the programme. While the entry point of ICT4RED indeed is teachers as mobile technology users, the programme does extend to learners as well. As part of the mobile learning design, a 1:1 model of tablet provision is applied; though this is phased in gently with teachers receiving tablet devices first before rolling the programme out to selected classes of learners, and eventually to the entire school involved. The reasons for focusing on teachers in my case study relate to access and ethics.

[75] The UJ-BCURE programme: https://africacentreforevidence.org/uj-bcure_description-4/

In terms of access, a language barrier between myself as an English speaking researcher and the learners as isiXhosa speakers prevented an extension of the research to students. In rural Eastern Cape, a translator would have been required to involve a diverse group of learners within the case study, which I did not have access to. In addition, to conduct research on students in the Eastern Cape informed consent of the guardian of each learner was required in 2015[76]. I did not have sufficient resources to track each guardian and seek their permission to involve their children in the research. This points to a range of additional ethical concerns when conducting research with minors (e.g. Alderson & Morrow 2011). In addition to the pragmatics of seeking informed consent, I also felt unable to provide a research environment in which I could have sufficiently balanced the multiple inherent power relations between me as a researcher and the involved minors. This would have required a larger pool of research resources, for example translation services, time spent in the local communities, and research skills. It is important to note that the decision to limit the research to teachers only was taken before the findings of my mixed-methods systematic review were available.

It is also important to keep in mind the nature of the collected data and its relation to the analytical frame of the CA. As outlined in chapter 4, section 4.3.3, while the nature of data collected followed an inductive approach with interview and observation schedules being semi-structured, the introduction of the CA as an analytical frame was deductive. That is, I explicitly coded the qualitative data according to the analytical devices of the CA: functionings and capabilities. In this, the guiding frame to code my data referred to indications of whether teaching with mobile technologies foster valued being and doings and enhanced the perceived opportunities of teacher to live a life they have reason to value. To operationalise the conceptual coding framework[77], I relied on a range of guiding questions such as whether there is an indication that teachers can transform access to mobiles in order to become the kind of teacher they aspire to be. It is therefore important to keep in mind that the research results expressed in terms of functionings and capabilities is but one way to read the available data. A different conceptual framework would have generated different types of themes.

Within these analytical frame and the applied conceptual devices of coding for functionings and capabilities, individual content themes were then derived inductively following standard

[76] The Eastern Cape Department of Education has undergone extensive changes in senior management since 2015. ICT4RED has been informed that this access policy is in the process of being revised and there is currently uncertainty on the Department's policy in this regard.
[77] For related examples of operationalising the CA as a conceptual framework in ICT4D, see Kleine (2013) and Gigler (2015).

processes of thematic analysis of qualitative data. There is some overlap between the content themes derived in my case study research and in my thematic synthesis in the systematic review. In terms of research process, the data collection and analysis of the case study was conducted after the meta-analysis but before the thematic synthesis. Given the methodological overlap between the thematic analysis in the case study and the thematic synthesis in the systematic review, I cannot rule out the possibility that the themes derived in the case study influenced my coding of the data in the thematic synthesis. However, the thematic synthesis did not adopt the CA as an analytical device and instead focused on a mechanism-context framework. All developed codes in the thematic synthesis are linked on EPPI-Reviewer to text on research findings reported in included primary studies allowing for an interrogation of the link between the underlying data and my interpretation of it in the thematic synthesis; and whether this interpretation might have been influenced by my prior case study research.

Lastly, as flagged in chapter 4, there is also a question to what extent my primary research might have been subject to desirability bias, which I discuss in detail in appendix 7.1

7.3 Investigating teachers' use of mobile technologies from a capabilities perspective

This section present the results of my qualitative case study research investigating teachers' use of mobile technologies in rural South Africa from a capabilities perspective. The section is structured according to the four dimensions of capabilities emerging from the data: informational, educational, economic, and societal capabilities. Each dimension of capabilities indicates a set of valued opportunities that teachers reported to being able to explore following the provision of mobile technologies. I first developed an initial list of all capabilities indicated by teachers before thematically grouping these into the four dimensions of capabilities. For example, a number of capabilities were related to valued educational opportunities, while other pertained to valued opportunities in teachers’ social rather than professional lives. This thematic grouping of capabilities resulted in the four dimensions of capabilities.

In total, the four dimensions of capabilities comprise 21 valued opportunities linked to teachers’ use of mobile technologies. As explained in chapter 4, each of these capabilities is based on teachers’ functionings identified in the collected qualitative data. Therefore, behind each of the 21 capabilities is a set of functionings. Appendix 7.2 provides an exhaustive list of all 91 functionings and how they relate to the capabilities reported here.

7.3.1 Informational capabilities

The first dimension of capabilities identified in the case study of the ICT4RED programme refers to how teachers used their tablets for a wide variety of functionings associated with the expansion of their informational capabilities. I define informational capabilities as the teachers’ capabilities to transform access to the tablets into valued functionings related to the use of the specific affordances of the mobile technologies. Informational capabilities therefore group together the valued opportunities that teachers reported in reference to their use of the technological affordances of the tablet devices such as their mobility and constant connectivity. In total, the dimension of informational capabilities consists of five capabilities, which in return are based on 26 reported functionings (Appendix 7.2). The five informational capabilities are listed below in no particular order and discussed in turn in this section.

- ICT usage—to be able to use ICTs effectively
- Information literacy—to be able to find, evaluate, use, and process information
- Connectivity—to be able to connect and communicate

- Mobility—to be able to engage in one's professional identity and practice anywhere, anytime
- Merging contexts—to be able to extend professional beings/identities across contexts

ICT usage—to be able to use ICTs effectively

Teachers expressed satisfaction and pride from achieving what some termed 'ICT literacy' or 'being a tech champion'. This referred to the independent operation of the tablets and their affordances as well as, importantly, the process of obtaining this proficiency. For many teachers being able to operate tablet devices themselves was a major motivation to participate in the ICT4RED programme. The acquisition of ICT skills and associated functionings such as being able to use emails, social networks, and multi-media features of the tablets was highly valued. Teachers repeatedly compared the tablets to PCs highlighting how the applications they found on the tablets made their integration into classroom activities easier. The value of ICT skills also emerged in the context of little pre-existing exposure to educational technology. As one teacher observed: "I spent 22 years in a teaching system but I didn't know anything about technology. I knew nothing about tablets or computers. So I was so interested in this project to see if I can also use these tablets" (Primary teacher; day 3.)

The process of acquiring ICT skills itself was a strong source of well-being as teachers reported high levels of pride for mastering technology usage. In some contexts, teachers reported that their initial inability of using mobile technologies made them feel ashamed given how proficient their students were with the devices. Overcoming such fears and becoming 'confident ICT users' motivated teachers to 'keep trying new things' and teachers valued the process of experimenting with the devices to discover new affordances that might be of support to their teaching.

Teachers also referred to the intrinsic value of ICT skills and their choices in engaging with technologies on their own terms. For example, while few teachers used the blogging facility of the ICT4RED website, the blogging itself was repeatedly mentioned in the data as a valued opportunity. This variation between the opportunity sets identified by teachers and their actual pursuit of such opportunities was also observed between schools. While all schools were provided with the same ICT infrastructure throughout the programme, the conversion of these resources highly varied. In the school with the most advanced use of tablets, teachers completely facilitated lessons using white boards linked to their tablets, whereas in the least advanced contexts, tablets were mainly used as a substitute for a lack of text-books and writing pads.

Information literacy—to be able to find, evaluate, use, and process information

Teachers perceived the constant and up-to-date access to information, which the tablets facilitated, as a major contribution to their lives. As one teacher expressed it, “these tablets are filled with knowledge” (Primary teacher; day 15). Accessing this knowledge independently and tailored to personal preferences enhanced teachers’ sense of choice as the below quote indicates:

> “They [tablets] are an educational tool and the most important educational tool as we are getting a lot of information from them—it is not just for fun. It upgrades your knowledge. Internet is the most important because you're able to get anything you want from it. And to connect with friends and teachers I use the internet and email. You get so excited checking your inbox and I am able to look for anything I want. Information is quick and you don't have to go somewhere to research something. Even if you are travelling, once you are at home you can access information.” (Primary teacher; day 9).

The above quote highlights the value that teachers placed on having a choice in how to apply the tablets in line with their own needs. Being able to ‘look for anything you want’ and to merge the translation of access to information into professional and social uses was highly valued. Teacher could use the tablets to access information relevant to their teaching profession, for example using google for teaching materials or asking colleagues for advice; but they could also use the tablets to access information relevant to their personal and social needs. Examples of this use of social information was the often mentioned ‘bible app’ that teachers used to participate in church services and to teach their own children.

Teachers valued this choice and opportunity of being able to find and use information and to feed this information into both their professional and social realities. More so, being able to engage in this opportunity on their personal devices was described as ‘being independent’. Teachers explained that they no longer had to wait for information and updates from the education department or the unions to reach them, but that they now could proactively access them on their own terms. The convenience and independence of accessing information on mobile devices was thus another valued functioning.

Connectivity—to be able to connect and communicate

The capability to be able to connect and to communicate also emerged as a key informational capability. Connectivity and communication allowed teachers to maintain and build their social networks as the tablets provided a channel for instant and personal communication. Teachers made deliberate choices in what connectivity features of the tablets to pursue and to what ends. In this, teachers again valued this capability for both personal and professional reasons. The opportunity to exchange ideas with other teachers and staying in touch with graduate learners was valued as much as the opportunity of connecting with former colleagues, family, and friends.

The capability to build and maintain professional networks was valued particular highly by teachers who had conducted their teacher training in urban institutions and were now assigned to rural schools. Two of those teachers for example referred to their most memorable moment of using the tablets when they received an email from a former colleague at graduate school whom they had lost touch with after completing their courses. Similarly, the capability to remain in contact with former learners who had received scholarships to go to South Africa's most prestigious universities in Cape Town and Johannesburg was cited as a major source of professional well-being and motivation.

In the context of the rural location of the schools, this capability to connect and communicate seemed to present an important source of agency decreasing teachers' sense of isolation:

> "I have joined LinkedIn and though I'm not at hundred percent, I know what is going on. It makes you to connect with other people that you have never met before. You look at other profiles and you realise people are working and it motivates you. It motivates you to post what you doing in your own corner and people must know that is your school, and we're doing our work in our little corner (…) It makes you so happy when you connect." (Primary teacher; day 6).

This opportunity to overcome a sense of isolation was referred to throughout the collected data and teachers cited examples of using the tablets to connect to friends and colleagues from countries as diverse as Sweden, USA, Russia, Kenya, and Australia. Not all of these mentioned interactions and connections had evident professional benefits, but were largely valued by teachers for 'making us feel to be closer'.

Mobility—to be able to engage in one's professional identity and practice anywhere, anytime

Teachers highly valued the capability to use the tablets anywhere, anytime; and by extension, to engage in their professional practice at time and location of their choice. 'The tablet goes where I am going' and 'it's all there in the tablets' were commonly used phrases to describe the virtue of being mobile. Teachers described a range of benefits from being able to use the devices anywhere, anytime. Most teachers travelled more than 30 minutes to work every day and attended at least three departmental or union meetings per month in Cofimvaba. Being able to have all their administrative material and teaching resources in one place was therefore highly valued in this context. Teachers also referred to the convenience of not having to carry text-books and other teaching materials. There was a general perception that carrying tablets appeared more professional and allowed one to behave like a 'dynamic professional'.

Teacher reported many instances of educational uses of the tablets facilitated by the devices' mobility. This included the creation of teaching content on the go, most commonly by taking pictures and audio/video recordings of content relevant to the planned lessons. Teachers also reported using the devices at home to prepare for next day's lessons, which was preferred over having to prepare the lessons at the school's facilities. Teachers also hypothesised that it would be possible for them to teach pupils remotely via their tablets, for example when they had to attend departmental meetings. However, more common instances of this in practice referred to situations in which a teacher had to teach and monitor two classrooms at the same time. In an observed lesson, the teacher switched between using instructional videos on her tablet connected to a white-board in one classroom with her regular lesson plan in another classroom. Though, this type of mobility was not valued by educators for a loss of teaching time and quality in both classrooms.
In summary, the mobility and constant availability of the tablet devices allowed teachers to convert the devices into centralised teaching tools, which more conveniently stored all their educational content and allowed them access to it on their own terms. In reference to this, a High school teacher (Day 12) remarked: "It [the tablet] is my office". Teachers valued having such a tool for personal reasons too as they perceived it to be more professional and allowed them more opportunities to engage in their professional identity and practice.

Merging contexts—to be able to extend professional beings/identities across contexts
A cross-cutting informational capability was teachers' opportunity to move in and out of their professional practice and identity across contexts. Using the affordances of the tablets, teachers explored different ways in which they could act and be perceived as professionals outside the classroom. A range of these have been discussed as part of other informational capabilities already and others will be discussed in the remaining dimensions of capabilities. This indicates that the opportunity to merge contexts was valued by teachers and, given its nature, influenced a range of educational and societal capabilities too.

Without pre-empting or repeating this cross-cutting capabilities, in summary teachers valued the use of tablets to cross and merge three main contexts. First, they used the tablets to cross geographical contexts, for example collecting educational content on the go or connecting virtually with teachers from other schools. Second, teachers crossed temporal contexts using the tablets to connect with past colleagues, to stay in touch with learners leaving the schools, and to relive and access educational opportunities denied to themselves during the apartheid regime. Third, teachers bridged social and professional contexts using the tablets to extend their professional identities into their social lives, for example recording their lessons for children and community members not being able to attend and access lessons in school; or, vice-versa, to extend their social identities into their professional contexts, for example recording speeches of themselves at church and using these as content and inspiration for learners in class.

7.3.2 Educational capabilities

The second dimension of capabilities related to teachers' use of the tablets to create and explore a range of educational opportunities. Educational capabilities are defined here as teachers' capabilities to transform access to the tablets into valued educational beings and doings. Educational capabilities thus comprise the opportunities related to teachers' use of the tablets to expand their functionings in a professional context, for example achieving their professional goals as a teacher. I identified six valued educational opportunities associated with the dimension of educational capabilities. These six capabilities consist of 28 functionings identified in the qualitative data (Appendix 7.2). The six capabilities are listed below and will be discussed in turn in this section:

- Student success—to be able to improve learning achievements
- Pedagogies—to be able to change and explore teaching methods
- Role of the teacher—to be able to become a facilitator of knowledge
- Occupational satisfaction—to be able to enjoy teaching more
- Innovation—to be able to innovate
- Collaboration—to be able to work in collaboration

Student success—to be able to improve learning achievements

Central to teachers' educational use of the tablets was the ambition to integrate the tablets into their overall efforts to provide their learners with quality education. Teachers valued the tablets in this remit in a practical sense as a tool to support them in supporting their learners to achieve academically. Being able to improve their learners' academic achievements, for example through increasing engagement and providing a wider variety of educational content, was one of the most frequent cited valued doings of the teachers involved in my research.

Teachers reported that using the tablets as an educational tool made it easier to motivate learners for education. Learners were for example described as ‘excited’, ‘having more fun’, and ‘paying attention’. Teachers linked this change in leaners’ enjoyment both to the novelty effects of the tablets and the teaching strategies that the tablets allowed teachers to facilitate. Being able to motivate learners for education and being able to provide them with a more enjoyable learning experiences then supported teachers’ key teaching goals of supporting learners to do well academically. This capability set was captured in one of the teachers’ own words as: “I like my learners and I want to move them to have better chances. I want them to fly high on the sky. And the tablets will help them flying high” (Primary teacher; day 4). Supporting learners’ success was a key driver of teachers’ own motivation and identity as professionals. And teachers believed the tablets to enhance their capabilities to achieve this goal. The tablets were therefore regarded by teachers as an additional educational input that they could apply in their pursuit of improving the learning achievements of their own students.

Pedagogies—to be able to change and explore teaching methods

In line with ICT4RED’s main objective, the teachers explored a variety of different teaching opportunities based on the educational affordances of the tablets. In the ICT4RED programme, technology adoption and usage was embedded into efforts of promoting more learner-centred teaching methods in rural schools. Teachers valued these more learner-centred teaching strategies (e.g. role plays; jigsaw; group work) as they believed them to enhance a range of their valued educational abilities. Being able to increase interaction and participation in their classroom lessons, for example, presented a valued educational capability that teachers perceived to be able to explore with the help of the tablets.

However, often it was not so much a particular teaching strategy itself that teachers valued, but their own ability to adapt their teaching to what teachers’ perceived as a rapidly changing educational environment. Teachers expressed for example that the ‘traditional way’ of teaching was not suitable for ’21st century learners’ and that they wanted to be able to ‘keep up’. Teachers were convinced that frontal teaching methods with little learner involvement did not stimulate learners sufficiently, which they then contrasted to learners’ reaction when being taught with the integration of tablets in lessons. As a result, teachers valued the opportunity to adapt their teaching strategies; but this was not limited to any particular strategy or underlying pedagogy per se. I will comment more on the implications of this capability set on the applicability and usefulness of formal mobile learning pedagogies in chapter 9, section 9.3.2.

Teachers further valued to their ability to use the access to additional information and educational content on tablets to integrate different and more appropriate content in their lesson plans, for example supplementing the lessons with localised multi-media inputs such as YouTube videos of local events. Teachers valued this access to more information and content in relation to their own subject knowledge too.

This general perceived increase in educational capabilities provide teachers with more choices on how to teach allowing them to be more creative and diverse in their chosen teaching strategies—an educational opportunity that had intrinsic value to teachers. Also, being able make their educational activities more interactive and diverse—characteristics that were attributed with increased learner motivation and performance—linked back to teachers' valued opportunity of providing their students with high quality education.

Role of the teacher—to be able to become a facilitator of knowledge

Teachers in particular appreciated the opportunity to alter their teaching methods to allow learners to 'become the problem solvers' and to co-produce knowledge. This educational capability was a sub-set of the capabilities related to pedagogies presented prior to this. However, this capability to be able to become a facilitator of knowledge was mentioned so consistently and in great detail by teachers that it merits to be mentioned in its own right. Using the tablets allowed teachers to redefine their educational role and to become "the facilitators of knowledge, not the source of knowledge" (High school teacher; day 13). This shift in teaching approach was valued as teachers reported it to lead to more engaged learners and interactive lessons, which in return were assumed to lead to increased learning outcomes. Hence, being able to become a facilitator of knowledge allowed teachers to pursue their valued educational functioning of supporting learners to succeed. The educational value of using the tablets to become facilitators of knowledge in the eyes of the teachers is captured in the below excerpt:

> 'It [the tablet] has improved my teaching and learning styles and the learning outcomes have improved. (…) My teaching style is no longer teacher-centred. When I'm in class I'm no longer standing in front, I let the learners do the work so I'm not the person who keeps the knowledge and I am just facilitating it. The teaching strategies we learnt helped a lot. I did the storytelling for example and the children told really exciting stories (Primary teacher; day 10).

I observed a number of examples of this teaching strategy in practice. Teachers in particular liked the teaching activity of story-telling in which learners were given tablets to create a multi-media story about the customs and life histories of elders in the community. Teachers, in particular if they were assigned to the rural schools from urban teacher training institutions, explained how this activity had led to a two-way learning experience and that they had invited community elders in some instances to co-present lessons on local histories. I note that these teaching strategies are close to social-constructivist ideas of education but were not framed by teachers in this manner.

Occupational satisfaction—to be able to enjoy teaching more

Teachers also reported a range of cross-cutting functionings derived from the use of the tablets that allowed them to being able to enjoy teaching more. These functionings merged educational and informational affordances of the tablets. As already reported, teachers believed the tablets to support them in controlling the classroom as learners were better behaved and more attentive. Tablets were seen as a tool to reduce teachers' workload and to facilitate teachers' daily tasks as teachers for example no longer had to carry heavy text-books on their daily commutes. This was often referred to as to 'boost our morale' and teachers indicated the pleasure derived from the ease of use of administering educational tasks on the tablets. 'You just tab and it is all there' was a common used expression and teachers applied the tablets to store learners' assignments, attendance records, and reports on their tablets, among other. This was contrasted to keeping paper records in the school's facilities which the teachers regarded as an inferior method of EMIS. In sum, these practical and educational functionalities of the tablets were generally regarded as to make being a teacher 'more enjoyable'.

Innovation—to be able to innovate

Another valued educational capability related to teachers' opportunity to innovate their educational practices. This capability encompasses the pedagogical innovation mentioned above already but extended beyond it emphasising the intrinsic value of being able to engage in a process of innovation itself. Many teachers reported that they were initially scared of the technologies as they were worried that they would make mistakes when integrating them into their teaching. Teachers do not have many opportunities for professional development in the rural Eastern Cape and therefore were worried that a change to their teaching methods acquired during their formal teacher training would lead to mistakes in their teaching undermining their ability to support learners' educational successes. The ICT4RED programme actively designed for this contextual factor ensuring that the professional development training provided a 'fail-safe' environment in which mistakes were framed as learning opportunities (Herselman & Botha 2015).

Teachers valued this ability to try out something new without fearing the professional repercussions of making mistakes. For example, one teacher observed that, “the main advantage [of using tablets] is that you realise not everything in life is difficult, even if you don't know something you can try to do it.” (Primary teacher; day 16). The value of this sense of discovery accompanying teachers’ joint exploration of the tablets as educational tools was expressed in multiple themes such as ‘learning by doing’, ‘make mistakes together’ and ‘you just try again’. This experience of reframing failure as an opportunity for innovation then reflected in an enhanced tolerance of learners’ mistakes too, which teachers began to refer to as ‘mistakes are part of the solution’.

Teachers were impressed with their own ability to master the tablets rapidly as educational tools and to innovate their educational practice. This opportunity to innovate was also valued in the contexts of ‘keeping up’ with learners. As indicated above, teachers believed educational contexts and practices to be in flux and did not want to be left behind. Being able to teach with tablets was seen as an opportunity to become ‘modern’ or 21st century teachers—a deliberate expression to match their perception of dealing with 21st century learners who are advanced in their technology usage already.

Collaboration—to be able to work in collaboration

The final capability mentioned by teachers referred to their value of the opportunity to work in collaboration. Aspects of this capability have already been covered under the informational capability ‘connectivity’. From an educational perspective, teachers in particular valued the tablets’ connection and communication affordances to collaborate with other teachers. Observed examples of this included the exchange of teaching content, asking for and providing advice, joint development of lessons plans on Google Docs, and the collaborate planning of school districts events using the full suite of Google’s collaborative tools. Collaboration was also a key facilitator of technology adoption and peer-to-peer learning and joint technology assignment presented valued mechanisms through which to integrate the tablets into teaching practices.

7.3.3 Economic capabilities

The third dimension of capabilities referred to the economic opportunities that teachers associated with their ability to use mobile technologies in an educational setting. Economic capabilities can since be defined as teachers’ capabilities to convert the technological input into valued economic functionings. The dimension of economic capabilities therefore groups together valued economic opportunities, for example looking for a job or supplementing one’s professional credentials, that teachers explored as part of the ICT4RED programme.

In the rural context of the ICT4RED schools, teachers sensed five economic capabilities based on a total of 18 observed functionings (Appendix 7.2). The five capabilities are listed below and discussed in return:

- Employment—to be able to be employed
- Economic capital—to be able to build economic capital
- Online education—to be able to extend educational opportunities
- Marketing—to be able to ‘build the brand’
- Digital services—to be able to access digital services

Employment—to be able to be employed

Above all, teachers assumed that their own—as well as their learners’—capability to be employed had increased due to the involvement in the ICT4RED programme. The opportunity to translate access to mobile devices into enhanced employment prospects was a strong theme in the collected data and teachers cited it as a central capability derived from their use of tablets. For example, being able to teach with mobile technologies was seen as a major advantage in order to apply for teaching posts and to stay employable in the ‘modern’ times. There was a notion among teachers that ‘ICT is in demand these days’ and that being proficient in the use of mobile technologies had made teachers an ‘asset’ for current and future employers. This notion extended to their learners too, and teachers assumed them to have higher chances of finding employment due to their gained IT skills as well.

As a result of their enhanced and in-demand ICT skills, teachers mentioned a range of different employment opportunities that they now could explore as ‘ICT champions’. This related to posts in schools in more affluent areas that were already using educational technologies and to posts in the provincial education department. Teachers also expected the ICT4RED programme to be expanded to additional schools in the province and assumed that they would be able to act as trainers of the trainers in this process. Within this theme, there was no observed functioning of teachers actually transferring and it seemed to be the opportunity of having professional choices itself that teachers valued. For example, one teachers remarked:

> “It [the tablet] also gives me more opportunities. If I want to transfer from my school I will have a great advantage to find a new job because I know how to use tablets. Being a mobile teacher gives me more choices where to work and how to work.” (Primary teacher; day 9).

Teachers positioned their opportunity be employed in the context of a changing education profession. There was a strong perception that the future of the education profession lies in embracing technology. ‘In future, only technology will be used’ or ‘technology is everywhere’ were common expression to describe this perception. Teachers’ valuing of the gained ICT skills and subsequent perceived employment opportunities, then, not only related to exploring new opportunities, but as much to being able to stay employable in a changing time.

Economic capital—to be able to build economic capital

Teachers also applied the tablets to explore different aspects of their economic capital. This exploration drew in particular on the connectivity and access to information affordances of the tablets. Teacher highly valued the ability to access and upload employment related information. This opportunity was two-fold as one teacher explained:

> “You have more chances. Even if you are looking for a certain post, it is easier to get it. First, you can know about it online first before everyone else. Second, you can advertise your own work online. People can find you.” (High school teacher; day 13).

This quote illustrates the parallel aspects of using the tablets to enhance economic capital. Teacher employed the tablets widely to gain access to more up-to-date employment information, for example posts advertised by the Department of Education. The tablets allowed them to become aware of opportunities ahead of others as the usual advertisement channel was a paper-based monthly bulletin distributed to all schools. As a result, teachers reported to be able to have advantages in their job search and that they had an increased choice and access to employment-relevant information. But, teachers also valued the capability of being able to proactively advertise themselves online. Teacher referred for example to their ‘profile’ online, which usually related to accounts they maintained on LinkedIn and SchoolsNetSA, and that people were now able to find them.

A further aspects of the economic capital capability relates to the ability to share this employment-related information with learners in order to guide their career paths. This capability overlapped with teachers’ professional goal of supporting learners’ to succeed and often was valued particular highly in references to information and careers paths that were not accessible to teachers themselves when they were in school. Below one teacher describes how a lack of relevant information and career advice in her student days almost led to her becoming a nurse rather than a teacher:

> “Teaching was my second choice and it was nursing that was my first choice. I was so stupid, I only liked it because of their [nurses] uniforms. That is a rural environment for you. I didn't know

> better and no one gave me any other option. And what was it with the uniform? Why would you want to be a nurse just because of the uniform? But back in the day all I knew about was a policeman or a nurse—you don't know about other professions. Today this would be much better and learners can find out about the world. Of all, learners have more information about this also because we are more informed as teachers. Now I can tell them to google all the jobs they can do with a matric and explain to them what is what.” (Primary teacher; day 6).

Teachers valued this opportunity to guide their learners to make more informed professional choices. Again, the main emphasis was on the intrinsic value of having a choice and knowing one’s options, rather than prescribing a particular career path or choice.

Online education—to be able to extend educational opportunities

Teachers also applied the tablets to enhance educational opportunities for themselves and others. These opportunities were framed in narrow instrumental terms as either increasing teachers’ own qualifications or as supporting their own and other relatives’ children’s academic achievements. In terms of their own qualifications, a sizable number of teachers were enrolled with distance learning institutions to further their formal qualifications. The University of South Africa’s BeD Education was the most popular programme and teachers highlighted how much easier the administration and pursuit of their distance learning studies had become due to the tablets. For example, before obtaining the tablets, teachers had to use the internet cafe in the districts capital to submit their assignments, which presented a challenge for many given the travel distance and operating hours of the cafe. Content-wise, teachers involved in distance learning courses also valued the ability to engage in research for their course assignment on their tablets.

But, equally so, teachers valued the extension of educational opportunities through the tablets in terms of providing education to others after school hours. This usually referred to teachers’ own children and/or children of teachers’ relatives. The use of tablets for commercial after-school tutoring was not reported. Interestingly, the opportunity to make use of online education was valued so highly that teachers reportedly installed WIFI connections in their homes too in order to allow their spouses and children to supplement their educational efforts without depleting the teachers’ mobile data allocation.

Marketing—to be able to ‘build the brand’

Teachers also reported a valued economic opportunity related closely to the ICT4RED programme itself. The capability to use the ICT4RED brand to support their own schools and reputation. Teachers reported that the news of the schools’ approach to teaching with technologies had spread rapidly throughout the community leading to an increase in enrolment of learners at ICT4RED schools. Teachers valued this trend and perceived it as a recognition of their schools' ability to provide high-quality education by local communities. Teachers also derived personal benefits of being associated with the ICT4RED programme and reported that community members dubbed them 'technology teachers' —a reputation teachers received positively. This combined valued functionings obtained from being able to market oneself as part of the ICT4RED was captured in the below quote.

> "They recognise us, in fact not only the community the entire district in the entire Eastern Cape. They all knows us. When we go to the workshops we used to take pictures with our tablets and everybody was so impressed. Other people are asking when this project is coming to them and they want to know if it is working. And believe me it is working so much for the children. We even have more learners coming to us now. I have over 50 [learners] now and I had 30 last year." (Primary teacher; day 7).

Digital services—to be able to access digital services

A final economic capability referred to the use of tablet devices to explore a range of practical applications related to digital services. Teachers mentioned using the tablets to make online appointments, use online banking, access online call rates, and order catering service, among other. Access to these digital services was valued highly for teachers residing in remote locations as they otherwise would have to travel to the nearest urban centre to conduct their business. Digital services had economic value as it saved teachers time and money. The opportunity to have access to digital services further was valued as teachers assumed it to be the 'advanced' way of doing things and did not want to be excluded from it as the below quote shows:

> "Now we are living in an advanced technological world whereby you don't even have to queue to go to the bank in order to send money to your kids. You can use your e-wallet. And it makes life easier. You can even make an appointment through your phone. So teachers need to change too." (Primary teacher; day 9).

7.3.4 Societal capabilities

The mastery and application of the tablets as an educational tool also did affect teachers' societal capabilities, which is the fourth and last dimension of capabilities identified in my case study. Societal capabilities refer to teachers' capabilities to explore and pursue valued being and doings in society as a result of gaining access to and proficiency of the tablets. This dimension of capabilities thus encompasses valued opportunities in society, for example being respected as a professional, that teachers were aiming to achieve through the educational use of tablets. The teachers involved in the ICT4RED programme appropriated the technological input to support five societal capabilities, which consist of 20 reported functionings (Appendix 7.2). The five societal capabilities are listed below and discussed in return:

- Professional identity—to be able to create a professional teaching identity
- Respectability—to be able to be impress
- Recognition—to be able to be ‘on the same page’
- Self-actualisation—to be able to grow as a person
- Community development—to be able to support the local community

Professional identity—to be able to create a professional teaching identity
A major source of valued being and doings reported by teachers was the capability to be regarded and to present themselves as professionals. Teachers applied the tablets in a variety of ways in order to enhance their standings as professionals and to display their professional identity. The ability to apply the tablets in this pursuit of constructing a professional identity was aided heavily by the intrinsic association of the possession of tablet devices with being a professional. As one teachers remarked: “People just assume that you are a more professional being. They are impressed automatically by just seeing you with the tablet.” (Primary teacher; day 1). In the rural context of the Nciba district, the mere possession of tablets was regarded as a social and professional status symbol. Teachers were able to exploit this perception of the devices and applied it in order to support their standing as professionals.

Teachers enjoyed their possession and use of tablets and often referred to how they ‘looked like someone who is professional and organised’. In a telling quote one teachers observed that she appeared as “someone who knows what you are doing” (Primary teacher; day 5). A large part of teachers’ opportunity set to use the tablets to construct a professional identify was thus driven by outside perceptions rather than observed changes in teachers’ actual behaviour. This positive outside perception, however, set in motion a virtuous circle of encouragement for teachers who observed this shift in outside perceptions carefully and used it to carve a niche for themselves as professionals. This sentiment is captured well in the below two quotes:

> “Yes It makes us look more professional than before. Before we normally took ourselves as layman, as traditional teachers; now we can see that we are modern teachers; we are teachers of time.” (Focus group; day 17).

> “It has given us confidence to feel that we are teachers and that we are unique from other

> teachers." (Focus group; day 17).

Here it becomes evident that teachers not just adopted the narrative of being professionals. They further defined themselves as 'modern' and professionals 'of time'. The teachers involved in the ICT4RED therefore used their functionings as teachers who use technologies to define their professional identity as technology users. In line with this constructed professional identity, teachers rebranded their school's names during the public ICT4RED graduations in the communities as 'Technology University of Mdanstane' or 'Thembalethu Institute of Technology'—emphasising their ability to use technology in an educational setting.

Teachers valued to be regarded as successful and qualified in their profession and pointed to a range of examples how these experiences supported their professional identities. In a context of low pre-existing perceptions of the teaching profession, teachers were in particular pleased to be able to attract learners into the career path of being a teacher. This attraction was directly supported by the ability to use tablets in an education context as expressed in the below quote.

> "We have some learners now, when they talk about careers they tell us now that as you [teachers] are advanced we also want to become teachers. Our country is providing you with technology and I can follow the same teaching profession as our government is updating you." (High school teacher; day 11).

In sum, teachers felt more valued in their profession and were able to carve out a professional niche identifying as technology teachers. Such a positive professional identity was often lacking as explained in the next section, and using the tablets to support the construction of such an identity was a highly valued opportunity—the opportunity to become 'a full teacher'.

Respectability—to be able to impress

Linked to their capability to construct a valued professional identity was the capability of being able to impress. This referred to teachers' valued functioning of being respected by learners, other teachers, and the wider community. This active desire for respect and the subsequent application of tablets to pursue it comes in the context of South African teachers having been subject to extensive public (including government) criticism due to their perceived lack of performance (e.g. Motala et al 2012). How important the functioning of being respected is to teachers shows the below quotation:

> "It [teaching with tablets] makes us being more respected. They think we are BEE, because we

have those fancy tablets. They think we are the most important people. Now we have dignity as teachers." (Focus group; day 17).

The teachers here refer to the dignity of teachers and in a previous quotation teachers referred to themselves as 'laymen'. This language seems to give a sense of the low professional perceptions teachers had of their own occupation and how it affected their societal capabilities. In the above quote, BEE stands for the South African government's 'Black Economic Empowerment' scheme, an affirmative action programme aimed at previously disadvantaged groups to create a wealthy African middle-class. The reference shows how, in this rural setting, the possession and use of mobile technologies is intrinsically associated with being successful and qualified. It is a stark shift from the perception of teachers without dignity to teachers being on par with BEE professionals. The opportunity to elicit respect and increase the standing of the teaching profession presented an important societal capability for teachers.

Recognition—To be able to be 'on the same page'

A second capability linked to teachers' construction of their professional identity and quest to be respected was teachers' capability to be recognised. This capability was more specific than the overall capability of being respected. Teachers' reference of the value of being recognised was linked to specific grievances that they had experienced as part of their teaching positions in the rural Eastern Cape. At the most micro level, teachers felt the tablets allowed them to be on the same page as Model C schools in the Eastern Cape, such as Selbourne. Model C schools refer to public schools in the highest income quintile of South Africa's schooling districts, which too have the highest educational achievements across South Africa's public schools. Teachers repeatedly expressed statement such as 'now we are on the same level as Selbourne' or 'I can go teach at Selbourne now'.

The Eastern Cape is South Africa's worst performing region in terms of educational outcomes. At the time of submission, the provincial education department is under national administration due to its inability to provide educational services to all learners in the province. This dimension of deprivation was also repeatedly mentioned and teachers remembered how their friends and colleagues from other provinces had 'looked down on us'. The opportunity to become technology teachers, however, changed these relations and teachers felt that they were able to level the playing field. In a personal anecdote one teachers recalled:

"For example last year I was at the funeral and so then my friend from the Western Cape attended as well. And I wanted to boost in front of her. So I took out the tablet and recorded the

> funeral because they always say education is better in the Western Cape. So I wanted to show what we have in the Eastern Cape. She was so impressed." (Primary teacher; day 15).

The last reference of being able to be on the same page referred to teachers' perceptions of spatial inequalities in the education system. Teachers expressed hopes that the use of tablets at their schools might allow them to balance the flight of learners from rural to urban schools. In this, teachers assumed that learners and their parents could realise that they can receive 'modern', high quality education at their rural schools too; and that therefore there would be no need to send their children to more expensive urban schools. The educational use of tablets and their intrinsic positive associations with educational quality was thus valued by teachers as a means to enhance the status of their own rural educational contexts.

Self-actualisation—to be able to grow as a person

Teachers' societal capabilities of being able to construct their professional identity, gain respect, and recognition as professionals then directly translated into their perceived capability to grow as a person. This process of self-actualisation was a highly valued societal capability as it directly affected teachers' social well-being. Teachers described themselves to move from a state of 'being blank' or 'uneducated' to a state of 'being enlightened' or 'uplifted'. Being able to master technology, assume a more positive professional identity, and to support their learner academically left the teachers 'proud', 'confident', or 'accomplished'. Using the tablets in support of their professional societal capabilities therefore spilled over into teachers' personal development outcomes and their general self-perceptions. Teachers' ability to 'grow as a person' through exploring the use of tablets at the intersection of their social and professional contexts is captured well in the below quote:

> "The tablets increased my well-being. I have become a trainer by training myself. It equipped myself with a lot of skills. I never knew I could divide my attention like this. Now I can even present for an older audience. I can facilitate anything now. And before I didn't have that skill but now I do. I was afraid of presenting to them, but now I'm the expert of ICT." (High school teacher; day 14).

Teachers further framed this capability of self-actualisation in terms of their professional contribution to society. As explained above, a central valued educational capability was the opportunity to support the students' academic success. A core part of teachers' professional and social self-actualisation therefore was linked to enabling this educational success of students. Teachers referred to this valued functioning of seeing their learners achieve as their 'patriotic duty' and 'contribution to society'. Another metaphor used to evoke this sense of social and professional self-actualisation referred to the ‘production of professions’ by teachers. As one teacher explained:

> “I value being a teacher because you can produce more professions from you. I produce doctors, politicians, and businessmen. Even you [points at me] are a product of a teacher. I'm very proud of that. And the tablet has helped me to produce more. (High school teacher; day 11)

The last sentence of the quotes indicates how the technological input fits into this teacher’s construction of their societal capability of being able to grow as a person. The use of the tablets is appropriated and embedded into an interconnected set of different dimensions of educational, informational, and societal capabilities, whose interplay allows the teacher to pursue their personal well-being and development objectives.

Community development—to be able to support the local community

The final societal capability emerging from the data referred to teachers’ opportunity to support the local community. This capability has been touched on already with related functionings being reported as part of the capability of building ‘economic capital’ and ‘building the brand’. At its core, the community development capability referred to the spill-overs effects of teachers being able to provide higher quality education and the status associated with schools teaching their pupils with tablets. In addition to the increase in student enrolment, teachers also reported community members visiting schools to experience the tablets for themselves. Teachers described extensively how excited local communities and partners were about the provision of tablets to their local schools and how it became a source of local pride. Parents, as much as teachers, believed the tablets to allow their learners to obtain higher grades and that being skilled in ICT usage would increase their employment prospects. As one teachers observed, “they [parents] see the tablets as an integral part of their children’s future”. (Primary teacher; day 10).

Teachers valued the opportunity to contribute to the local community development through the tablet programme. For one, it increased their own status in the local community linked to their professional identity. More so, teachers also reported a range of practical benefits of being able to support the local community. At one school, regular break-ins reportedly ceased after the start of the ICT4RED programme, which teachers interpreted as reflecting the community’s recognition that the teachers now provided a quality education to the learners and that stealing the tablets would compromise the learners’ opportunity of gaining access to tertiary education. At another school, the local community reportedly contributed materials to build a storage for the tablets. In all schools more positive relationships and interactions between the school and local communities were reported by the school's principal.

Conclusion

This chapter has presented the results of my qualitative case study of a ML4D programme in rural South Africa. I provided qualitative data on how teachers involved in the ICT4RED programme used the mobile technologies to expand their capabilities. That is, I collected data on how teachers appropriate the technologies to aid the pursuit of what they had identified as valued beings and doings. Through this, I derive a list of valued opportunities that the teachers themselves attempted to explore by using the mobile devices. I find that these valued opportunities can best be understood as four thematic dimensions of capabilities: informational, educational, economic, and societal capabilities.

In this chapter, I have described the four identified dimensions of capabilities and to provide evidence of the underlying data for each. I have made minimal references to the detailed interplay between the dimensions of capabilities and how they relate to teachers' well-being and human development. Throughout the presentation of the four dimensions of capabilities, however, these intersections of capabilities have been hinted at. I therefore next transform my case study findings into a more formal analytical framework of teachers' use of mobile technologies from a capabilities perspective, which is outlined in chapter 8.

Chapter 8. Conceptualising mobile learning for development from a capabilities perspective

Introduction

This chapter uses the findings from my qualitative case study to develop a conceptualisation of mobile learning for development (ML4D) based on the Capability Approach (CA)[78]. To be more precise, it first presents a descriptive framework to synthesise and visualise the main case study findings on teachers' use of mobile technologies in a resource-constrained setting from a capabilities perspective. The framework is derived from the valued functionings and capabilities that teachers reported to explore as part of the Information Communication and Technology for Rural Education Development (ICT4RED) programme. I synthesise these primary research findings into a descriptive framework to outline the interplay and relations between the four identified dimensions of teachers' capabilities. To recall, in the case study I identify four dimensions of valued beings and doings and corresponding capabilities that teachers reported: informational, educational, economic, and societal capabilities. In this chapter, I explore how these four dimensions of capabilities relate to teachers' well-being and human development and how these relations can be used to guide a conceptualisation of ML4D based on the CA.

The objective of formalising my case study findings into a descriptive framework is to generate a visual tool to represent the case study research results on assessing ML4D from a capabilities perspective. As explained in chapter 4 and 7, my qualitative case study of the ICT4RED programme served an instrumental purpose of operationalising the CA as a conceptual device to assess ML4D. This operationalisation is of interest to my wider attempt of providing an alternative conception of ML4D based on the CA. Therefore, I require a descriptive overview of my case study findings in order to translate these findings into a foundation on which to establish my alternative positioning of ML4D, which the framework provides.

This chapter is structured as follows. I first present and describe the framework. I then

[78] In chapter 9, I will lastly bring together the developed capabilities conception of ML4D with the systematic review findings.

expand on the case study's findings in understanding the interplay between the four dimensions of capabilities and how these related to teachers' well-being and human development. To illustrate this interplay in more detail, I then provide three vignettes of the intersectional nature of the dimensions of capabilities and how teachers' explored their conception of a good life through the pursuit of overlapping capabilities. I then use these insights to propose a conception of ML4D from a capabilities perspective. The chapter ends with an overview of the key findings presented and a brief conclusion.

8.1 A framework of teachers' use of mobile technologies as an educational tool from a capabilities perspective

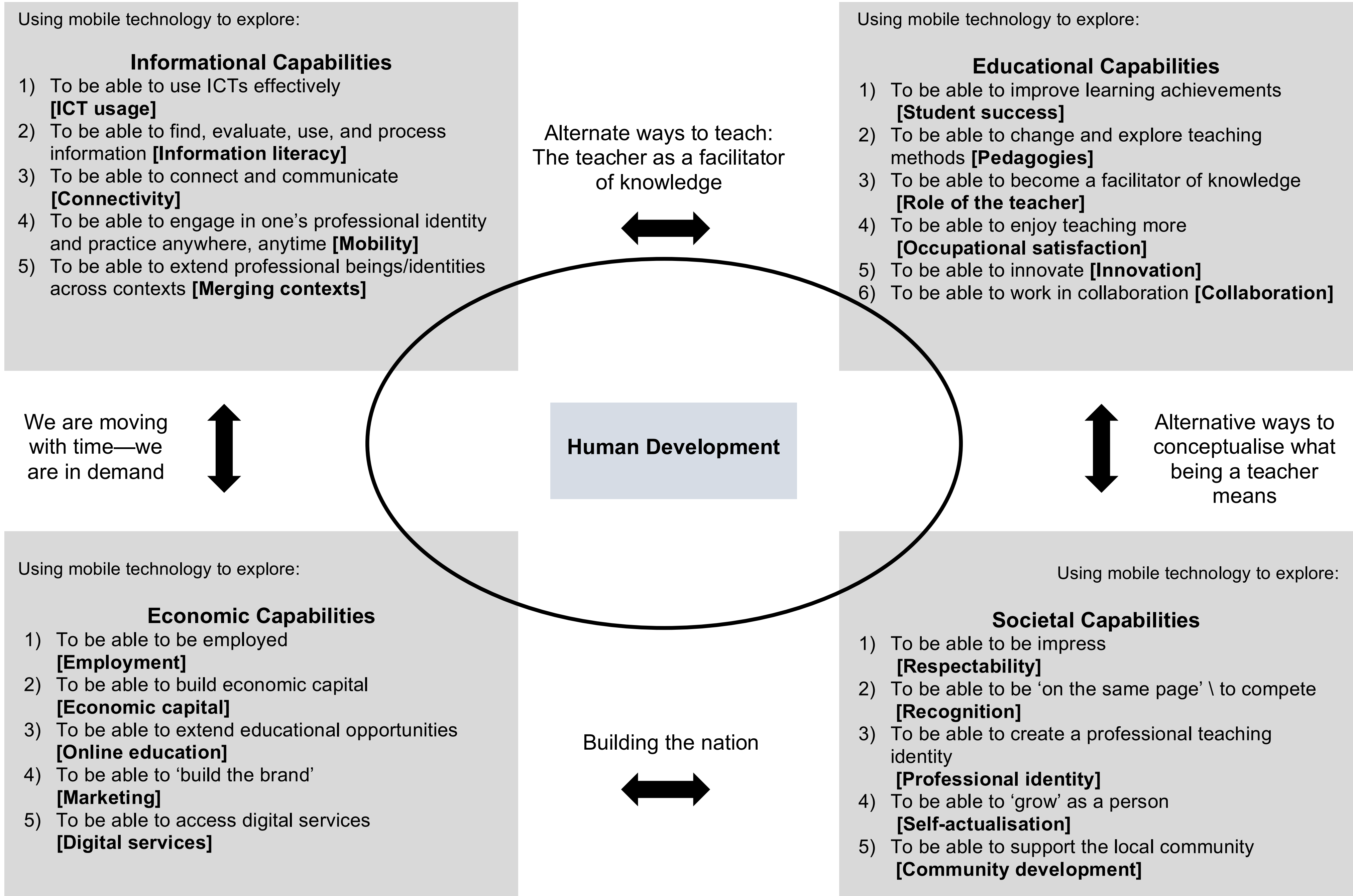
This section introduces and outlines my descriptive framework for teachers' use of mobile technologies as an educational tool based on my case study findings of the ICT4RED programme. I first outline the key components of the framework before discussing how the framework should be interpreted and the limitations to its application.

8.1.1 Introducing the capabilities framework

My framework of teachers' use of mobile technologies as an educational tool from a capabilities perspective is presented in figure 8.1 and explained here in detail. As outlined in chapter 7, my qualitative case study of the ICT4RED programme found that teachers perceived their educational use of tablet devices to contribute to four dimensions of capabilities: informational, educational, economic, and societal capabilities. This distinction between the four dimensions of capabilities became apparent after reviewing the initial list of capabilities developed in the thematic analysis of the case study data. This list consisted of 21 valued opportunities that teachers explored using the mobile technologies. It reflects the valued beings and doings that teachers pursued through the conversion of access to mobile technologies. Reviewing this list, I identified the four dimensions under which the 21 capabilities could be grouped. For example, a number of capabilities were directly related to valued educational opportunities, such as to be able to improve learners' educational attainment and to be able to act as facilitator of knowledge. Other capabilities, however, did not fit the label of valued educational opportunities and were linked closer to teachers' economic opportunities or valued beings and doings related to the use of mobiles' technological affordances. As a result of this thematic grouping, four dimensions of capabilities were identified, which do have some overlap between individual capabilities, but in themselves present distinct dimensions of teachers' valued capabilities.

These four dimensions of capabilities—alternatively also referred to as dimensions of opportunities (Sen 1999; Deneulin 2009; Gasper 2007)—present the building blocks of the framework and are presented in four boxes in figure 8.1. In each box, the relevant capabilities are listed with an abbreviation in brackets to ease overview. It is important to keep in mind that these lists of capabilities are not normative and only attempt to reflect the range of capabilities valued and explored by the teachers involved in the ICT4RED. As described above, each capability listed in the boxes was derived inductively from teachers' reported and observed valued functionings.

Figure 8.1 A framework of teachers' use of mobile technologies as an educational tool from a capabilities perspective



The first proposition of the framework is then that the use of mobile technologies to enhance teachers' capabilities to live a life they have reason to value can be understood to comprise four dimensions of capabilities. Each dimension represents a different set of valued opportunities that teachers perceived to result from the application of the tablets in an educational setting.

The second proposition of the framework is that teachers' human development comes as a result of the interplay between these four dimensions of capabilities, not through a pursuit of individual capabilities (see 8.2 for more detail). To illustrate this, human development is placed in the centre of the framework in a circle cross-cutting all four dimensions of capabilities. This circle in the centre represents teachers' conception of a life they reasoned to value.

However, this is not to suggest that there exist a singular formula or configuration of capabilities that reflects and contributes to teachers' human development and well-being. Teachers will vary in their exploration of capabilities as they vary in their conception of the good life and teachers' configurations of capabilities will therefore vary between and within different dimensions of capabilities. To illustrate that this interplay of different dimensions of capabilities is not unidirectional and does not have to involve all four dimensions, the framework indicates four areas of interplay between different sets of two dimensions of capabilities that translate into teachers' well-being and human development. These are positioned between the four boxes and indicated with arrows. For instance, combining their educational and societal capabilities, teachers were able to explore alternative ways to conceptualise what being a teacher means, which translated in reported contributions to their human development and well-being. *The emphasis of the framework is therefore firmly on the interplay between capabilities and dimensions of capabilities.*

Lastly, the framework illustrates the centrality of the mobile technologies and the mobile learning programmes in teachers' exploration of the reported capabilities. Each dimension of capabilities is explored by the use of mobile technologies, which is articulated in each of the four boxes clearly. The framework presents a bottom-up view, based on teachers' own perspectives, about what value the educational use of the tablets contributed to their lives. The mobile technology and its educational use as part of the mobile learning programme is therefore informing every single aspect of the framework. That is, each capability presented on the framework, was explored by the teachers through the appropriation of the mobile devices as a tool to explore valued opportunities in line with the teachers' definition of a good life[79]. Mobile technologies and the applied mobile learning programme can therefore best be understood as a resource that contributes to the capabilities; but the use of the technology, or the technology itself, cannot be linked to a single dimension of capabilities. Teachers' use of mobile devices in an educational setting was framed and understood by themselves in multiple dimensions of opportunities and promoted their human development and well-being through a combination of different capabilities—which is illustrated in more detail in section 8.2.

8.1.2 How to interpret and apply the framework

There are a few aspects to consider when interpreting my capabilities framework and how it could be taken forward. First, it is important to reiterate that my identified list of 21 valued capabilities is not a normative framework for the use of mobiles as an educational tool in Low- and Middle-Income Countries (LMICs). That is, it should not be seen as an attempt akin to Nussbaum's version of the CA to develop a normative list of capabilities that all ML4D programmes should strive to attain in order to support human development. The 21 listed capabilities as well as their four corresponding dimensions are a synthesised representation of the rich set of opportunities valued and explored by the 25 teachers in my case study. These capabilities should be seen as descriptive and indicate that these 21 capabilities are important aspects that contribute to teachers' conception of a good life; but they do not claim to represent a conception of the good life itself. The framework can therefore not be used as a tick-box exercise for mobile learning programmes assuming that that the use mobile technologies in an educational setting can only be linked to human development and well-being if all 21 capabilities are enhanced.

Second, and following from this rejection of a normative reading of the list of capabilities, the framework is firmly meant as a descriptive overview of my case study results. The case study's key argument that the interplay between the four dimensions of capabilities allows mobile learning programmes to make a contribution to human development should not be seen a normative attempt to define ML4D either. That is, I am not putting the framework forward as my conceptualisation of ML4D comprised of the four dimensions of capabilities and their interplay. The framework is too bounded by the case study data on which it is based in order to make a universal claim to the applicability of the four dimensions of capabilities as a conceptualisation of ML4D at this stage. Rather, I make a normative case

[79] This is of course not to say that these capabilities can *only* be explored through the use of mobiles. In the context of this research and my findings, however, the capabilities were primarily explored through the use of mobiles, which the framework attempts to capture.

for using the CA as an analytical tool to conceptualise mobile learning's contribution to development, which is outlined in 8.3.

Third, the framework is not an empirical measurement of capabilities or well-being or agency achievement. It should be clear from my methodological set up in chapter 4 that the framework is derived from a qualitative case study that assessed teachers' reported and perceived opportunities following participation in a mobile learning programme. The framework is not a reflection of an impact evaluation of teachers' freedom to achieve well-being and agency or their actual achievement as provided by other capabilities scholars such as Buckler (2015) and Brandolini and D'Alesio (2009); neither does it attempt to rank or weight different capabilities or capability sets in their contribution to human development as for example suggested by Walker (2006).

How should the framework be interpreted and applied then? I would suggest to read the framework in line with Sen's version of the CA, which is much less prescriptive than Nussbaum's version. That is, the developed framework presents an important contribution to the literature on ML4D as it illustrates that the CA can be operationalised to assess the effects of mobile learning programmes in LMICs. Based on this empirical verification of the operationalisation of the CA as well as the conceptual argument for the CA outlined in chapter 2 and 3, I contend that there is a strong normative case for applying the CA to guide a conceptualisation of ML4D. This includes a strong case for the use of the CA as an analytical framework in primary research on ML4D as evidenced in my case study.

In sum, I would position the framework as an open-ended tool to guide empirical and conceptual research on ML4D. It does not present a conceptualisation of ML4D. It does, however, present a structure to unpack mobile learning's contribution to development in terms of four dimensions of capabilities and their interplay in supporting human development and well-being. This investigation is illustrated in detail next.

8.2 Development as freedom and ML4D

Sen's definition of development as freedom repositions development to be evaluated in terms of an expansion of capabilities. This is both the primary end and the principal means of development (Sen 1999). In my framework, the central circle presents enhanced capabilities as an end, whereas the capabilities in the boxes present enhanced capabilities as a means of development. This section is concerned about the interplay between capabilities as a means of development and how this interplay translates into the final outcome of enhanced capabilities as a primary end of development. For ease of discussion, I am referring to the enhancement of capabilities as an end of development as human development or well-being.

In the context of my case study findings, development thus refers to teachers' effective freedom to live a life they have reason to value[80]. This positioning of an expansion of freedom—defined more technically as capabilities—inescapably focuses on individual's—teachers'—agency as a core component of the process of development. Freedom cannot meaningfully be supplied top-down or provided access to; freedom needs to be explored and generated by the teachers themselves to have meaningful value. Capabilities without the agency to explore them in a self-determined manner do not present effective freedoms. Teachers need to be able to conceive their own conception of well-being and human development and then to be able to explore this in a self-determined manner. The argument presented in my case study is that the ML4D programme supported teachers' self-determined exploration of their conception of a good life; if so, we can then speak of mobile learning for development *as freedom*.

To be more precise, this argument can be unpacked further to include my four dimensions of capabilities and the centrality of their interplay. This leads to an expanded conception of mobile learning for development as freedom as: that the ML4D programme supported teachers' self-determined exploration of *four dimensions of valued capabilities whose interplay enhances teachers' reported human development and well-being*. This expansion seems necessary to highlight the four dimensions of capabilities and their interplay which are a unique result of the particular nature of ML4D interventions. While I by no means claim that any of the identified capabilities can only be enhanced through ML4D interventions, their simultaneous exploration is a key contribution of ML4D programmes. It is precisely this simultaneous exploration which can bring about teachers' human development and well-

[80] Note that this definition differs from most definitions of development in the wider ML4D literature.

being and the facilitated interplay between different dimensions of capabilities therefore constitutes ML4D's specific contribution.

I next attempt to unpack this abstract discussion of the need to focus on the interplay of dimensions of capabilities with two practical examples from the ICT4RED case study.

My argument that to frame teachers' well-being and human development in terms of only a single capability dimension (or single capability) would be overly narrow and neglect the diverse ways in which teachers appropriate their usage of the technology to foster their agency and well-being is illustrated in the response of a primary teacher (Day 5):

> 'I like imparting knowledge to learners. Besides, I am a parent to them. I value it and it doesn't end in the classroom. Even after they go to high school and tertiary you wonder how they did in life? For example, I didn't do some subjects in high school I wanted to do; I couldn't do BCom as it was those days [Apartheid]. But when I taught BCom for the first time, I felt like I was fulfilling my past dream and the tablets gave me the access to the content so I can get more information. Now my first group of learners is at university level and they do BCom accounting and economics at the university in Cape Town. So, I am so proud of that and I always check their progress using my tablet through WhatsApp and Facebook.'

In this excerpt it is evident how the teacher constructed her professional and social identity in multiple and overlapping ways (being a teacher and being a parent) and how she navigated the newly gained capabilities from using the tablets to pursue what she defined as valued beings and doings. This teacher has discovered that the use of the tablet supports her with a valued opportunity that she was denied by institutional discrimination during Apartheid. In a literal sense, she did not have the freedom to study for a BCom, but during the ICT4RED programme explored whether the tablet could support her to start teaching her own pupils in the subjects that she was denied. This valued educational capability then is further enhanced by the informational capabilities of remaining connected with her pupils throughout their tertiary careers. The appropriation of the technology to pursue multiple dimensions of capabilities has provided this teacher with the agency and capability to transform her educational and social reality in line with her own definition of freedom.

This exploration of capabilities linked to past unfreedoms was a rich theme in collected data. Without leading too much on numerical frequencies, 11 out of 25 teachers made this reference. Teachers explained how they could not study for certain subjects or pursue certain professions because of growing up under the Apartheid regime. They appropriated the use of tablets to explore whether they could now address some of these past unfreedoms by providing their learners with the opportunities denied to themselves. To recall, supporting their learners' academic and professional success was a core capability and part of teachers' professional identity. Being able to apply the tablets, for example through accessing content and lesson plans linked to subjects they had not been formally trained to teach, enhanced this valued capability and through merging it with the pursuit of an opportunity denied to themselves became a major source of well-being and human development. The value teachers attached to this pursuit is evident in their subsequent efforts to stay in touch with and to continue support their learners, a capability that again is supported by the use of tablets.

A second illustration of this concept of addressing unfreedoms or barriers to their human development, emerged in relation to rural education. Teachers illustrated how the rural areas in which they taught were systematically excluded during Apartheid and how rural education was still perceived as inferior to urban education. The provision of 'modern' mobile technologies in a rural education context was in stark contrast to general perceptions of rural education with one teacher expressing a common sentiment in a focus group of: "we were thinking we are not supposed to get this technology and do this [teaching with technology]. It is something we have been crying for." (Focus group; day 8)

Teachers, in particular younger ones, explained how they had a strong interest in technology in general, but that neither the social or professional context in which they operated provided them with an opportunity to explore their interest in technology. This narrative of not having had the freedom to explore technology was then transformed as part of the ICT4RED into a configuration of valued opportunities such as 'ICT usage', 'Innovation', 'Self-actualisation', and 'Marketing'. Taken together, this configuration of capabilities and the agency to explore them, in the context of past deprivation and structural discrimination, presented a major avenue to teachers' well-being and human development. This notion is summarised in a teacher's own words as:

> "It [ICT4RED] has changed me, I have changed. I have always been interested in technology and now it has changed my life. Even at home when my children ask me something unpleasant, I just google it and now they say how come you've been so advanced? I have grown. It has made a difference in my life. Firstly, I'm computer literate now. Secondly, it supplements my teaching methods. It is also my office. It gives me the option to teach, I can either use that or not use it." (Primary teacher; day 9)

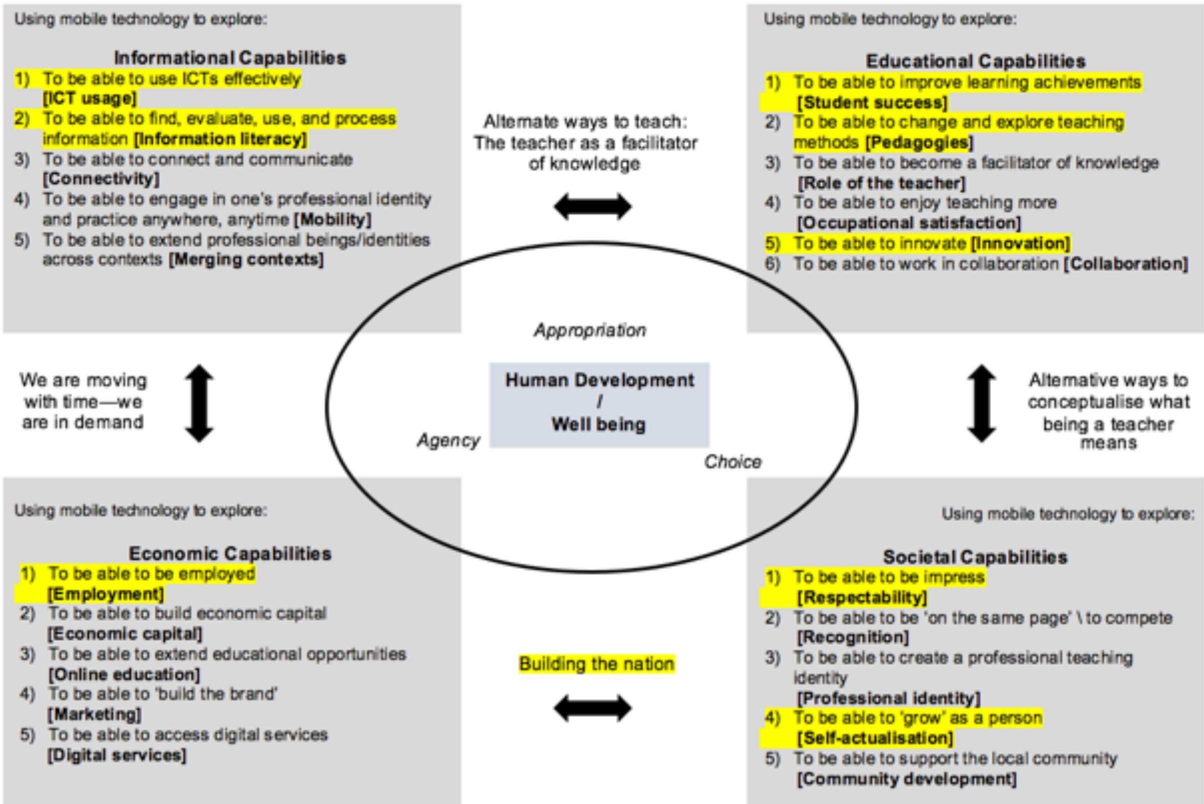
To conclude, to pursue their own conception of a live a life they valued teachers explored the use of tablets to support a configuration of overlapping dimensions of capabilities. In this process, they appropriated the technology to explore valued beings and doings not directly related to the intended ICT4RED programme design, and closer related to addressing past and current unfreedoms. It is this agency or ability to choose a life one has reason to value rather than following an exogenous or predefined notion of the good life that constituted a major source of well-being and development. Adapting Kleine's (2013) question of 'technologies of choice?', this then opens the question of whether tablets can be regarded in this ML4D programme as a 'technologies of freedom'? I will return to this question at the end of this chapter in section 8.3 when I have presented a more diverse set of configurations of dimensions of capabilities that teachers explored to further their well-being and human development. In this remit, I next present three brief vignettes capturing a diverse set of these capability configurations[81].

[81] Note that figure 8.1 presents four vignettes. The fourth vignette, 'alternate ways to teach: the teacher as a facilitator of knowledge' is discussed in chapter 9, section 9.3.2.

8.2.1 Vignette: Building the nation

> "As a teacher you are like a leader, you are a role model. If you see the child doing well you get this patriotic feeling because you are building the nation. The teacher is a builder of the nation and the tablets have helped me a lot to build the nation." (High school teacher; day 13).

Figure 8.2 Capabilities configuration for 'building the nation'



A key configuration of the dimensions of capabilities referred to teachers' appropriation of tablets to pursue their objective of 'building the nation' (Figure 8.2). Building the nation expresses a narrative generated by South Africa's ruling party after leading the country through a peaceful transition from apartheid dictatorship to democracy, and calls on teachers to educate the first generation of 'born-free' South Africans (Motala et al 2012; SADTU 1996). Teachers' professional mandate is since framed at delivering high-quality education to contribute to the nation's socio-economic development. It presents their professional contribution to society.

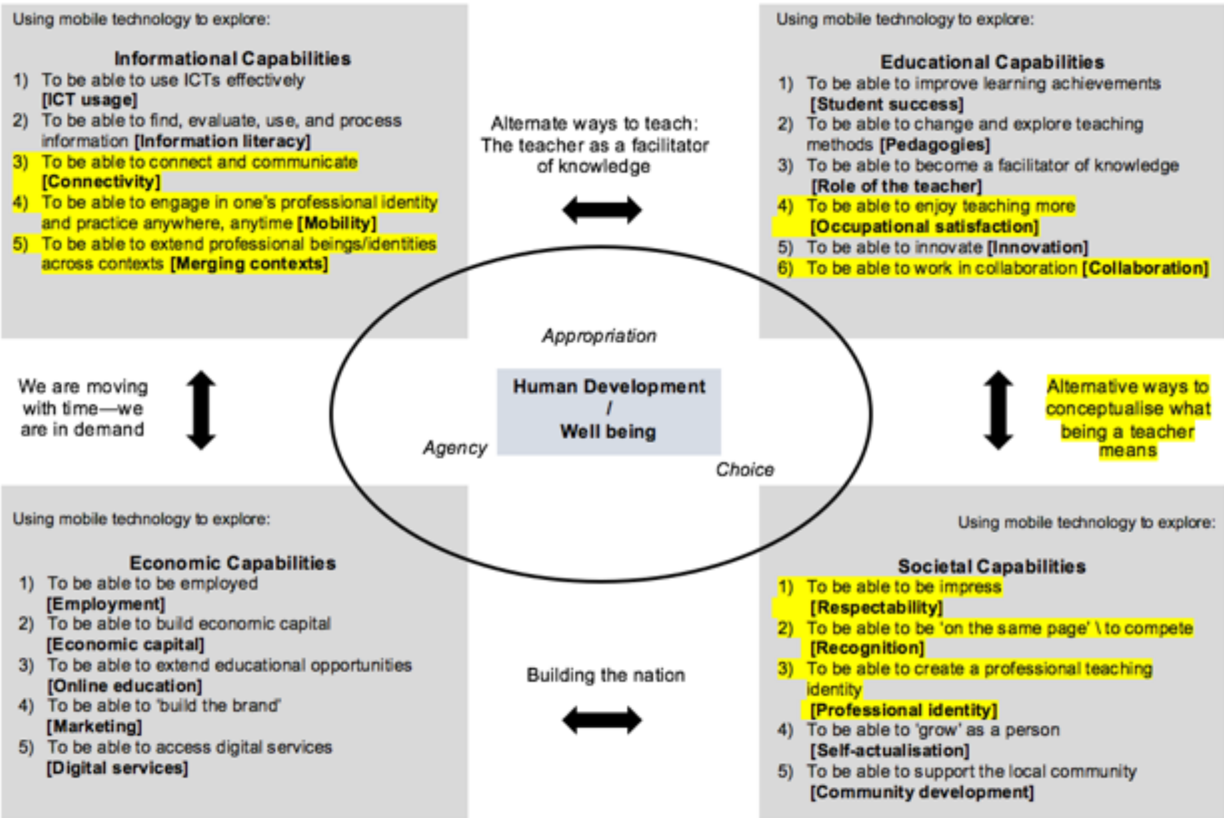
The teachers interviewed were highly supportive of their role in building the nation and flourishing in this role was reported as a major component of their professional identity as teachers and the life they valued. Teachers derived professional and social well-being from being able to contribute to building the nation. As a result, teachers actively arranged the capabilities derived from using the tablets to shape their contribution towards building the nation. Figure 8.2 provides an example of a capabilities configuration to pursue teachers' goal of building the nation: The capabilities of being able to use mobile technologies and to gain access to more information (informational capabilities) contributed to teacher' educational opportunities. Being able to integrate mobile devices and the enhanced access to information into their teaching efforts gave teachers additional opportunities to support learners through more diverse and innovate teaching methods (educational capabilities). Being able to help learners achieve in return supported teachers' social capabilities as they felt they were fulfilling their destined role of building the nation and thus earned enhanced status and recognition in society. It lastly also supported their economic opportunities vested in the assumption that the school and the teachers would be rewarded for contributing so effectively towards national development.

This short vignette illustrates how teachers applied and appropriated the mobile technologies in a self-determined matter to pursue their personal objective of contributing towards the building of the nation. Building the nation was a core component of the life they had reasoned to value and the teachers configured overlapping dimensions of capabilities in order to be able to pursue this source of well-being and human development.

8.2.2 Vignette: Alternative ways to conceptualise what being a teacher means

> "We are more respected. We knew all about laptops and tablets of other office people, so now we have them too. It [tablet] promotes the standard of teaching, even children now want to be teachers. They see that teachers are acknowledged and advanced." (High school teacher; day 12).

Figure 8.3 Capabilities configuration for 'alternative ways to conceptualise what being a teacher means'



A second way in which teachers arranged different dimensions of capabilities to enhance their well-being and human development was to pursue the exploration of an alternative and more positive professional identity (Figure 8.3). The need for this professional identity arose in the context of low public perceptions of the teaching profession as well as government and media criticisms paired with challenging working conditions and modest salaries (Motala et al 2012; Booyse et al 2011). The construction of this professional identity encompassed a range of different capabilities, an example of which is provided in figure 8.3. To start with, teachers reported how their use of tablets as educational tools facilitated a more enjoyable teaching experience. For example, the use of tablets eased some administrative burdens and allowed teachers to apply strategies that made it easier to control the classroom. A second valued educational and informational capability supporting increased occupational well-being related to the use of tablets to connect and collaborate, leading to less isolating teaching experiences.

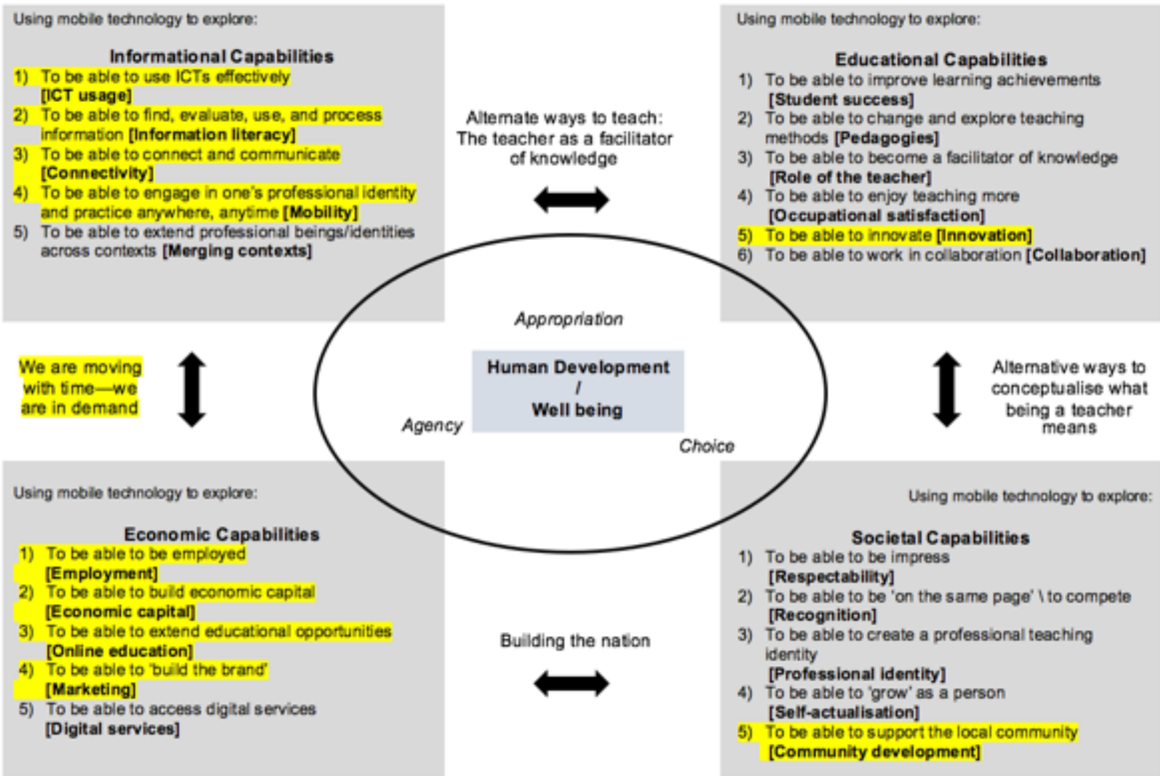
This increased perception of a more enjoyable teaching experience then was complemented by a change in outside perceptions of the teaching profession too. Societal capabilities such as recognition and respectability explained how teachers' status within the local community and within schools themselves had increased due to the mastery of tablets as an educational tool. But, a key in the configuration of these capabilities to support teachers' construction of a professional identity to further their well-being was the capability to merge this identity across contexts. That is, the tablets' technological affordances allowed teachers to transfer and apply their professional identity in social contexts. For example, teachers used the tablets to showcase their technological and educational skills at social events in order enhance their standing within communities. Likewise, teachers transferred their social identities to the classroom by showcasing to their colleagues and pupils important social achievements, such as leading the community prayer. As a result, teachers could merge in and out of their preferred identities in changing contexts.

In sum, teacher appropriated the use of the tablets to explore a range of capabilities linked to their own construction of an alternative and more positive professional identity. These capabilities allowed them to feel more valued in their profession and to practice teaching in a proud and confident manner, which then was transferred across contexts to support both their social and professional well-being.

8.2.3 Vignette: We are moving with time—we are in demand

> “A perfect teacher is one that is not left behind by time. If you don't know technology you know nothing currently. Because we are now living in an advanced technological world whereby you don't even have to go to the bank to queue. Being a mobile teacher gives me more choices where to work and how to work.” (Primary teacher; day 6).

Figure 8.4 Capabilities configuration for ‘we are moving with time—we are in demand’



A third configuration of different dimensions of capabilities that allowed teachers to pursue a life they had reasoned to value referred to teachers’ objective of being able to fully participate in the ‘modern’ society and economy (Figure 8.4). Teachers applied the tablets to explore a range of opportunities mitigating their perceived fear of being left behind by time. This fear was a major component of perceived unfreedoms and reinforced by the rural education context in which the teachers operated. As a result, the teachers directly applied the tablets to explore a range of functionings to stay up-to-date. This referred initially mainly to informational capabilities such information literacy and ICT usage, which were valued intrinsically as teachers assumed that they presented the required key capabilities in the 21st century.

However, teachers then integrated these informational capabilities into their educational and economic capabilities to enhance their agency to mitigate the fear of being left behind by time. Being a teacher of time who masters and integrates mobile technologies in her teaching strategies became an integral part of teachers' professional objectives. This valued educational opportunity then further translated into economic capabilities since, as a teacher of time, it would be easier to secure new and current employment opportunities. Instead of being left behind, teachers perceived the opportunity to be able to move with time and benefit professionally from possessing the ICT skills that were in demand. Further configurations included using the informational capabilities to enhance one's own educational efforts through distance learning and thereby progression in the teaching career; or, alternatively, to use one's informational capabilities to share access to economic opportunities to thereby support societal capabilities such as community development.

This last vignette again illustrated the intersectional nature of the dimensions of capabilities. Teachers' human development and well-being did not result from the mere possession of informational capabilities or the ability to integrate technology into their teaching activities. It resulted from the opportunities that these configurations of capabilities created in their self-determined pursuit of a good life—in this case the agency to not be excluded from the 'modern' society and economy and to be able to fully participate in the professional chances and choices associated with both.

8.3 Towards a capabilities conception of ML4D

My case study of the ICT4RED programme outlines teachers' use of mobile technologies as an educational tool from a capabilities perspective. It attempted to test the feasibility of the CA to assess and unpack the effects of an ML4D intervention. In this section I will move beyond the insights gained grounded in the case study data and explore the implications of my case study findings for a wider conceptualisation of ML4D using the CA as relevant theoretical foundation. That is, I am aiming to use my case study results to develop a capabilities conception of ML4D.

My case study research provided an empirical grounding for the feasibility of the CA as a conceptual lens to unpack the effects of ML4D interventions. It illustrated how teachers' own experiences of using tablets as an educational tool as part of a mobile learning programme in rural South Africa could be framed and analysed using the CA. This analysis led to the identification of 21 valued capabilities that teachers explored through the use of tablets in a rural educational setting. The CA therefore served as an effective conceptual framework to investigate the links between the use of mobile technologies, education, and development in LMICs.

Following the successful application of the CA as an analytical tool, I then expanded on my case study data to unpack how the identified capabilities could be understood in relation to Sen's notion of development as freedom—the final outcome of development in a capabilities conception of ML4D. In this, I make two propositions: (1) that the use of mobile technologies to enhance teachers' capabilities to live a life they have reason to value can be understood to comprise four dimensions of capabilities; and (2) that teachers' well-being and human development comes as a result of the interplay between these four dimensions of capabilities, not through a pursuit of individual capabilities. In a last step, I merge these two propositions with the CA's emphasis on individuals as active agents to control and determine the conception of what constitutes relevant freedoms and a live they have reason to value. This investigation leads me to conclude that, in the context of my case study, ML4D can be conceptualised from the capabilities perspective as: the use of mobile technologies as an educational tool to support teachers' self-determined exploration of four dimensions of valued capabilities whose interplay enhances teachers' reported human development and well-being.

However, there are a few obstacles in this capabilities conception of ML4D that negate its application beyond the particular context of my case study. First, the developed list of valued functionings, corresponding capabilities, and subsequent dimensions of capabilities is based on data collected in one particular context. The context of the nature of the ICT4RED programme as a ML4D intervention as well as the particular nature of the South African education system bound the transferability of my developed capabilities framework and the conception of ML4D derived of it. It is crucial to highlight that the developed framework does not claim to provide an exhaustive list of capabilities that constitute an effective application of mobile technologies as an educational tool in LIMCs. It since should not be confused with an attempt to develop a list of essential capabilities as proposed by Nussbaum (2011). I agree with Sen's (2009) position that while a normative focus on capabilities and functionings to conceptualise development processes and outcomes is justified, a normative prescription of specific important, arguably even universal, capabilities can only be developed on a case to case basis. As a result, I am reluctant to position my four dimensions of capabilities and their interplay as a necessary component of a general CA conception of ML4D.

Second, and linked to the first line of critique, the developed capabilities conception is linked to teachers' use of mobile technologies. Any broader conception of ML4D needs to apply a more inclusive focus, which is likely to change the composition of capabilities identified. I therefore require a conception that can accommodate all educational agents and processes, not just teachers and the integration of mobiles into teaching activities. Third, to serve as a more general conception of ML4D, I require a more open-ended formulation of the outcomes and processes associated with ML4D. The developed conception is fairly prescriptive in terms of dimensions of capabilities and the need to focus primarily on the result of their interplay. This limits the conception's application to different ML4D programmes that use technologies in different ways and for different purposes.

Taking into consideration the above caveats, I reformulate my conception of ML4D from a capabilities perspective as:

> *the use of mobile technologies to support an endogenous transformation of education in LMICs anchored in the primary objective of enhancing the capabilities and agency of educational agents.*

In this conception, I retain the focus on an expansion of valued beings and doings as the space in which the effects of ML4D programmes should be assessed, but exchange the prescriptive nature of my case study-bounded conception with a more open-ended understanding of 'enhancing the capabilities and agency of educational agents'. This sequence likewise drops a focus on teachers in favour of a more inclusive focus on any educational agent (learners, teachers, parents, school administrators, etc.). In addition, my proposed definition introduces a focus on the use of mobiles to support ‘an endogenous transformation of education in LMICs’. This sequence aims to introduce an indication of the nature and scale of the educational changes and contribution that one might expect of ML4D. The rationale for this addition links directly to the discussion started above on whether to position ML4D and the use of mobiles as: ‘technologies of freedom’.

To recap, in section 8.2 I introduced the notion that if the use of mobile devices supported teachers to advance their effective freedoms including the removal of key unfreedoms, then tablets might be regarded as ‘technologies of freedom’. This expression presents an adaptation of Dorothea Kleine’s concept of ‘technologies of choice’ in the ICT4D sector. Adopting this expression would indicate a positioning of ML4D and its potential contribution to education and development in a grander sense than my current expression of being able to support an endogenous transformation of education in LMICs. Surely, if ML4D were to be positioned in line with an idea of ‘technologies of freedom’, the suggested nature and scale of the educational changes and ML4D contribution to it as an endogenous transformation seems modest.

The concept of ‘technologies of freedom’ was introduced by Sen (2010: 4) in reference to mobile phones, which he positioned as “generally freedom-enhancing”. It assumes that technologies and their affordances support inherently freedom-enhancing usages due to the vast range of opportunity sets they allow users to explore. Notwithstanding, I would propose a more cautious and modest interpretation based on two shortcomings of this line of argument given the data collected in my case study. First, if I equate freedom with choice as Kleine suggest, tablets as part of ML4D intervention did enhance teachers’ perceived choices in line with four dimensions of valued opportunities. However, neither of these four dimensions in themselves nor the configuration of them is dependent on the actual use of technologies. Take the educational and societal capabilities as an example: it seems challenging to argue that most of these capabilities require a technological input for teachers to explore them. Educational and societal capabilities were an integral part of teachers’ freedom to live a life they have reason to value; technologies, on the other hand, were but one tool to support these capabilities. It therefore seems as an overreach to claim that the tablets can be positioned as inherently freedom-enhancing. Their main contribution seems to lie in the simultaneous support to multiple dimensions of opportunities.

Second, one could argue that by directly addressing past unfreedoms (e.g. providing what teachers have been denied under Apartheid), technologies become a tool of freedom. However, this overlooks the importance of the choice of teachers to use the tablets in this manner. Applying the tablets to explore capabilities linked to the rectification of past discrimination was one configuration of capabilities; and, albeit being a powerful configuration, remains one of many options of how teachers appropriated the use of the technologies. It does not seem warranted to equate tablets with constituting a technology of freedom only because of this being one of the identified appropriations. For some teachers, the main valued beings and doings derived from the use of tablets were the enhanced ability to control the classroom and that they had to carry less text-books on their daily commutes. There was rich evidence in my case study data that tablets can be positioned as freedom-enhancing in certain contexts, but to generally position them in this matter seems too 'grande' a positioning based on the evidence that I have presented and formalised in my case study.

While the above discussion seems to be able to refute a positioning of the nature and scale of the educational changes induced by ML4D in line with the conception of 'technologies of freedom', it does not explain my adoption of a positioning of the nature and scale of the educational changes induced by ML4D as to present an endogenous transformation. The term endogenous transformation attempts to capture the locus and space of the educational change (i.e. endogenous) and the nature and scale of the change (i.e. transformation).

In the CA, there is no formal conception of the term transformation and it does not present one of the CA's analytical devices as functionings or effective freedoms do. However, the CA does require an in-depth analysis of how access to and use of mobile technologies leads to changes in individual's valued beings and doings. This analytical technique of the CA necessary sensitises and forces one to focus on the transformative effect that using technologies as part of the ML4D programme has on individuals as the initial unit of analysis[82]. In an CA analysis of ML4D programme the starting point is thus very likely to be how individual technology users can appropriate the mobile devices in order to align technology's affordances with users' pursuit of the life that they had reasoned to value. There then should be little contestation for my adoption of the term 'endogenous' to represent that the locus of change is likely to be within and aligned to existing conceptions of the good life, most likely those of individuals.

[82] For a full discussion on designing a systematic in-depth investigation of individual's technology usage applying the CA to focus on transformational effects, I refer to Kleine (2013) chapter 2 and 7.

However, the alignment of technology usage to pursue the life one has reasoned to value then can take multiple forms. In my case study research, this alignment let to a series of small steps, first developing individual capabilities to then leading to a configuration of different dimensions of capabilities, whose interplay finally contributed to teachers' human development and well-being. The observed nature of change in my research did not work through the exploration of one central or uber capability associated with an inherent affordance of the technologies, for example being ICT literate or being connected, which then led to an unlocking of teachers' effective freedoms and path to explore their conception of a good life. Such a linear link between a capability inherent to the technological device and expansions in technology users' real freedoms could rightfully be positioned as a notion of 'technologies of freedom'. Rather, I observed a careful configuration of capabilities, which, according to teachers' preferences and contexts, allowed them to step-wise develop agency to move closer to their conception of a good life. It is this process that I attempt to capture under the term 'transformation' and it represents a type of educational change that works largely through changing educational agents from within in a process of small steps informed by the objective of enhancing the capabilities and agency of agents at each step. It is important to note though that this distinction between the nature and scale of the educational change induced by the ML4D intervention and my preference to describe this change in the language of an endogenous transformation, at this point, is not normative but a reflection of my case study data.

Conclusion

To conclude, I retain my proposed capabilities conception of ML4D as: the use of mobile technologies to support an endogenous transformation of education in LMICs anchored in the primary objective of enhancing the capabilities and agency of educational agents. This conception defines the space in which the effects of ML4D interventions should be assessed as the valued beings and doings and corresponding capabilities of educational agents. It defines ML4D's contribution to education and development as to foster an endogenous transformation located within educational agents and structures based on their self-determined exploration of beings and doings aligned to their conception of a live they reasoned to value.

In my case study, I illustrate one practical manifestation of this specific contribution of ML4D to education and development. Based on the ICT4RED programme as an example of a ML4D intervention in a rural education context, I showcase how the specific properties of a ML4D programme allowed for a simultaneous exploration of four dimensions of capabilities. This simultaneous exploration and the facilitated interplay between different dimensions of capabilities, which brought about teachers' human development and well-being, therefore constituted ML4D's specific contribution. However, for a range of reasons, I shun away from positioning this case study-bound conception of ML4D as a general framework for ML4D. Though, I would argue that the developed four notions of informational, educational, societal, and economic capabilities probably do have a wider application in investigating the transformational potential of mobile technologies as an educational tool in LMICs. But, at this point, and given the empirical data presented, a prescription of these four dimensions of capabilities and how their interplay supports human development and well-being seems premature.

In this chapter, I have developed a capabilities conception of ML4D. However, I have not discussed the implications of this conception for the positioning of ML4D in the wider discourse on mobile technologies, education, and development. If the potential of the educational application of mobile technologies in LMICs can be expressed in terms of a transformative expansion of human capabilities and agency of educational agents, as argued here, this claim needs to be juxtaposed and contextualised with existing discourses on ML4D. It is not sufficient to define the specific contribution of mobile learning to international development through the CA without comparing this perspective against existing definitions such as framing its contribution in terms of human capital expansions. These discussions are provided in the next chapter in which I attempt to investigate the implications of my capabilities conception of ML4D in order to guide a rethink of the positioning of ML4D.

Chapter 9. Rethinking ML4D—positioning mobile learning in international development

Introduction

This chapter presents my alternative conception of using mobile technologies as an educational tool in Low- and Middle-Income Countries (LMICs). It combines my capabilities conception of Mobile Learning for Development (ML4D) with the findings of the mixed-methods systematic review in order to position mobile learning's role in international development. In this, it discusses my capabilities conception of ML4D in the light of the available evidence-base on the use of mobiles to support education and development in LMICs in order to investigate gaps and overlaps between both. I then juxtapose the capabilities conceptualisation of ML4D with existing conceptualisations of mobile learning in international development. This aims to show how the developed conception differs from existing understandings of ML4D and why I assume that a capabilities conception allows for stronger links between the educational use of mobile devices in LMICs and development outcomes. This justification directly answers the thesis's main research question of how the use of mobile technologies as an educational tool in LMICs can be conceptualised as a development intervention.

This chapter is structured as follows. I first provide a discussion of my capabilities conception of ML4D in the context of the mixed-methods review findings. This illustrates whether my proposed conception can be reconciled with the implications of the systematic review findings, in particular with the developed theory of change for ML4D. Having done so, I then proceed to compare my conception of ML4D against existing understandings of mobile learning in international development. This presents my rethink and positioning of ML4D. In the remainder of the chapter I then elaborate on the overlap and contrast of my capabilities conception of ML4D with a wider body of literature. This discussion aims to explore the periphery of the thesis's argument and to place boundaries around its contribution to the literature.

9.1 Comparing the capabilities conception of ML4D with my systematic review findings

In chapter 6, I argued that the main contribution of my systematic review findings is to empirically set up the need for an alternative conception of ML4D. By establishing that the synthesised evidence-base on the effects of using mobile technologies to support education and development in LMICs does reject the positioning of mobile learning as a development intervention, the systemic review provides my empirical justification for the exploration of an alternative conception and positioning of ML4D. However, it would seem hypocritical to not subject my own proposed capabilities conception of ML4D to the same scrutiny of the available evidence-base. That is, if I use my systematic review findings to challenge a techno-centric conception of ML4D and refute its claims to disruptive and large-scale impacts on education and development, my own conception needs to be contextualised in the light of my systematic review findings too. I therefore first elaborate on to what extent my capabilities conception is reflected in the systematic review findings.

To recall, in the previous chapter I positioned mobile learning's contribution to development as:

> *the support of an endogenous transformation of education in LMICs anchored in the primary objective of enhancing the capabilities and agency of actors in the education system.*

This definition was derived from my qualitative case study and the developed capabilities framework featuring four dimensions of capabilities that reflected teachers' valued opportunities, explored through the educational use of mobile technologies. These dimensions referred to informational, educational, economic, and societal capabilities and reflected 21 individual capabilities. In my systematic review, I first conducted a statistical meta-analysis of the effects of using mobiles to support education in LMICs, which found mobile learning interventions to have a significant effect only on learning outcomes. With regard to my meta-analysis findings, I cannot provide an empirical assessment of ML4D interventions that apply an intervention design inspired by the Capability Approach (CA) as compared to intervention that apply, say, a techno-centric design. There were no CA-inspired ML4D interventions identified in systematic search for evidence. I can therefore not comment on whether a capabilities conception of ML4D would lead to more effective mobile learning programmes. This is a question that requires further primary research first.

With regard to the thematic synthesis findings, there is a strong overlap between dimensions of capabilities as well as individual capabilities represented in the case study framework and the mechanisms and contexts identified in the systematic review. For example, the mechanisms of 'changing pedagogy and practice' and 'teaching practice' directly relate to valued educational capabilities reported by the teachers involved in the Information Communication and Technology for Rural Education Development (ICT4RED) programme. Contextual themes such as 'technology as a social and professional status symbol' and 'positive perceptions' are also reflected in valued informational and societal capabilities identified in the case study. There is a particularly strong overlap between the mechanism themes of 'social capital', 'economic capital', and 'self-efficacy' and valued societal and economic capabilities. However, this overlap cannot be assumed to be a validation of my capabilities conception of ML4D. Rather, it presents a validation of my primary research findings indicating that a range of themes discovered overlap with findings of teachers' use of mobile technologies reported in the wider literature.

Once I turn to my combined systematic review findings and the developed theory of change for the use of mobiles to support education in LMICs, the overlap between a capabilities conception of ML4D and the systematic review becomes stronger. In chapter 7, section 7.1, I outlined a range of potential overlaps, which I can now flesh out with empirical data from my case study research. First, I argued that the observed lack of effects on development outcomes might be explained by a too narrow framing of development outcomes and pathways to such outcomes in terms of human capital. The vast majority of ML4D interventions conceptualised pathways to development through an increase in skills and human capital. Based on my capabilities framework, I can now offer a concrete expansion to this narrow conception, positioning my four dimensions of capabilities as additional components of individual's well-being and agency. These four dimensions of capabilities could thus be integrated into the theory of change spanning the pathway between final outcomes and impacts. This would allow, for example, a greater emphasis on teachers' professional well-being as an outcome of development. It could also facilitate the introduction of agency and control over one's life as an outcome and driver of development, which is currently only partially referenced under the mechanism of 'self-efficacy'. In sum, the introduction of my four dimensions of capabilities into my theory of change could significantly alter its design highlighting a richer and more complex set of pathways to human development.

With regard to my second line of argument based on the review finding that mobile learning's positioning as a development intervention is held back by a reproduction of structural inequalities, the developed capabilities conception of ML4D makes explicit provision for this. By arguing for an emphasis on anchoring ML4D programmes in the primary objective of enhancing the capabilities and agency of educational agents, the focus of the programme design and theory of change should shift towards the effective opportunities that learners and teachers can generate of the technological inputs. This would lead to the introduction of conversion factors as part of the theory of change, which could be expressed as either mechanisms or contexts. It would likewise shift the focus of the programme design towards more participatory and people-focused approaches as programme objectives would have to be aligned with people's reasoned choice of how to integrate the use of mobiles into their pursuit of valued beings and doings. Taken together, adopting the proposed capabilities conception of ML4D would force the theory of change to introduce conversion factors and agency and choice in addition to the current components. This would be enhanced with the above introduction of the four dimensions of capabilities leading towards a programmatic outline of ML4D interventions that seems to offer a more relevant representation of the links between mobile technologies, education, and development in LMICs.

All in all, I therefore conclude that the capabilities conception of ML4D can indeed be reconciled with the findings from the mixed-methods systematic review. Introducing a capabilities perspective to the review findings, the developed theory of change in particular, seems to be able to address some of the shortcomings in the existing ML4D intervention designs that were identified as barriers to mobile learning's contribution to development outcomes. Having reconciled my capabilities conception of ML4D with the systematic review findings, I next discuss the implications of this conceptualisation of ML4D for the existing positioning of the role of mobile learning in international development.

9.2 Finding a space for mobile learning in international development

In chapter 2, section 2.2–2.3, I outlined the existing conceptualisation of mobile learning's role and contribution in international development as well as three key critiques of this conceptualisation. I then conducted a mixed-methods systematic review in order to assess the empirical validity of the claimed contribution of mobile learning to education and development in LMICs. My review finds that claims of ML4D's effectiveness and potential to support development in LMICs are based on simple causalities rather than reliable systematic evidence. What is more, the magnitude of claims to mobile learning's large impact on education and development in LMICs seems to be subject to a displacement of scope (Wagner 1962), i.e. that the claims made about ML4D are out of perspective with what could possibly be achieved. This raises doubts whether proponents of ML4D at a development policy level have thoroughly conceptualised how the use of mobile devices is believed to support education and development in LMICs. I find that on closer examination techno-centric and access- or input-based conceptions of ML4D run the risk of justifying the creation of separate educational structures circumventing, rather than supporting, the existing educational structures. In sum, I conclude that existing conceptualisations of ML4D fail to make a convincing conceptual and empirical link between teaching and learning with mobiles in LMICs, increased education outcomes, and enhanced livelihoods and socio-economic development.

Based on my rejection of existing positionings of mobile learning's role and space in international development, I then develop a capabilities conception of ML4D based on the qualitative case study of the ICT4RED programme. This capabilities conception provides an alternative perspective on how the use of mobile technologies as an educational tool in LMICs can be conceptualised as a development intervention. I argue that conceptualising ML4D through the CA supports a focus on an endogenous transformation of education in LMICs anchored in the primary objective of enhancing the capabilities and agency of actors in the education system. In the absence of evidence supporting mobile learning's impact on development outcomes, a focus on the role of mobile technologies to expand teachers' and learners' valued functionings and capabilities presents an alternative conception of the links between mobile technologies, their use for educational purposes in LMICs, and development outcomes. This understanding and positioning of mobile learning in international development differs from existing conceptualisations by shifting the focus of mobile learning interventions away from access to technologies and content provision towards four different foci of interest: (1) an opportunity focus; (2) a people focus; (3) an education focus; and (4) a transformation focus. I discuss each briefly below.

9.2.1 Opportunity-focused ML4D

In a capabilities conception of ML4D, the effective freedom or opportunity of actors in the education system to achieve agency and well-being becomes the central objective of using mobile technologies. This presents a shift from a techno-centric positioning of technology provision and access to technology and content as the main objective of ML4D interventions. Rather than assuming that a mobile phone presents a 'teacher in the pocket' or that all what learners in LMICs are lacking is a 'classroom in a box', my CA conception of ML4D focuses on the valued opportunities of teachers and learners in their educational context. That is, it neither focuses on access to technology nor on predefined instrumental uses of technologies, but aims to explore what effective freedoms teachers and learners would like to explore and how the use of technologies can be integrated in their exploration of these opportunities. Such an opportunity-focused objective of ML4D then requires an explicit design of mobile learning programmes to address this objective. An example of such an opportunity-focused design could relate to a closer integration of mobile learning with critical theories such as Freire's Pedagogy of the Oppressed (Freire 1972).

An opportunity-focused understanding of ML4D also shifts the focus of mobile learning programmes away from reductionist notions of the processes and outcomes of both education and development. In existing conceptions, the use of mobile technologies in education is overly framed in an instrumental fashion (Winters et al 2017) focusing on increases in skills and human capital. These are then linked to development outcomes, which are largely defined as finding employment and increasing productivity. A capabilities conception of ML4D enhances these objectives of using mobile technologies in education in LMICs, for example highlighting the intrinsic value of education in supporting learners' and teachers' agency to take control over their lives. Development is understood as an expansion of people's freedoms, which does include economic freedoms such as being able to find decent employment and to make a productive contribution to society, but goes beyond these economic capabilities to include a richer and more diverse understandings of valued beings and doings. These richer and more diverse freedoms, for example, could relate to the four dimensions of valued opportunities presented in my capabilities framework.

9.2.2 People-focused ML4D

A second shift in ML4D's positioning in international development supported by a capabilities conception is an increased focus on educational actors, teachers and learners in particular, as the key agents in mobile learning programmes. The CA stresses that people are at the centre of any development effort and cannot be regarded as passive recipients of "the fruits of cunning development programs" (Sen 1999: 53). People need to be in control of the pursuit of their valued beings and doings and need to have the ability to define their own conception of a live they have reason to value. Mobile learning programs then assume developmental potential by people's active and deliberate appropriation and integration of the educational use of technologies in their pursuit of valued being and doings. In short, it is people's own choices and aspirations that determine mobile learning's contribution to development. This understanding seems to be at odds with top-down conceptions of ML4D such as provided by UNESCO and the GSMA in which the contribution of mobile learning to development is already predefined (in relation to the former MDGs and EFA targets in UNESCO's case, and in relation to disrupting education in LMICs in GSMA's case).

From a programme design perspective, it is equally crucial to apply a people-focused lens to ML4D interventions. The CA highlights the need to take into consideration a range of conversion factors that individuals possess when translating access to inputs, such as mobile devices, into capabilities in order to achieve well-being. This is particular important in the context of learning and teaching with mobiles in LMICs as the conversion factors of educational actors and thus their ability to transform access to mobiles into effective opportunities will vary greatly. For example, a girl learner in a society with patriarchal norms will have a different ability to explore learning across contexts as a girl learner in an affluent urban environment with more egalitarian gender norms. Applying a participatory, people-focused approach to the design of ML4D programmes is therefore a key implication of a CA conception of mobile learning's role in international development. Such a people-focused approach could then be able to counter ML4D's existing risk of reproducing structural inequalities as it requires a focus on the diversity of people's abilities to translate access to technological inputs into effective opportunities. This also allows for a greater integration of teachers into mobile learning programmes, who often are bypassed and marginalised in current programme designs (c.f. Winters 2015).

9.2.3 Education-focused ML4D

An implication of the above two shifts in the positioning of mobile learning's role in international development is further that the contribution of mobile learning has to be framed more strongly in educational terms. That is, the contribution that mobile technologies make requires a stronger pedagogical grounding. The systematic review as well as the case study both found that the richest applications of mobile technologies in education in LMICs are connected to the use of explicit mobile learning pedagogies. In the systematic review, pedagogically-rich mobile learning programs were found to have a larger effect, while in the case study the embedding of technology use in an explicitly pedagogical mobile learning programme led to a range of rich opportunities explored by teachers. This is in contrast to techno-centric conceptions of ML4D in which the educational underpinning of mobile learning is often an after-thought rather than an integral programme component.

In a CA conception of ML4D, focused on expanding people's effective opportunities, mobile learning in LMICs therefore needs to be primarily positioned as an education intervention. It is through the exploration of mobile technologies' particular affordances, which give rise to a range of different teaching and learning approaches, that the educational actors in LMICs can explore a diverse range of opportunities. Without a primary focus on these educational opportunities, mobile learning lacks a plausible theory of change to support a transformative change on education and development outcomes. Positioning mobile learning in international development from a CA perspective, therefore would require a shift back towards a learning activity-based, pedagogical definition of ML4D.

9.2.4 Transformation-focused ML4D

Lastly, conceptualising ML4D through the CA leads to a transformation-focused positioning of the educational use of mobile devices in LMICs. That is, the contribution of mobile learning to development is framed in terms of an endogenous transformation of education in LMICs, not in terms of a 'disruption' or 'revolution' of education in LMICs. In Chapter 2, section 2.2.3–2.3.3 the implications of an exogenous positioning of mobile learning as an adjunct rather than integral part of the education system are discussed, highlighting that this fuels a deficit model of education in LMICs with negative consequences for cost-intensive educational inputs and actors, in particular teachers. My systematic review then further underlined this critique illustrating that there is little evidence to support the assumption that mobile learning programmes can effectively be implemented outside of existing educational structures. Framing mobile learning's contribution to development in terms of disrupting and revolutionising education is thus conceptually and empirically problematic.

Applying a CA conception of ML4D supports this critique and showcases how mobile learning interventions can be positioned as endogenous to the existing structures. The identified configurations of capabilities in the case study and how they relate to teachers' well-being and human development pay testimony to this. For example, the narrative of building the nation illustrates clearly how teachers' appropriation of technologies in line with the pursuit of their valued beings and doings took place within educational structures. Only through their perceived professional mandate of 'building the nation' and subsequent professional identity did the application of mobile devices receive a space in which it was valued by teachers for professional beings and doings. While there certainly were a range of capabilities explored by teacher that lay outside the existing educational structures, the main application of the devices and exploration of valued opportunities lay inside the existing educational structures. In this, I observed a careful configuration of capabilities, which, according to teachers' preferences and contexts, allowed them to step-wise develop agency in order to move closer to their conception of a good life. This transformation represents a type of educational change that works largely through changing educational agents from within in a process of small steps informed by the objective of enhancing the capabilities and agency of agents at each step. As a result, a CA conception of ML4D proposes a type of educational change that can best described as an 'endogenous transformation' as a contrast to a disruptive, revolutionary educational change.

Summary: Rethinking ML4D

In summary, applying a capabilities perspective to conceptualise ML4D shifts mobile learning's role and contribution in international development in line with an opportunity-, people-, education-, and transformation-focused understanding of using technologies as an educational tool in LMICs. It is in this conception that I would position mobile learning as a development intervention. This shifts the conceptual focus away from a techno-centric, access-based view of mobile technologies towards a view that prioritises how educational actors can apply these technologies to enhance their capability and agency to live a life they have reason to value.

Rethinking ML4D, I thus position the educational application of mobile technologies in LMICs to carry the potential to contribute to an expansion of human capabilities and agency. However, in order to achieve this contribution of mobile learning to development, mobile learning programmes need to be carefully designed for this particular objective. It is not an inherent property of ML4D interventions to exercise this expansion of human capabilities and agency. A key consideration in this explicit design effort refers to acknowledging that the particular educational and informational attributes of mobile learning can allow for a more multidimensional use of the technology, which supports individuals to simultaneously explore different dimensions of capabilities integrating their social and professional contexts and identities. Given these particular attributes of mobile leaning, it can therefore be positioned to support the expansion of a different set of capabilities, which thus far have been overlooked in previous research applying the CA in education and technology.

This positioning of ML4D and line of argument would call for more humility in the advocacy on ML4D than currently displayed by international development and mobile vendor organisations. It positions mobile learning's contribution as to foster a series of step-wise endogenous changes in educational practices and processes driven by educational actors' own definitions of valued beings and doings. It thereby targets an endogenous transformation of education in LMICs to which the educational use of mobile technologies can make but one contribution. By no means, however, does mobile learning present the potential to single-handedly revolutionise education in LMICs. And, I would argue that it should be understood as one of many educational interventions in LMICs whose contribution needs to be considered against its costs and the respective contributions of other education interventions. To be clear, ML4D has a strong contribution to offer to educational change in LMICs, that is the ability to foster a simultaneous exploration of dimensions of capabilities comprising human development and well-being; but whether its contribution is the most relevant among the many potential educational contributions of other programmes needs to be considered carefully on a case to case basis.

9.3 Defending the argument for my conception of ML4D

I have now proposed my capabilities conception of how the use of mobile technologies as an educational tool in LMICs can be positioned as a development intervention. However, there are a few lines of critiques that could be put forward to challenge this conceptualisation and positioning. Below, I address what I perceive to be the five most pressing challenges to my capabilities conception of ML4D and subsequent positioning of mobile learning as a development intervention.

9.3.1 Transformation from within, undermining structural changes?

In section 8.3, I outlined my case to use the term endogenous transformation to characterise the nature of the educational change targeted in a capabilities conception of ML4D. This attempted to capture the locus and space of the educational change (i.e. endogenous) and the nature and scale of the change (i.e. transformation). I justified my use of this term based on the data collected and analysed rather than through a conceptual argument. An endogenous transformation represents a type of educational change that works largely through changing educational agents from within in a process of small steps informed by the objective of enhancing the capabilities and agency of actors at each step.

I then supplemented this descriptive argument with a conceptual argument outlining the risks of positioning technology as exogenous to the existing educational structures and to attribute it a disruptive, revolutionary potential for change. In short, positioning mobile learning as an exogenous educational input risks creating conflict between (i) existing educational structures and its actors vs the new technological innovation; (ii) between a focus on technology innovation vs a focus on education innovation; and (iii) between a disruption of education from the outside vs a transformation of education from the inside. Based on this conceptual exploration and the empirical findings of my systematic review, I concluded that a capabilities conception of ML4D needs to focus on an endogenous transformation of education in LMICs.

However, there is an important counter-argument to this conception that needs to be taken into consideration. By embedding ML4D firmly within existing educational structures, mobile learning programmes might not be able to affect structural inequalities within these structures. That is, if mobile learning aims to influence a step-wise transformation from within, it might lack the ability to change larger structural issues in the education system. For example, if the existing educational structures discriminate against girl learners, embedding mobile learning in these structures risks reproducing these inequalities. If, on the other hand, we position mobile learning as exogenous to these structures, the technology input might be able to create separate, more equal structures that replace the existing unequal structures. This rationale for example underlines the idea that providing girl learners with access to more information on mobile phones can lead to their empowerment.

As much as this is a conceptually coherent challenge, my data sets also underlines that there is a danger that a 'transformation from within' position of ML4D risks trapping mobile learning in existing systemic inequalities. In my systematic review, I establish that indeed mobile learning programmes in LMICs are designed in such a way that they do not run counter to existing inequalities such as prioritising urban schools over rural schools. However, the same holds true for my capabilities framework of teachers' use of mobile technologies. For example, in the teachers' narrative of building the nation, which presented a key source of their well-being and human development, one could argue that teachers in fact follow a predefined conception of a good life, and not their own. The narrative of building the nation was developed by the South African government and teachers have internalised it as a part of their professional identity. Teacher also felt thankful for, and valued by, the government for providing them with tablets.

Yet, at the same time teachers were employed at schools and school districts that exhibit large structural inequalities within the South African education system. There was no indication at all within my primary research that teachers intend to use the tablets to actively address these structural inequalities. While being conscious of them, it did not challenge their narrative of wanting to build the nation. To the contrary, teachers directly resisted any application of the tablets that could be seen as undermining their building of the nation. This referred in particular to using the tablets to access or generate teaching materials that were not part of the prescribed national curriculum. Teacher rejected this application of the tablets as it would not support their learners in passing the annual assessment, thereby undermining teachers' contribution to supporting socio-economic development in South Africa. The ICT4RED mobile learning programme is thus embedded to such an extent into the existing education system that it might lack the ability to affect large-scale structural change.

In sum, by focusing on transformation from within and the valued beings and doings of educational actors, mobile learning might be limited in its ability to address existing inequalities within the education system. If educational actors do not value structural changes and these are not part of their conception of a good life, it is difficult to see how the mobile technologies would be applied to this end. In such a situation an exogenous intervention might be more relevant to create effective educational changes. But, before I proceed to formulate a reply to this challenge, it is important to note that this conceptual challenge is not unique to my case study. There is a rich debate on the CA's ability to deal with structural changes. Scholars, for example, have extensively debated the individual focus of capabilities and suggested that collective capabilities might be a more relevant level of analysis (Ibrahim 2009; 2006; Stewart 2005). Likewise, Zheng and Stahl (2011; 2012) and Popova and Roberts (2017) suggest to marry the CA with critical theory in order to allow a more structural type of investigation. Sen, too, has acknowledged this issue, for example in form of an emphasis on taking into account adaptive preferences of individuals (Sen 1992; 1999).

In order to defend my 'transformation within' conception of ML4D, I turn to the distinction of defining developmental changes between a 'liberation within' and a 'liberation from' developed by Kullmann and Lee (2013). Their suggestion combines Latour's concepts of 'actor-networks', 'collectives' and 'moments of translation' with Sen's capabilities, agency, and conversion factors—a combination which I found most adequate in the context of my conceptual challenge as it is not only focused on the nature of the capabilities itself, but further also on the described nature of the change observed. Kullman and Lee introduce Latour's (1993) conceptual devices into Sen's definition of freedom. This allows them to make a distinction between two distinct concepts of freedom:

> "Where 'freedom' is often understood as liberation *from* one's social and material surroundings, we will use the Sen/Latour encounter to clarify a view of freedom as liberation *within* one's environment. Liberation does not involve rendering the environment irrelevant by breaking existing relations with it. Instead liberation is composed through gradual changes in everyday socio-technical relations of specific collectives." (Kullman & Lee 2013: 40, emphasis in the original)

In an understanding of 'liberation from', individuals are able to become independent and removed of their immediate environments; or, more formally, individuals can "transcend the surrounding social and material relations so that it becomes safe to ignore those relations" (Kullman & Lee 2013: 44). The authors illustrate this practice of 'liberation from' with a case study of the OLPC program showing how the OLPC attempted to allow children to remove themselves from the limitation of an educational context in LMICs by providing them with laptop computers that were assumed to facilitate learning without the need for a formal educational intervention. Children thereby were 'liberated from' absent teachers, a lack of relevant content, poor educational infrastructure, etc.

'Liberation from within', on the other hand, assumes individuals to be defined by their immediate environments and regards the surrounding social and material relations as crucial to individual's development as it is these relationships that foster individual or collective agency. Liberation from within thus asks individuals to explore their opportunities to change their immediate environments, which is described as a process of "careful and gradual 'conversion' or 'translation' of everyday relationships in order to make more space for situated forms of human 'development' and 'growth'" (Kullman & Lee 2013: 45). Applying this concept of 'liberation within' similarly to the OLPC, the authors show how collaborative learning activities that children explored with the provided laptops generated a stronger set of capabilities and functionings than using the laptops to "reach an abstracted state of 'liberation from'" (Kullman & Lee 2013: 53). Reflecting on their contrasting of both concepts of freedom, the authors conclude that:

> "Taken together, Sen and Latour invite a systematic empirical analysis of developmental projects in terms of 'liberation within' rather than 'liberation from'. This means that the quality of the relations among persons, technologies and environments is more important than minimizing dependencies between people and their surroundings" (Kullman & Lee 2013: 54).

The distinction between 'liberation within' and 'liberation from' is conceptually more rigorous than my distinction between an endogenous transformation and a disruption or revolution of education in LMICs. I therefore adopt Kullman and Lee's supplementation of Sen's concept of freedom and position ML4D from a capabilities perspective as to support a 'liberation within' educational actors in LMICs. In this, I assume that mobile learning is better suited to enhance the quality of the relations among persons, technologies, and environments allowing for a gradual and situated process of development. This does not negate that mobile learning might have the potential to support structural changes and address existing unfreedoms and inequalities embedded within the education system. In fact, teachers suggested that the tablets supported them to rectify past unfreedoms to some extent. However, based on my review of the overall evidence-base, mobile technologies as an educational tool do not seem to provide a close fit to address structural changes in the education system. In my conception, I therefore position mobile learning to support a 'liberation within' as the small, well-defined functions that mobiles do uniquely well in an educational context can only translate into powerful educational interventions through the mediation of social practices (Roschelle 2003). In regard to fostering a 'liberation from', which I do see as important too, I believe there to be more potent educational interventions that can lay claim to institute such structural changes; for example, changes in teacher training, national curricula, budget mechanisms such as gender mainstreaming, and school-based decision-making, among other. Also, perhaps once ML4D has established itself as a viable tool to support a ‘liberation within’, research and practice on mobile learning in LMICs might reconsider the objective of using mobiles to support a ‘liberation from’. At this point, however, I am positioning ML4D firmly as to primarily relate to efforts of contributing to a ‘liberation within’ education in LMICs.

9.3.2 Mobile learning pedagogies and development as freedom

As part of my positioning of mobile learning as a development intervention, I claimed that the educational use of mobiles in LMICs needs to be anchored in a stronger pedagogical understanding. That is, that the specific pedagogies that the particular affordances of mobiles can support need to be more closely integrated with the conception of ML4D. However, throughout my thesis I have mainly provided evidence for the importance of a deliberate pedagogical approach to teaching and learning with mobiles per se, rather than evidence for the specific mobile learning pedagogies themselves. This is largely due to the positioning of the thesis in literature on international development rather than in the educational domain. Yet, throughout my thesis the importance of not just any, but particular mobile learning inspired pedagogical underpinnings of the educational application of mobile devices is touched upon. Below, I aim to illustrate these dispersed references to the more specific pedagogical approaches identified with mobile learning in a development context in a bit more detail.

To start with, in the meta-analysis of my systematic review I found that pedagogies mattered in the design of mobile learning interventions in LMICs. The mere delivery of content, for example through daily text messages (Aker et al 2012) on mobile devices, was significantly less effective in improving learning in LMICs. Interventions using mobile technologies to design context-aware, game-based, and collaborative learning experiences, on the other hand, were found to be more beneficial in improving learning. This finding about the importance of explicit pedagogical underpinnings was echoed in the thematic synthesis, which identified pedagogy to be a key mechanism supporting the effects of mobile learning on education outcomes. The thematic synthesis identified the following features of pedagogical approaches as most prominent in the qualitative evidence on teaching and learning with mobiles in LMICs: interaction, collaboration, authenticity, personalisation, targeting, access to information, and an enhanced variety of teaching strategies.

In my qualitative case study, I then investigated a mobile learning programme in rural South Africa that was explicitly designed to nurture pedagogical innovation in line with a more learner-centred teaching approach. I found that this mobile learning programme did indeed allow teachers to explore a range on valued educational opportunities, including a more learner-centred education approach in which the teacher becomes the ‘facilitator of knowledge’. This could be positioned as to constitute strong evidence that the particular mobile learning pedagogies taught by the ICT4RED were the key contribution of the mobile learning programme to teachers’ and learners’ development.

But, this conclusion would be at add odds with my developed capabilities framework of teachers’ use of mobiles, which positions teachers’ well-being and human development to be a function of an interplay between different dimensions of capabilities. It also hides the active facilitation of these particular pedagogies by the ICT4RED. Teachers further varied in their exploration of educational opportunities, and while some valued integrating mobile learning into their daily teaching, others merely valued the tablets as a tool to facilitate their daily routines. It is also interesting to note that teachers often linked the changes in educational capabilities to the use of tablets when it is not clear why non-technological inputs could have not been applied to the same effect.

Development as freedom in the capabilities conception of ML4D should not be linked directly to any specific pedagogy at this stage. That is, it would be an overstatement to claim that a positioning of ML4D is only valid if an explicit mobile learning pedagogy is embedded into the programme design. In my current conception, I therefore deliberately highlight an ‘education-focused’ approach, but refrain from prescribing a specific ‘mobile learning-focused approach’ that would advocate for particular mobile learning pedagogies such as experiential or context-aware learning. This attempts to reflect that a pedagogical anchoring of ML4D is crucial for mobile learning to make a relevant contribution to development outcomes, but that the specific nature of this pedagogical anchoring is open-ended.

In conclusion, mobile learning pedagogies can and should be integrated with the conception of ML4D. And, there is a reliable evidence that points towards the beneficial impacts of this integration, for example by merging informational and educational capabilities. However, in order to support an endogenous appropriation of technologies and a people-driven exploration of their educational usages, specific pedagogies should not be singled out as the defining attributes of a conception of ML4D. To illustrate the range of potential pedagogical applications of mobile technologies in LMICs, I conclude this discussion with a last vignette of my case study research.

Vignette: Alternate ways to teach—the teacher as a facilitator of knowledge

> “It (the tablet) has improved my teaching and learning styles. Also, it has improved learning outcomes and they (the students) learn quicker. My teaching style is no longer teacher-centred. When I'm in class I'm no longer standing in front; I let the learners do the work so I'm not the person who keeps the knowledge. I am just a facilitator and the teaching strategies help us a lot in this. I did the storytelling exercise and the children told really exciting stories. Also learning with tablets in general is very helpful. In geography, to have evidence that they visited the place I need them to take pictures. We just recently did map work. I asked them to go outside and create a map of the area using the templates and Google maps and pictures. They also put up the constructed and natural features.” (Primary teacher; day 7)

In my case study research, I identified a rich range of different teaching approaches that teachers explored with the support of mobile technologies. The above quote illustrates one prominent example. Here, the teacher used the particular affordances of mobile technologies to enhance her teaching of Geography. Learners used the technologies to learn across contexts and towards an authentic and relevant task, that is enriching the Google map features of their communities. I also observed other such examples in particular in natural science teaching and history and economic lessons such as the story telling exercise mentioned in chapter 7, section 7.3.2. In addition, one innovative example stands out: in order to teach the concept of arbitrage, a teacher split her class in six teams that were sent into the local community, while one team stayed behind in the classroom. The teams in the community surveyed local Spaza shops and recorded the prices for a basket of goods, which were sent in real time to the coordinating team in the classroom. The classroom team then compared the different prices of the community shops against each other, as well as against whole sale market prices of these goods. The learners then calculated profit margins per shop as well as for their own fictitious start-up business, which was supposed to act as a middle entity between wholesalers and Spaza shop owners.

My case study therefore illustrated that pedagogical-rich mobile learning did take place in a resource-poor rural setting. These pedagogical-rich practices largely resulted from a configuration of teachers’ informational and educational capabilities in an effort to create more learner-centred educational processes. In order to enhance their valued educational opportunities, such as supporting their learners to succeed, teachers subscribed to a narrative of ‘becoming the facilitator of knowledge’, which expressed their desire to allow students more participation and interaction in the learning process. However, it needs to be mentioned that many of the resulting teaching strategies, as well as the overall learner-centred pedagogical approach, were suggested in the ICT4RED teacher training manual and further practiced in the professional development classes. Teachers' adoption of these learner-centred teaching strategies and the desire to become a facilitator of knowledge therefore need to be understood in the context of this professional development programme. Teachers also varied in their adoption and implementation of these learner-centred teaching strategies and oftentimes the link between the conducted teaching strategy and the need for it to be facilitated through the tablet devices is not clear. For example, the popular teaching strategy of story-telling in which learners surveyed community elders to make a multi-media portfolio on the tablets could arguable also have taken place using traditional learning materials. The tablets certainly added richness to the task in terms of information presentational and storage, but were not inherently needed to facilitate the learning activity.

9.3.3 Meta capabilities: A quest for the magic bullet capability?

A third challenge against my conceptualisation and positioning of ML4D could arise from a different direction, questioning whether my positioning of mobile learning might not be too modest. It could be argued that, if I claim that mobile learning through its intersection between technology and education pertains to the expansion of multiple set of capabilities, I should position mobile learning as some form of meta- or uber-capability. Seeing that the educational use of mobile devices nurtures the subsequent generation of dimensions of capabilities, it could be seen as a higher-order capability. In fact, this line of argument, i.e. to identify meta-capabilities, has some currency in the capabilities literature. Sen (1999) suggests some form of basic capabilities such as education and health to be required to explore further capabilities. Nussbaum (2011), too, sees a range of core capabilities while Wolff and De-Shalit (2009) coin the concept of 'fertile capabilities' to explain a form of capability that is required to be present in order to generate additional capabilities.

Outside the theoretical CA literature, a range of capabilities have been positioned as of special importance too. Venkatapuran (2011) argues to regard the capability to be healthy as a meta-capability. However, this would contradict Kleine (2013) and Gigler (2015) who position technologies and informational capabilities respectively to be of central importance among different types of capabilities. It seems then that there might be a risk to follow a quest for a magic bullet capability by adding mobile learning to this list.

I have already discussed why I do not regard mobile technologies in education to constitute 'technologies of freedom' (see section 7.3). And, I would again caution here that while mobile learning in LMICs can support a diverse set of capabilities, this is neither a necessary outcome of the educational use of mobiles, nor are these capabilities a unique property of mobile learning itself. Other interventions might yield similar capability configurations and I do not see the educational use of mobiles to present some form of higher-level capability construct. In this, I disagree with Gigler (2015), who positioned informational capabilities as a core central capability required for technology users to then explore their social capabilities. While I do agree that this linear progress might indeed be the case, I do not assume that informational capabilities are a necessary condition for social capabilities to be generated.

To position myself in this debate on meta-capabilities then, I would agree with Sen's position that there probably exist a range of basic capabilities; but as he does, I do not think a universal list of these can be created, and neither would I add a capability to use mobile technologies to this. Sen (1999) and Unterhalter (2005) both regard education as a basic capability. I agree with this conceptualisation and it could be argued that this sufficiently covers mobile learning's capability set too. Suggestion to add a basic capability around access and use to information and ICTs seem to be increasingly justified too, and I would again regard mobile learning to present a sub-set of this higher-level capability.

Sectoral thinking and multipurpose technologies

The above discussion, however, highlights the needs to elaborate a bit further on the implications of mobile learning's contribution to multidimensional capability sets. Mobile technologies do indeed present multipurpose technologies (Kleine 2013) allowing them to support the exploration of multiple dimensions of capabilities simultaneously. Alas, sectoral thinking within the Capabilities and Development literature seems to "not adequately grasp the full transformative and often highly personalised effect that access to the internet or even a mobile phone can have on people's lives" (Kleine 2013: 7). Current capability frameworks therefore run at risk to analyse human well-being and development in silos. It seems unintuitive, for example, that both the capability to be healthy and the capability to be educated are discussed as if one capability should take precedent over the other (c.f. Venkatapuran 2011; Walker 2006), when both seem to be of equal importance to any individual's well-being and development. This sectoral thinking is in particular irrelevant for cross-cutting interventions such as ICTs and mobile technologies, who by design allow individuals to choose what type of capability set and opportunities to explore.

An interesting suggestion in this regard in raised by Donner (2016). An early proponent of mobiles for development (M4D), in his 2016 book 'after access' he suggests that "it is time to retire the term M4D" (Donner 2016: 190). He reaches this conclusion based on the observation that the boundaries between devices, functionalities, and application between mobiles and other ICTs have blurred to such an extent that is makes little sense to distinguish between ICT4D and M4D. While this is a welcome contribution to the wider discourse on technologies and development, I do not think this argument is applicable to ML4D too. The educational component of mobile learning is too central in my conception of ML4D as to allow a full merging of mobile learning in LMICs with the ICT4D domain.

9.3.4 Revisiting the gap in existing capabilities frameworks

In chapter 2, section 2.4.1–2.4.4 I discussed existing capabilities frameworks in ICT4D and education in LMICs, and held that none of them provided an off-the-shelf conception that could be transferred to ML4D. In order to fill this conceptual gap, I therefore generated a capabilities conception unique to ML4D. However, to safeguard against constructing a straw man argument, it seems relevant to briefly revisit my argument for rejecting existing frameworks and whether my developed capabilities conception is indeed substantially different from these.

My argument for rejecting existing frameworks was based on three pillars. First, there was no existing framework tailored to mobile technologies and the potential capabilities that users might develop from their particular affordances. Most work on ICT4D has focused on ICT policies and fixed infrastructure such as telecentres, desktop computers, and access to the internet in general (c.f. Kleine 2013; Gigler 2015). This overlooks important aspects of mobile technologies, which are far more widespread in terms of access, and personal in terms of use, than other ICTs. Frankly, mobile technologies might be relevant to a more diverse set of valued opportunities and functionings. Second, because conceptual work on the CA and ICTs has focused on fixed technologies, it is often overly sectoral and not geared towards the diverse applications of mobile technologies to support users' pursuit of a good life. Mobile technologies, due to their constant and personalised use in all areas of life, might be able to help users explore multiple types of capabilities simultaneously.

Third, from an educational perspective existing work on the CA has not investigated the use of technology, either fixed or mobile. While there is a rich body of literature on teachers' capabilities, this literature does not feature the use of technologies as an educational tool at all. There seems to be good reason to believe that learners and teachers can generate different types of capabilities and valued functionings from the conversion of mobile technologies as an educational resource. Existing work on the CA in education and LMICs has not explored these opportunities and there thus remained a gap on investigating mobile learning in LMICs from a capabilities perspective.

Reviewing these arguments, it appears that my capabilities framework indeed fills a relevant gap. The four dimensions of capabilities illustrate the interplay of different opportunity sets that users explored through the educational use of mobiles. The four dimensions of capabilities and their interplay to support human development come about through the simultaneous exploration of diverse types of capabilities related to different affordances of mobiles. For example, the ability to use mobiles to communicate and access information across contexts, which fixed ICTs do not provide, can give rise to informational, educational, and societal capabilities at once. Existing capabilities frameworks of ICT4D and education in LMICs have not catered for this simultaneous exploration and overlap in capability sets. This is probably the strongest rationale for the development of a tailored capabilities conception for ML4D.

However, in addition, my descriptive framework also reflects a range of individual capabilities that are not covered in existing work. Seeing that there is no existing work on investigating the use of educational technologies in LMICs from a capabilities perspective, the developed educational capabilities and their interplay with the other three dimensions of capabilities present a contribution to the literature. Likewise, a range of induvial capabilities linked to the particular affordances of mobile devices have not been reported in the context of LMICs before. Though, I would position these individual capabilities as slightly less prominent as they are contextualised by the nature of the ICT4RED intervention and the socio-economic realities of teachers in rural South Africa. All in all, I would therefore reinforce my initial assessment that the development of a descriptive capabilities framework tailored to ML4D was warranted.

Comparing my capabilities framework for teachers' educational use of mobile technologies directly with Gigler's (2015) capabilities framework for 'Development as freedom in a digital age' illustrates a few additional differences. For Gigler (2015), informational capabilities consist of: (a) ICT capability; (b) information literacy; (c) communications capability; and (d) content capability. In my case study research, the technological focus from fixed ICT infrastructure to support indigenous development was changed to a mobile learning initiative to support rural education development. This change in context changed the composition of valued informational capabilities adding the notions of being able to be mobile and to merge social and professional contexts and realities. In the context of the ICT4RED case study, teachers also attached little value to the idea of using the tablets to generate independent teaching content—akin to Gigler's content capability. Creating educational content was seen as the government's responsibility, whereas it was teachers' responsibility to ensure that learners successfully mastered the provided content in order to build the nation. To develop their own independent content then was perceived by teachers as to undermine their educational efforts. Again, this highlights the importance of context in the definition of valued capabilities and underlines my caution to position my 21 individual capabilities as a general framework to guide the assessment of ML4D interventions.

Furthermore, my capabilities conception of ML4D differs from Gigler conception in terms of the positioning of informational capabilities. As discussed in the prior section (9.3.3), I do not regard informational capabilities to present a catalyst for the development of subsequent capabilities. I regard them as one of four dimensions of capabilities whose interplay should be the focus of the analysis. This focus on the interplay then presents a second distinction to Gigler's capabilities framework, which assumes a linear progression from informational capabilities to social capabilities. Such a linear progression of capabilities is also inherent in Venkatapuram's conception of the capability to be healthy, which presents a starting point for the exploration of different capabilities once it is met. In addition to rejecting the idea of informational capability as a meta-capability, I would therefore also reject the idea of a linear progression between capabilities in favour of a multi-dimensional interplay between capabilities.

Comparing my framework to Kleine's Choice Framework, also highlights a range of differences. First, and crucially, her framework is normative while my framework is descriptive. That is, Kleine's framework was developed a priori and then applied to a case study in Chile to test it; in contrast, my framework was developed as a tool to describe teachers' educational use of mobile technologies from a capabilities perspective. I only positioned my capabilities conception of ML4D as normative.

Second, as a normative framework, Kleine offers a range of additional conceptual lenses that my framework does not provide. This refers in particular to her rich unpacking of conversion factors (structure), aspects of agency, and degrees of empowerment. It is in the former two—that is, conversion factors and aspects of agency—that my framework could benefits from a closer integration with Kleine. Third, Kleine's focus on empowerment as an operationalisation of the freedom to achieve development outcomes is too narrow in the context of ML4D. This layer of her framework is akin to my four dimensions of capabilities. The particular nature of mobile learning interventions requires a more diverse conception of capabilities, which is reflected in my four dimensions. Fourth, and last, her framework is not catering for the educational use of technologies as it departs from a different starting point, that is ICT use by Chilean entrepreneurs. All in all, Kleine's framework provides helpful insights into the conversion factors and agency aspect when using technologies, which seem directly relevant to a potential redesign of my theory of change for ML4D as suggested above in 9.1

9.3.5 In defence of human capital and economic growth

A last consideration in the defence of my capabilities conception of ML4D refers to my positioning of human capital and growth-focused understandings of education and development in LMICs. Throughout the thesis, I have criticised both and bemoaned an overly narrow focus on these as a manner in which to conceptualise ML4D. It thus seems helpful to briefly clarify the context of these critiques and their applicability given the empirical data presented in this thesis.

First, in terms of the empirical data presented, both the systematic review and the case study highlight the intrinsic importance of increases in human capital and economic growth (i.e. employment opportunities). While the meta-analysis and theory of change do not establish any impacts on development outcomes as defined in terms of human capital and employment, this is based on a lack of evidence evaluating these outcomes. In the thematic synthesis, however, a range of mechanisms pointed to increases in economic capital. The same applies to my case study findings, in which economic capabilities presented one of four dimensions of valued opportunities explored by teachers through the use of tablets. What is more, one of the teachers' key configurations of capabilities in order to pursue their valued beings and doings—the configuration of building the nation—had a strong human capital and productivity focus. This thus suggests that my capabilities conception of ML4D is indeed compatible with a human capital / growth-focused conception of development.

Second, this finding is in line with the general positioning of Sen's CA, which is not assumed to be mutually exclusive with different approaches to development including growth-focused or income-based approaches. In the words of Sen (1999: 7): "It is hard to think that any process of substantial development can do without very extensive use of markets, but that does not preclude the role of social support, public regulation, or statecraft when they can enrich—rather than impoverish—human lives" and, further, "Growth of GNP or of individual incomes can, of course, be very important *means* to expanding the freedoms enjoyed by the members of society." (Sen 1999: 2, emphasis in the original). That human capital- and employment-focused aspects then feature strongly within my empirical findings including the case study results should not surprise as much. The CA inherently is positioned to present a more encompassing conception of human well-being and development, which includes the important role that increases in human capital and economic growth have to play in this. However, the CA extends beyond these as does my conception of ML4D.

In sum, my position of ML4D should not be seen as in conflict with human capital and growth-focused approaches to development. They provide but one component of the many components of human well-being, agency, and development. My critique of these is in the context of these approaches to development dominating conceptions of ML4D at the expense of other voices on how the use of technologies can support education and development in LMICs. Chimamanda Adichie's parable of the 'Danger of a single story' perhaps best captures my positioning of human capital and growth-focused conceptions of development. As she explains: "The problem with single stories is not that they are untrue, but that they are incomplete. They make one story become the only story…." (Adichie 2014: 4).

Conclusion

This chapter has concluded my exploration of the positioning of mobile learning's role and contribution in international development. It conceptualises mobile learning's contribution to development as the use of mobile technologies to support an endogenous transformation of education in LMICs anchored in the primary objective of enhancing the capabilities and agency of educational agents. In the absence of evidence supporting mobile learning's impact on development outcomes, I present a focus on the role of mobile technologies to expand teachers' and learners' valued functionings and capabilities as an alternative conception of the links between mobile technologies, their use for educational purposes in LMICs, and development outcomes. This understanding and positioning of mobile learning in international development differs from existing conceptualisations by shifting the focus of mobile learning interventions away from access to technologies and content provision towards four different foci of interest: (1) an opportunity focus; (2) a people focus; (3) an education focus; and (4) a transformation focus.

To support this line of argument, this chapter has juxtaposed my capabilities conception of mobile learning with the findings of my mixed-methods systematic review. It also has outlined five challenges to my conception and positioning of ML4D and suggested responses to each. I thereby illustrate that my developed conceptualisation of ML4D directly answers my thesis's research question of how the use of mobile technologies as an educational tool in LMICs can be conceptualised as a development intervention. Having done so, I next discuss limitations of my research and implications for future work in the final chapter of thesis, which will also provide a brief overview of the main findings and conclusions.

Chapter 10. Conclusion of the thesis

Introduction

This chapter concludes my thesis. It provides an overview and summary of the main findings of my empirical research and the argument developed. It also recounts the contributions of my thesis to the wider research and practice on mobile learning for development (ML4D) and outlines some implications of my research findings for policy and practice. The chapter commences with a summary of the thesis's findings and contributions followed by some of the implications thereof and suggestions for further research. The chapter concludes with a few last remarks on the future of ML4D.

10.1 Limitations of the research

As all research, the empirical research conducted as part of this thesis is subject to a range of limitations. This applies equally to the systematic review research and the case study research. I outlined the limitations for both research methods in chapter 4, section 4.2.6 and 4.3.5. These limitations should be kept in mind when considering the below summary of findings and implications of my research.

10.2 Summary of findings and contribution of the thesis

Having reviewed and cautioned the limitations of the empirical research conducted as part of this thesis, I next provide a summary of the main findings and the contribution of the thesis.

10.2.1 Summary of findings and argument

My thesis commenced on the premise that the positioning of mobile learning's role and contribution in international development was neither grounded in an empirical evidence-base nor grounded in a thorough conceptual foundation. In my literature review, I outlined how mobile learning is assumed to contribute to education and development outcomes but then highlighted three key critiques that challenged how ML4D has been understood and positioned in development policy and practice. First, there is a disconnect between the claimed vast development potential of ML4D and the empirical evidence-base cited to support these claims. Second, there is a lack of an explicit theory of change for how the use of mobile technologies is assumed to support education in LMICs and subsequent development outcomes. Current ML4D programmes and policy positions assume simplistic causalities and under-define both education and development. Third, due to its techno-centric positioning, ML4D interventions run a risk of circumventing and undermining the existing education system. This positioning presents ML4D as exogenous to existing educational efforts and is at odds with a people-focused perspective of education and development in Low- and Middle-Income Countries (LMICs).

I then conducted a mixed-methods systematic review in order to assess the empirical validity of the claimed contribution of mobile learning to education and development in LMICs. My review findings reject a link between using mobile technologies as an educational tool in LMICs and development outcomes. Having systematically reviewed and synthesised both quantitative and qualitative studies investigating the effects mobile learning programmes in LMICs, I provided four linked sets of findings to support my argument that, in its current application, *mobile learning programmes cannot claim to support development outcomes*.

First, my mixed-methods systematic review found an absence of evidence between the provision of mobile technologies as an educational tool in LMICs and impacts on socio-economic development. Second, while my systematic review identified a statistically significant impact on learning outcomes, these effects were not sufficient to claim a meaningful change in learners' abilities and human development. Third, two structural biases in who is included in mobile learning programmes undermined the positioning of the mobile learning interventions to target development outcomes: mobile learning interventions overlooked the most disadvantaged groups in society and reflected existing structural inequalities within education systems in LMICs. Fourth, a narrow conception of development as an increase in human capital hindered mobile learning's potential to support development outcomes. I therefore concluded that mobile learning cannot be positioned as development intervention based on current evidence and showed how this finding runs counter to popular narratives on ML4D.

The findings of my mixed-methods systematic review provided my empirical justification that a rethink of the positioning and conceptualisation of ML4D is required. Based on its application in related bodies of literature, I identified the Capability Approach (CA) as a relevant theoretical framework to guide a conceptualisation of mobile learning's role and contribution in international development. I then tested the CA's operationalisation for this purpose using a qualitative case study of a mobile learning programme in rural South Africa. In the case study, I investigated whether teachers' use of mobile technologies allowed them to explore valued functionings and capabilities. The case study found that teachers' use of mobile technologies can best be understood as an expansion in four dimensions of capabilities: informational, educational, societal, and economic capabilities, which taken together can enhance teachers' well-being and human development. This was based on the observation of 22 individual capabilities that teachers explored using mobile technologies, which were then synthesised into an analytical framework to illustrate how the careful configuration of these capabilities, according to teachers' preferences and contexts, allowed them to step-wise develop agency in order to move closer to their conception of a good life.

I then applied the case study results on teachers' use of mobiles technologies to derive a conceptualisation of ML4D based on the CA. I formulated my conception of ML4D from a capabilities perspective as: *the use of mobile technologies to support an endogenous transformation of education in LMICs anchored in the primary objective of enhancing the capabilities and agency of educational agents.* This conception defines the space in which the effects of ML4D interventions should be assessed as the valued beings and doings and corresponding capabilities of educational agents. It defines ML4D's contribution to education and development as to foster an endogenous transformation located within educational agents and structures based on their self-determined exploration of beings and doings aligned to their conception of a live they reasoned to value. In the absence of evidence supporting mobile learning's impact on development outcomes, a focus on the role of mobile technologies to expand teachers' and learners' valued functionings and capabilities presents an alternative conception of the links between mobile technologies, their use for educational purposes in LMICs, and development outcomes. This conceptualisation and positioning of mobile learning in international development differs from existing understandings by shifting the focus of mobile learning interventions away from access to technologies and content provision towards four different foci of interest: (1) an opportunity focus; (2) a people focus; (3) an education focus; and (4) a transformation focus. I concluded my argument with a defence of my capabilities conception of ML4D and the subsequent positioning of mobile learning in international development against a selected range of potential critiques.

In sum, rethinking ML4D, I thus position the educational application of mobile technologies in LMICs to carry the potential to contribute to an expansion of human capabilities and agency. Applying a capabilities perspective to conceptualise ML4D shifts mobile learning's role and contribution in international development in line with an opportunity-, people-, education-, and transformation-focused understanding of using technologies as an educational tool in LMICs. It is in this conception that I would position mobile learning as a development intervention. This shifts the conceptual focus away from a techno-centric, access-based view of mobile technologies towards a view that prioritises how educational actors can apply these technologies to enhance their capability and agency to live a life they have reason to value.

10.2.2 Review of thesis contributions

In chapter 1, section 1.3 I outlined the specific contributions of my thesis, which I briefly revisit here. On an empirical level, my thesis advances the evidence-base on the use of mobile technologies to support education and development in LMICs. It systematically brings together, appraises, and synthesises the published research evidence on mobile learning in LMICs. I used this rigorous synthesised evidence-base to contribute to existing debates on the perceived impact of mobile learning on education outcomes and development progress. This contribution aims to ground the narrative and claimed potential of ML4D in reliable research evidence. The systematic review also allowed me to construct a detailed theory of change for ML4D programmes. This theory of change contributes an explicit investigation of the presumed links between mobile technologies, education, and development allowing for a detailed investigation of their empirical and conceptual validity. Taken together, the systematic review supports a shift in the discourse on ML4D away from anecdotal evidence, good intentions, and plausible but simple theories of mobile learning's contribution to development.

The thesis also contributes the first case study of applying the CA as an analytical framework in a primary research project on ML4D. It presented a list of capabilities that teachers explored resulting from the use of mobile technologies in an educational setting and highlighted the interplay between the identified capabilities to contribute a novel empirical lens on the effects of mobile learning programmes in LMICs. The case study further confirms the assumption that the CA can be operationalised to investigate mobile learning programmes adding to its existing application in related bodies of research such as ICT4D.

On a conceptual level, my thesis developed a detailed conceptualisation of ML4D, which I have outlined above. This conceptualisation defines and grounds the contribution of mobile learning to development firmly in the use of technologies to support educational agents in LMICs to live a life they have reason to value. I have outlined how this shifts the discourse on ML4D towards a more opportunity-, people-, education-, and transformation-focused understanding of using technologies as an educational tool in LMICs. This conceptualisation aims to complement existing understandings of ML4D, in particular human capital and growth-focused approaches. It contributes an alternative way to think about ML4D that hopefully can contribute towards more effective mobile learning policy and programme design in LMICs.

Lastly, the conducted mixed-methods systematic review makes a methodological contribution to a nascent body of work on using mixed-methods approaches to systematic reviews of development programmes and policies. My thesis also makes a minor methodological contribution to the operationalisation of the CA as an analytical device by illustrating the CA's versatility in a body of research in which it had not been applied before.

10.3 Implications of the research findings for policy and practice

The findings of my research carry a range of implications for both ML4D policy-making and practice. These implications can be separated into the implications of the empirical findings of my systematic review of the ML4D evidence-base and the implications of my developed capabilities conception of ML4D. Both are discussed in return.

10.3.1 Implications of my systematic review findings

The findings of my mixed-methods review indicate a clear mismatch between the claimed and the empirical impact of mobile learning in LMICs on development outcomes. Above all, the implications of these results are a strong call for a more evidence-informed approach to ML4D policy and practice. Proponents for the large-scale use of mobiles to support education in LMICs carry the responsibility to present proportional evidence claims to justify their position. Given the clear results of my systematic review that the current evidence-base does not support claims to mobile learning's positioning as a tool for development, policy-makers and practitioners should exercise caution in the adoption of ML4D programmes.

The review further clearly implies the need for an explicit theory of change for how mobile learning programmes can be designed to support education and development outcomes. My thesis presented a first attempt to construct such a theory of change, which could serve as a tool for policy-makers and practitioners to assess and think-through the adoption of ML4D programmes. The theory of change illustrates the different pathways through which the use of mobiles in an educational context could influence development outcomes. It also indicates the different contextual factors and mechanisms at play in each of these pathways. The theory of change thereby could allow policy-makers and practitioners to interrogate their own assumptions of how mobile learning can be used as a tool for education and development in their respective contexts, and what pathway might be the most relevant and effective approach when implementing such mobile learning programmes.

Moreover, the systematic review and its theory of change make some direct recommendations for the design and implementation of ML4D programmes. Having appraised and synthesised all the available evidence on existing mobile learning programmes in LMICs three key design and implementation implications stand out. First, programmes using mobile technologies to support education in LMICs need to place greater emphasis on the pedagogical considerations underpinning programme design. A detailed integration of mobile learning pedagogies into programme design has the potential to enhance programme effects as well as to expand the range of applications of mobiles to support human development. For example, programme designs could draw on Kearney and colleagues' framework for the facilitation of pedagogical rich mobile learning experiences for teachers and learners. Referenced examples of promising mobile learning pedagogies identified in the thesis refer to game-based learning, context-crossing, authentic learning, and collaborative learning.

Second, mobile learning programmes need to be embedded within the existing formal education system. My review found no evidence that mobile learning programmes outside the formal education system present a viable and effective long-term intervention approach. It is therefore crucial to deepen the current integration of mobile learning programmes into the existing education system. Such an integration would require a greater focus on how mobile technologies can be used to support school management and administration as well as how they relate to developing educational leadership and management structures. This is an area of ML4D that remains under-explored despite seemingly possessing potential to affect more systemic changes in education in LMICs. This systemic angle on using mobiles to support school management and governance could further incentivise national governments in LMICs to play an increased role in driving investment into educational mobile technologies rather than leaving this drive to private sectors companies, research institutes, and NGOs.

Third, my systematic review findings constitute a strong recommendation to ML4D programmes to focus more on teachers during intervention design and implementation. The reviewed empirical evidence points towards the centrality of teachers in most pathways from the educational use of mobiles to development outcomes. Teachers are central to the effective adoption and implementation of ML4D programmes; and, further, in their own right present a major constituency that could benefit from the introduction of mobile learning programmes. Alas, the vast majority of ML4D programmes currently bypasses teachers to focus largely on learners, a practice which my research results suggest is neither sustainably in the long-term nor beneficial for the results of mobile learning programmes in the short term. Using mobile learning to support teacher training and development in LMICs stands out as a particular promising programme approach.

10.3.2 Implications of my capabilities conception of ML4D

In addition to my systematic review findings, my capabilities conception of ML4D has a range of implications for ML4D policy design and practice too. Applying a capabilities perspective to conceptualise ML4D shifts mobile learning’s role and contribution in international development in line with an opportunity-, people-, education-, and transformation-focused understanding of using technologies as an educational tool in LMICs. This shift implies a conceptual focus away from a techno-centric, access-based view of mobile technologies towards a view that prioritises how educational actors can apply these technologies to enhance their capability and agency to live a life they have reason to value. However, in order to achieve this enhancement of capabilities and agency of educational actors, mobile learning programs need to be carefully designed for this particular objective. It is by no means an inherent property of ML4D interventions to exercise an expansion of human capabilities and agency.

The explicit integration of the CA into mobile learning programme design is currently non-existent in the literature on ML4D. However, there are a range of examples from the broader

ICT4D literature in which the CA is applied directly to inform programme design[83]. For instance, Poveda and Roberts (2017) report on two examples of designing ICT4D interventions through a capabilities lens. This refers to the Asikana Network, an NGO formed by women working in Zambia's ICT sector, which uses technologies to provide training, mentoring, and networking activities to support women in the ICT sector experiencing gender discrimination. The second example is provided by CDI-Campinas in Brazil, a digital inclusion organisation providing ICT skills education with a particular focus on using ICTs to further social justice and empowerment. In both examples the authors highlight in detail how the CA was directly applied to shape an ICT4D intervention design in which participants can use ICTs to self-determine and self-actualise their own development.

This work resonates strongly with the implications of my capabilities conception for the design of future ML4D programmes. First, my thematic synthesis as well as my qualitative case study identified changes in self-efficacy, agency, and identities to be key mechanisms through which the use of mobiles by educational actors was linked to development outcomes. For example, teachers reported a range of valued opportunities related to personal and professional growth as well as related to addressing historical injustices, which were directly associated with their well-being. However, these mechanisms around personal empowerment are currently not integrated into mobile learning programme designs and largely emerge from qualitative studies of teachers' and learners' perceptions on using mobile devices.

Applying my CA conception of ML4D with its primary objective of enhancing the capabilities and agency of educational actors allows for a closer integration of these mechanisms into ML4D programme design. Rather than pre-specifying programme outcomes, a CA-inspired design would call for a more open-ended and participatory lens on programme outcomes. This would give rise to design aspects such as personal ownership of devices, constant connectivity, opportunities to use the devices across contexts, and more room for collaboration—each of which was highly valued by technology users and facilitated a range of valued opportunities. The key aspect here is however not the specific design criteria that a CA-inspired programme approach could bring to light, but the more over-arching design principle of a more open-ended and participatory understanding of programme processes and outcomes. Above all, a ML4D programme based on my capabilities conception would

[83] This further acknowledges that this thesis's positioning of the CA as a useful conceptual framework to assess and unpack ML4D interventions reflect parallel arguments made in the wider ICT4D literature (see more in chapter 3, sections 3.2–3.4.

allow technology users more power to self-determine technology usages and room to explore how best the technologies can be integrated with their own pursuits of a good life.

Such a more open-ended and participatory programme design then would have further implications on a related design aspect of ML4D: the risk that mobile learning programmes reproduce—rather than counter—structural inequalities by overlooking the most disadvantaged groups in society. For example, my systematic review found a strong bias towards urban areas and more affluent educational environments within ML4D intervention designs. Applying my capabilities conception, the emphasis in ML4D intervention design would shift from the provision of resources (i.e. mobile technologies) to the conversion factors of individuals to apply these resources to an effective use to further their own valued beings and doings. This capabilities lens thus highlights the discrepancy between the conversation factors of more disadvantaged groups, the technology and programme design provided, and the assumed development impacts. The suggested capabilities conception of ML4D should therefore reduce the risk of ML4D reproducing structural inequalities as to who is included and can benefit from ML4D interventions.

A last implication of my capabilities conception of ML4D relates to the integration of Freire's critical pedagogy within mobile learning programme in LMICs (Freire 1972). This particular type of pedagogy seems to hold large promise to guide the design of learning and teaching with mobiles to further development outcomes. Freire proposed an educational approach that supports marginalised groups to develop a 'critical conscious' allowing them to identify the root causes of their oppression and to formulate strategies to overcome this oppression. This pedagogical approach seems to provide a useful tool to operationalise my CA conception of ML4D which calls for an enhancement of the capabilities and agency of educational agents in LMICs to live a life they have reason to value. There is a small body of work that has explored a potential synergy between the CA and Freire's critical pedagogy (Unterhalter 2017; Roberts 2016; Petit & Santos 2014; Gigler 2015). However, none of this work provides an empirical or conceptual investigation of how mobile learning programmes in LMICs could support critical pedagogies in order to enhance the capabilities of educational actors to support their human development and agency.

Such exploration was unfortunately beyond the scope of my thesis, but seems to present a rich area for future research. For example, applying a critical pedagogy lens to the ICT4RED programme would have highlighted the lack of opportunities within the programme design for teachers to challenge existing narratives around their professional role and contribution. Poveda and Roberts show how the explicit incorporation of critical pedagogy techniques such as critical dialogue and problem-posing methods into ICT4D programme design leads to a use of ICTs that allows people to develop a critical agency and conscious required to take control over their own development and well-being. Mobile learning programmes such as ICT4RED could apply a number of designs that incorporate elements of a critical pedagogy to support educational actors to enhance their capabilities and valued functionings.

10.4 Implications of the thesis for future research

The findings of my thesis have implications for a range of areas for future research. Below, I briefly describe four main areas that could be explored by future research.

First, having confirmed the applicability and relevance of the CA as a conceptual tool to assess ML4D programmes, I would argue for an increased empirical research effort into the CA and ML4D. To my knowledge, this thesis presents the first empirical investigation of a ML4D project using the CA as an analytical lens. Research and practice on the use of mobiles to support teaching and learning in LMICs has so far not been based on the CA. Given the proposed capabilities conception of ML4D, further research applying the CA to investigate the use of mobiles to support teaching and learning in LMICs is required. This thesis has outlined how the use of the CA's analytical devices can support a rich empirical analysis of mobile learning in LMICs and proposed a conceptualisation of ML4D based on this investigation. However, so far, this conceptualisation is informed by a single case study and further research is needed to validate and refine my proposed conception. Such research should investigate applied ML4D programmes evaluating programme effects using a CA lens. This would allow for additional data sets on what valued capabilities and functionings educational actors in LMICs explored following the provision of mobiles, and why. A particular focus on learners' capabilities and functionings would be welcome as my case study research did not explore this angle.

Second, in addition to calling for an enhanced application of the CA to investigate ML4D, I would also advocate for an increased use of explicit mobile learning frameworks to inform future research on ML4D. For example, research could apply Kearney and colleagues' (2012) framework for mobile learning to investigate the pedagogical contribution of programmes using mobile technologies to support education in LMICs. This thesis has shown that while the pedagogical underpinnings of mobile learning programs are crucial for their educational impact, this pedagogical aspect is often under-explored in programme design and implementation. Incorporating educational research on mobile learning, in particular Kearney and colleagues' framework, could support mobile learning practice in LMICs. However, this requires a sound evidence-base comprised of primary research applying explicit mobile learning frameworks as well as research synthesis unpacking in more detail the extent to which existing ML4D interventions have adopted explicit pedagogical principles of mobile learning[84].

Third, further research also is required in relation to the CA's methodological individualism. In order to support an investigation of the structural and political factors mitigating individual's human development and agency, additional conceptual frameworks and tools are required. A rich body of work in this regard, which should be explored further in relation to my capabilities conception of ML4D, relates to the integration and combination of social justice theories and critical theories with the CA (e.g. Tilky & Barrett 2011; Venkatapuram 2011; Winters et al 2017; Zheng & Stahl 2011; 2013). A particular strong overlap for future research in this regard seems to rest in the incorporation of one particular type of critical theory with my CA conceptualisation of ML4D: Freire's critical pedagogy as flagged above (Freire 1972).

Fourth and last, a strong area for future research on the role of mobile learning in international development is to investigate the implications of the SDGs and new EFA targets and the shift in educational and developmental policy priorities that these reflect. Much of the core work on ML4D at a policy level has focused on mobile learning's role in the area of the MDGs (c.f. UNESCO 2012a; GSMA 2010; Unwin 2015). But, these policy priorities have now changed in the era of the SDGs, which were announced in September 2015 and provide a framework for sustainable global development from 2016 to 2030. From a mobile learning perspective, this shift in global development priorities should be a positive signal. As argued in this thesis, an access-based, techno-centric understanding of mobile learning is unlikely to unlock the full educational and developmental potential of learning and teaching with mobiles in LMICs. A policy environment that is more focused on quality rather than access to education thus supports a research and practice agenda on ML4D that is more focused on the pedagogical value and contribution of mobile technologies in an educational context.

[84] An example of such an investigation in the field of mHealth in LMICs is provided by Winters and colleagues (2017).

Conclusion

In this thesis I have proposed a rethink of ML4D. When I started my research, I was motivated by a surprising lack of rigorous evidence and conceptual models on what was (and is) a growing range of public and private programmes and projects on mobile learning in LMICs. The educational use of mobile technologies continues to enjoy high-level development policy support as much as high-level commercial private sector interest. Unfortunately, the need for a rethink of ML4D remains as acute now as it was in 2014 when I started my research. Despite more primary research being produced on the effects of mobile learning in LMICs, the highly optimistic narrative on mobile technologies' revolutionary potential to change education in LMICs has not been altered.

In this context, my thesis could be seen as a pessimistic contribution, challenging many of the claims laid to ML4D's impact as well as the conceptual arguments made in its favour. However, while I certainly would want to pose a strong challenge to current development policy thinking on ML4D, I would suggest a more reconciliatory reading of my thesis. Above all, I regard my thesis as a call for humility and curiosity among the ML4D community. Humility in terms of how we advocate for and portray the impacts of mobile learning in LMICs; and curiosity in terms of how we develop and extend our conceptual models of the range of applications in which the educational use of mobile technologies in LMICs can support people's lives. My empirical research in rural South Africa and the developed capabilities conception of ML4D illustrate a much larger range of valued beings and doings and opportunities that could be explored through the use of mobiles than what current understandings of ML4D incorporate.

Mobile learning can be a powerful tool to support education in LMICs; the rich pedagogical applications observed in my case study and systematic review pay testimony to this. Likewise, mobile learning can support individuals to enhance their opportunities to live a life they have reason to value; it can carry the potential to contribute to an expansion of human capabilities and agency. Though, this contribution is more adequately defined as a series of step-wise endogenous changes in educational practices and processes driven by educational actors' own definitions of valued beings and doings. By no means can and should ML4D be attributed revolutionary impacts. Mobile learning can only be effective alongside a healthy and functioning formal education system, which provides the educational structures required for mobile learning to make its distinct contribution to education and development in LMICs. Therefore, I would advocate strongly for an understanding of ML4D that focuses on an endogenous transformation of education in

LMICs to which the carefully designed educational use of mobile technologies can make but one contribution.

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Appendices

The below appendices are organised by chapter.

Appendix 4.1: Search strategy and report

Summary:

- An exhaustive search strategy, that is a search strategy that aims to identify and collect all relevant studies, was applied. This neglected the alternative options of purposeful or iterative searching.
- This exhaustive search was deliberately over-inclusive, and as broad as possible in design, to create a diversity of search sources, which overlap each other to some extent. A large number of search hits entailing a considerable number of duplicates was the result.

- The rationale behind this exhaustive and over-inclusive search strategy is three fold:
  (1) The literature on mobile learning for development is limited, and not structurally archived
  → need for more diverse search sources and flexible search terms.
  (2) Bias and limitation of being a single reviewer
  → need to control for bias such as personal condition (fatigue), or context (previous inclusions / exclusions), or administrative mistakes (not saving the pdf) by exposure to the same study multiple times under different conditions.
  (3) Methodological limitations of alternative search strategies
  → risk of missing important studies.

Search strategy

The search strategy developed a master search string applied in a range of academic and Grey literature sources.

Search terms: A master search string is presented below. A master string serves as an example of how the search will be designed for the most sophisticated search engines. In most cases however search terms will have to be adapted, or key word searches will apply.

<u>*Terms:*</u>

(1) *Intervention terms*:

(“mobile learn* “) OR mlearning OR m-learning OR (“mobile educat*”) OR meducation OR m-education OR (“mobile teach*”) OR “portable interactive learning technology” OR (“mobile phon*” AND learn*) OR (“mobile phon*” AND educat*) OR (“mobile phon*” AND teach*) OR (“smart phon*” AND learn*) OR (“smart phon* AND educat*) OR (“smart phon*” AND teach*) OR (“mobile devic*” AND learn*) OR (“mobile devic*” AND educat*) OR (“mobile devic*”

AND teach*) OR (“mobile technolog*” AND learn*) OR (“mobile technolog*” AND educat*) OR (“mobile technolog*” AND teach*) OR “mobile and contextual learning”

AND

(2) *Outcomes terms*

development OR “international development” OR “social development” OR poverty OR inequality OR “social change” OR livelihood OR empower* OR educat* OR learn*OR school* OR read* OR literate OR literac* OR numerac*

AND

(3) *Country terms*

A full list of countries based on the World Bank’s list LMICs was used combined with generic terms for LMICs

Africa OR Asia OR Caribbean OR “West Indies” OR “South America” OR “Latin America” OR “Central America” or Afghanistan OR Albania OR Algeria OR Angola OR Antigua OR Barbuda OR Argentina OR Armenia OR Aruba OR Azerbaijan OR Bahrain OR Bangladesh OR Barbados OR Benin OR Byelarus OR Byelorussian OR Belarus OR Belorussian OR Belorussia OR Belize OR Bhutan OR Bolivia OR Bosnia OR Herzegovina OR Hercegovina OR Botswana OR Brasil OR Brazil OR Bulgaria OR “Burkina Faso” OR “Burkina Fasso” OR “Upper Volta” OR Burundi OR Urundi OR Cambodia OR “Khmer Republic” OR Kampuchea OR Cameroon OR Cameroons OR Cameron OR Camerons OR “Cape Verde” OR “Central African Republic” OR CAR OR Chad OR Chile OR China OR Colombia OR Comoros OR “Comoro Islands” OR Comores OR Mayotte OR Congo OR Zaire OR “Costa Rica” OR “Cote d’Ivoire” OR “Ivory Coast” OR Croatia OR Cuba OR Cyprus OR Czechoslovakia OR “Czech Republic” OR Slovakia OR “Slovak Republic” OR Djibouti OR “French Somaliland” OR Dominica OR “Dominican Republic” OR “East Timor” OR “East Timur” OR “Timor Leste” OR Ecuador OR Egypt OR “United Arab Republic” OR “El Salvador” OR Eritrea OR Estonia OR Ethiopia OR Fiji OR Gabon OR “Gabonese Republic” OR Gambia OR Gaza OR Georgia OR Ghana OR “Gold Coast” OR Greece OR Grenada OR Guatemala OR Guinea OR Guam OR Guiana OR Guyana OR Haiti OR Honduras OR Hungary OR India OR Maldives OR Indonesia OR Iran OR Iraq OR Jamaica OR Jordan OR Kazakhstan OR Kazakh OR Kenya OR Kiribati OR Korea OR Kosovo OR Kyrgyzstan OR Kirghizia OR “Kyrgyz Republic” OR Kirghiz OR Kirgizstan OR “Lao PDR” OR Laos OR Latvia OR Lebanon OR Lesotho OR Basutoland OR Liberia OR Libya OR Lithuania OR Macedonia OR Madagascar OR “Malagasy Republic” OR Malaysia OR Malaya OR Malay OR Sabah OR Sarawak OR Malawi OR Nyasaland OR Mali OR Malta OR “Marshall Islands” OR Mauritania OR Mauritius OR “Agalega Islands” OR Mexico OR Micronesia OR “Middle East” OR Moldova OR Moldovia OR Mongolia OR Montenegro OR Morocco OR Mozambique OR Mocambique OR Myanmar OR Myanma OR Burma OR Namibia OR Nepal OR “Netherlands Antilles” OR “New Caledonia” OR Nicaragua OR Niger OR Nigeria OR “Northern Mariana Islands” OR Oman OR Muscat OR Pakistan OR Palau OR Palestine OR Panama OR Paraguay OR Peru OR Philippines OR Philipines OR Phillipines OR Phillippines OR Poland OR Portugal OR “Puerto Rico” OR Romania OR Rumania OR Roumania OR Russia OR Russian OR Rwanda OR Ruanda OR “Saint Kitts” OR “St Kitts” OR Nevis OR “Saint Lucia” OR “St Lucia” OR “Saint Vincent” OR “St Vincent” OR Grenadines OR Samoa OR “Samoan Islands” OR “Navigator Island” OR “Navigator Islands” OR “Sao Tome” OR “Saudi Arabia” OR Senegal OR Serbia OR Montenegro OR Seychelles OR “Sierra Leone” OR Slovenia OR “Sri Lanka” OR Ceylon OR “Solomon Islands” OR

Somalia OR Sudan OR Suriname OR Surinam OR Swaziland OR Syria OR Tajikistan OR Tadzhikistan OR Tadjikistan OR Tadzhik OR Tanzania OR Thailand OR Togo OR “Togolese Republic” OR Tonga OR Trinidad OR Tobago OR Tunisia OR Turkey OR Turkmenistan OR Turkmen OR Uganda OR Ukraine OR Uruguay OR “USSR” OR “Soviet Union” OR “Union of Soviet Socialist Republics” OR Uzbekistan OR Uzbek OR Vanuatu OR “New Hebrides” OR Venezuela OR Vietnam OR “Viet Nam” OR “West Bank” OR Yemen OR Yugoslavia OR Zambia OR Zimbabwe OR “developing country” OR “developing countries” OR “developing nation” OR “developing nations” OR “developing world” OR “less-developed countr*” OR “less developed countr*” OR “less-developed world” OR “less-developed world” OR “lesser-developed countr*” OR “lesser developed countr*” OR “lesser-developed nation” OR “lesser developed nation*” OR “lesser developed world” OR “lesser-developed world” OR “under-developed countr*” OR “under developed countr*” OR “under-developed nation*” OR “under developed nation*” OR “under-developed world” OR “underdeveloped world” OR “under developed world” OR “underdeveloped countr*” OR “under-developed countr*” OR “Under developed countr*” OR “under developed nation*” OR “under-developed nation*” OR “underdeveloped nation*” OR “lower middle income countr*” OR “lower middle-income countr*” OR “lower middle income nation*” OR “lower middle-income nation*” OR “upper middle-income countr*” OR “upper middle income countr*” OR “upper middle-income nation*” OR “upper middle income nation*” OR “low-income countr*” OR “low income countr*” OR “low-income nation*” OR “low income nation*” OR “lower income countr*” OR “lower-income countr*” OR “lower income nation*” OR “lower-income nation*” OR “Low-and Middle- Income countr*” OR “Low and Middle Income Countr*” OR “underserved country” OR “underserved countries” OR “underserved nation” OR “underserved nations” OR “underserved world” OR “under served country” OR “under served countries” OR “under served nation” OR “under served nations” OR “under served world” OR “deprived country” OR “deprived countries” OR “deprived nation” OR “deprived nations” OR “deprived world” OR “poor country” OR “poor countries” OR “poor nation” OR “poor nations” OR “poor world” OR “poorer country” OR “poorer countries” OR “poorer nation” OR “poorer nations” OR “poorer world” OR “developing economy” OR “developing economies” OR “less developed economy” OR “less developed economies” OR “lesser developed economy” OR “lesser developed economies” OR “under developed economy” OR “under developed economies” OR “underdeveloped economy” OR “underdeveloped economies” OR “middle income economy” OR “middle income economies” OR “low income economy” OR “low income economies” OR “lower income economy” OR “lower income economies” OR lmic OR lmics OR “third world” OR “lami country” OR “lami countries” OR “transitional country” OR “transitional countries” LMIC OR LMICs OR LIC OR LICs OR LMICs OR LMIC OR UMICs OR UMIC) OR (“khmer” AND “republic”) OR (“cape” AND “verde”) OR (“central” AND “african” AND “republic”)

(4) NOT medication

Combining these terms, the *default search* can be simplified as:

(1) AND (2) AND (3) NOT (4)

As stated above, the default search requires a sophisticated search engine to be applicable. This is usually only the case for major academic databases. Since those present only a minority of search sources (see below), search terms had to be adapted individually. In such instances, only key terms from (1) were applied ensuring the search strategy remains as broad as possible and no studies are overlooked. If the identified numbers appeared too large, a term of (2) was connected with the ‘AND’ boolean operator to reduce search hits. In general, a flexible approach to search terms was applied, carefully weighting their value against possible predefined key word categories in databases, and redefining the terms for most sensible usage in each individual database.

Search Sources: Studies connecting the ideas of mobile technologies, education, and international development will come from a variety of sources, including the academic as well as grey literature, and most likely published and unpublished reports. I therefore compiled a list of search sources comprising academic literature and Grey literature sources.

Academic sources

(1) Databases:

- EBSCO all databases including among other (Academic Search Complete, ERIC, EconLit, Education FullTexts, Teacher Reference Centre);
- EdITLib, (Digital Library for Education and Information technology),
- Ingenta Connect;
- JSTOR;
- SabiNet;
- SAGE Journals Online;
- Science Direct;
- Taylor&Francis Online;
- ISI Web of Science;
- ELDIS;
- Institute of education library guides, OER guide and DOAJ guide and International Education Guide

(2) Journals:
Most of the journals below are included in at least one of the database above. However, to double check that the databases search parameters did not miss relevant publications, individual key word searches will be conducted for the period of 2004-2014 in the journals listed below. Individual key word searches address the redundancy of applying the search terms rigidly; for example, it does make little sense to search for the term ‘mobile learning’ in a journal dedicated to the subject of mobile learning. Journals listed with an asterisk (*) are assumed to be key journals relevant to the type of publications this review seeks to identify, and will therefore be hand searched exhaustively on title and abstract for the same period.

Development related:

- Economic Development and Cultural Change
- Journal of Development Economics
- *Journal of Development Effectiveness
- *Journal of International Development
- Journal of Sustainable Development
- *World Development
- World Bank Research Observer

Education related:
- British Journal of Education
- Educational Researcher
- European Journal of Open and Distance Learning
- *International Journal of Educational Development
- Journal of the Learning Sciences

ICT related:
- African Journal of Information and Communication
- Computers and Education
- Computers and Human behavior
- Electronic Journal of Information Systems in Developing Countries
- Information, Communication & Society
- Information Technologies and International Development
- Information Technology for Development
- International Journal of Education and Development Using Information and Communication Technology
- International Journal of Mobile and Blended Learning
- International Journal of Education and Development Using Information and Communication Technology
- International Journal of Information and Communication Technologies for Human Development
- International Journal of Mobile learning and Organisation
- International Journal on Advances in ICT for Emerging Regions
- Journal of Information Technology in Social Change
- Journal of Computer Assisted Learning
- Learning Media and Technology
- South African Journal of Information Management
- International Journal of Learning Technology.
- International Journal of Interactive Mobile Technologies (iJIM)
- International Journal of ICT Research and Development in Africa
- Journal of Health Informatics in Developing Countries
- International Journal of Information Systems and Social Change
- International Review of Research in Open and Distance Learning

<u>(3) Thesis/Dissertation search:</u>
- ProQuest
- Ethos

Grey literature

(1) <u>Google, Google Scholar</u>

(2) <u>Websites of key organisations</u>

AusAID; Bill&Melinda Gates Foundation; Centre for Development Informatics; Consortium for Research on Educational Access, Transitions and Equity (CREATE);DFID; GSMA; MIT Poverty Action Lab; ICT4D blog (Heeks); IICD; IDRC; Innovations for Poverty Center; International Association for Mobile Learning; London Knowledge Lab; Network for Policy Research, Review and Advice on Education and Training (NORRAG); Network of Networks Impact Evaluation Initiative (NONIE); OECD; ODI; Research Consortium on Educational Outcomes and Poverty (RECOUP); UNESDOC; USAID (mEducation alliance); World Bank (especially their impact evaluation section); World Bank (EduTech blog); Word Bank (infoDev); 3ie.

(3) Conference proceedings:
elearning Africa; IADIS International Conference Mobile Learning (2005-2011), mEducation symposium (2011, 2012, 2013), mLearn,(2002-2011; UNESCO mobile learning weeks (2011; 2013;2014), Wireless, Mobile and Ubiquitous Technologies in Education (WMUTE); INTEL education summit (2011; 2012) ICTD (2006-2013).

Snowballing

(1) Expert contacts:

Mohamed Ally; John Cook; Jonathan Donner; Richard Heeks; Agnes Kukulska-Hulme; Dorothea Kleine; Tim Unwin; Mike Sharples; John Traxler; Michael Trucano; Niall Winters; Maggie Verster; Steve Vosloo

(2) Twitter search:
♯ m4d
♯ ict4d
♯ ict4e
♯ mlearning
♯ Edchat

(3) Reference/Citation searches of key publications:

- **Ally** (2009) Mobile Learning: Transforming the Delivery of Education and Training
- **Donner** (2008) Research Approaches to Mobile Use in the Developing World: A Review of the Literature.
- **Frohberg** (2009) Mobile learning projects – a critical analysis of the state of the art
- **Kinuthia & Marshal** (eds) (2013) On the move: Mobile Learning for Development
- **Kukulska-Hulme & Traxler** (2005) M-learning: A Handbook for Educators and Trainers.
- **Naismith** et al (2004) Literature Review in Mobile Technologies and Learning.
- **Pachler** et al (2010) Mobile learning: structures, agency, practices.
- **Sharples** et al (2007) A Theory of Learning for the Mobile Age.
- **Traxler** (2006) Mobile learning in developing countries
- **Traxler (**2009) Learning in a mobile age
- **Worldreader** (2012) iRead Ghana study. Final evaluation report.

- **IICD** Mobile Learning reports
- **GSMA** Mobile Learning Reports
- **UNESCO** Mobile Learning Reports turning on 8
- **WB** Maximizing Mobile

(4) Previous research synthesis (SRs, MAs) and their included studies:

Key words	Author	Type of review
Combined		
All interventions on enrollment; attendance; drop-outs; learning outcomes	3ie (2013)	3ie: Working Paper
All interventions on enrollment	Petrosino (2012)	3ie: SR
All interventions that improve learning at primary school level	McEwans (2013)	WB: SR & meta-analysis
Synthesis: Evidence-based education in Africa	JPAL (2013)	JPAL: Brief Synthesis
Synthesis: Overview of RCTs in developing-country education	Kremer (2009) Kremer (2013)	WB: Overview ScienceDirect
Effect of school resources on educational outcomes	Glewwe (2011)	WB: SR
Teachers		
Effectiveness of rise in teacher salaries	Carr (2011)	EPPI-centre: SR
Interventions to increase teacher attendance	Guerrero (2012)	EPPI-centre: SR
Strategies to improve performance of under-trained?	Orr (2013)	EPPI-centre: SR
Effectiveness of pedagogic approaches	Westbrook (2013)	EPPI: literature review
Health		
Female toilets on girl's enrollment and attendance	Birdthishle (2011)	SR: (LSHTM/IOE)
School feeding on nutritional outcomes	Kirstjansson (2006)	EPPI-centre: SR
Deworming and attendance & nutrition	T.-Robinson (2012)	EPPI-centre: SR
Effects of assessment programs on educational policy	Best (2013)	EPPI-centre: SR
ICTs		
ICT4D partnerships	Geldorf (2011)	DFID: SR
M4D approaches	Donner (2007)	Literature review
ICTs and other technology (no mobile)	Waxman (2003)	MA
Lit review of evaluations of OLPC	Nguhro (2010)	Literature review

Mobile computer-supported collaborative learning. A review of experimental research	Hsu (2013)	Review
Single interventions		
CCT/UCTs on enrollment; attendance; test scores	Baird (2013)	Campbell: SR
Effectiveness of school vouchers	Morgan (2013)	EPPI-centre: SR
Effectiveness of School-based monitoring	BarreraOsorio (2012)	WB: review
Effectiveness of school-based decision making	Carr-Hill (2016)	Campbell: SR
Other		
Effectiveness of higher education	Clifford (2013)	EPPI-centre: SR
Education and economic growth	Hawkes (2012)	EPPI-centre: SR
Access to education for people with disability	Bakhshi (2013)	EPPI-centre: SR

(5) Website search of mobile learning for development projects:

List of projects:

Road to reading; World Reader; Project ABC; Paje Nieta; EIA; Shaquodon; Yoza; MILLE; Programa Nacional de Alfabetización; Cambridge to Africa (deaf); PSU Movile learning assessment through mobile; Educational bridges; roots of mobile learning ; SMILE; Jokko intiative; Fire & Gold; eSchool 360; Impact network; mUbuntu; eLife; Tangerine; Total Reading Approach for Children; Cocoa Link; Global Literacy Professional Development Network; Ustad Mobile; FATIH project turkey; LISTA; 1001 across radio; AlfabeTIC; Bangladesh Virtual Interactive Classrooms; BridgeIT; Bridges to the future; Broad Class; Bunyad Mobile; Dr Math; eEGRA; FunDza; Interactive Radio Instruction; International Children's Digital Library; Women Mobile Literacy Afghanistan; SIRIP Somali Interactive Radio Instruction Program; Shellbooks; Mobiliteracy Uganda; MoMath; Senmobil; Nokia life tools; Earth Institute; Sesam; Teacher mate; Pratham; PIEQ; PAJEF; OLPC; Twaweza; Tessa; IFADEM

Overview of search results

Academic hits combined	24,010	Individual sources: 37/37
Grey literature	7,992	Individual sources: 71/71
ACADEMIC LITERATURE		
Total studies	**32,002**	**Individual sources: 108/108**
Databases	Hits (of interest)	Search terms / comments
ACM Library **keyword, abstract**	681 (4) 23 (1)	“mobile learning” “mobile education”
	0 296 (3)	“mobile teaching” ‘developing countries’ key word
EBCSO including: Academic Search Complete, ERIC, EconLit, Education FullTexts, Teacher Reference Centre	1144 (71) 3 9 (2) 5 (1) 65 5302 (82)	(1) AND (2) [‘LIC’ and ‘MIC’ terms not working] “mobile learning for development” “mobile education for development” “mobile learning” AND (“international development” OR poverty) mobile learning AND "develop* countr*" OR "develop* nation" OR "low income countr* " OR poor “mobile learning” OR “mobile education”
EdITLib (Digital Library for Education and Information technology)	1234 (36) 109 (8)	“mobile learning” “mobile education”
ELDIS	244	Mobile OR phone OR tablet OR device in ‘ICT for development category’
IOE library guides International Education Guide	0 0	“mobile learning” OR “mobile education” “mobile learning” OR “mobile education”

OER Guide	0	
JSTOR	3393 (22)	(“mobile learn* “) OR mlearning OR m-learning OR (“mobile educat*”) OR meducation OR m-education OR (“mobile phone” AND learning) OR (“mobile phone" AND education) OR (“mobile phone” AND teaching)
SabiNet	2324 (12) 153	“mobile learning” “mobile education”
Science Direct* *Saved search and weekly update via search alerts*	670 (12) 0 66 (4) 828 (18)	“mobile learning” “mobile learning for development” “mobile education” (((mobile learn* “) OR (mobile AND learn*) OR mlearning OR (“mobile educat*”) OR medication OR (mobile AND education) OR (mobile AND teach*”) OR (“mobile technolog*” AND learn*)) and development OR “international development” OR “social development” OR poverty OR inequality OR “social change” OR (“develop* countr*”) OR (“develop* nation”) OR (“develop* world”) OR (“low income countr*”) OR (“middle income nation”)))
Taylor&Francis *Saved search and weekly update via search alerts*	230 (12) 62 (4) 0 2245 (43)	“Mobile learning” “Mobile education” “mobile learning for development” in Abstract: (“mobile learn* “) OR mlearning OR m-learning OR (“mobile educat*”) OR meducation OR m-education OR (“mobile teach*”) OR “portable interactive learning technology” OR (“mobile phon*” AND learn*) OR (“mobile phon* AND educat*) OR (“mobile phon*” AND teach*) OR (“smart phon*” AND learn*) OR (“smart phon* AND educat*) OR (“smart phon*” AND teach*) OR

		("mobile devic*" AND learn*) OR ("mobile devic*" AND educat*) OR ("mobile devic*" AND teach*) OR ("mobile technolog*" AND learn*) OR ("mobile technolog*" AND educat*) OR ("mobile technolog*" AND teach*) OR "mobile and contextual learning"
ISI web of science *Saved search and weekly update via search alerts*	1272 (18)	"mobile learn*" OR "mobile educat*"
Database hits (screened on title, key word and abstract for relevant)	*21,014*	*Not controlled for duplicated*
Journals	Hits (of interest)	Search terms / comments
British Journal of Educational Technology	417 (9)	Mobile
Educational researcher	212 (0)	Mobil* OR tablet* OR phone* OR device*
European Journal of Open, Distance, and e-Learning	7 (1)	Keyword: Mobiles
Computers & Education	178 (4)	"Mobile learn*"
Journal of Sustainable Development	354 (0)	(mobile) OR (technologies) OR (ICT) OR (mobile learning)
Journal of Economic Development	270 (0)	(mobile)
Economic Development and Cultural Change	134 (1)	(mobile OR learning OR technology OR ICT)
South African Journal of Information Management	16 (2) 7 10	"mobile" "mobile learning" "mobile education"
International Journal of Interactive Mobile Technologies (iJIM)	65 (3) 0 2 (1)	"development" "poverty" "social change"
Electronic Journal of	0	"Mobile learning"

Information Systems in Developing Countries	10 (1) 18 201 (2) 18	“Mobile education” “Mobile phones” “Development” “Poverty”
Computers and Human behavior	49	“Mobile learning” OR “mobile education”
Information, Communication & Society	181	Mobile AND learning
Journal of the learning sciences	0 29 5 26	“Mobile learning” Mobile AND learning ICT Phones
Learning Media and Technology	3 (2) 1 (1) 162 (6)	“Mobile learning” “Mobile education” Mobile AND learning
World Bank Research Observer	37 (0) 2 (0) 115 (0)	Mobile ICT mobile AND technologies
World Development	468 (1)	(mobile learning) OR (mobile technologies) OR (mobile education)
Journal hits (screened on title, key word and abstract for relevant	*2996*	*Not controlled for duplicated*
Journals (hand-searched)	Hits (of interest)	Search terms / comments
African Journal of Information and Communication	Hand-searched (0)	N/A
Computers and Human behavior	Hand-searched 24	N/A
Information Technologies and International Development	Hand-searched 36	N/A
Information Technology for	Hand-searched 0	N/A

Development		
International Journal on Advances in ICT for Emerging Regions	Hand-searched (2)	N/A
International Journal of Educational Development	Hand-searched 2004-2014 (37)	N/A
International Journal of Education and Development Using Information and Communication Technology	Hand-searched (27)	N/A
Journal of Computer Assisted Learning (JCAL)	Hand-searched 2004-2014 (20)	N/A
Journal of Development Effectiveness	Hand-searched 2004-2014 (4)	N/A
Journal of Health Informatics in Developing Countries	Hand-searched (2)	N/A
Journal of International Development	Hand-searched 2004-2014 (7)	N/A
Academic hits combined	**24,010**	**Individual sources: 37/37**
GREY LITERATURE		
Online Sources	*Hits (of interest)*	*Search terms / comments*
AusAID	67 2	“education category” “mobile”
Bill & Melinda Gates Foundation	142	“mobile”
Centre for education Innovations	56	“educational technology category”
DIFD	98 (32)	‘ICTs in education category’

	10 (8)	(‘mobile learning’ OR ‘mobile education’)
EduTech blog	Hand-searched	N/A Blog printed out as PDF, to be screened
ICT4D blog	Hand-searched	N/A
Innovation for poverty action	116 (6) 78	(mobile OR learning OR technology OR ICT) ‘education category’
JPAL	Hand-searched 466 (7)	N/A
Google	2000	“mobile learning” AND development “mobile learning for development” (exact term)
Google scholar	1000 (14) 17 (4)	“mobile learning” AND development “mobile learning for development” (exact term)
GSMA	Hand-searched 238 (6)	N/A
IICD	33 (12)	‘education category’
IDRC (IDL)	127 (2)	"mobile learning" OR "mobile education" OR "mobile for development" OR "mobile learning for development"
International Association for Mobile Learning	148 (1)	Mobile learning bibliography
LKL	312 23	“Mobile learning” Publications category
NORAG	7 65	‘mobile’ ‘ict’
OECD	16 191	(“mobile learning” OR “mobile education”) ‘ICT AND Development’
ODI	6 4 16 (1) 190	“mobile learning” “mobile education” “mobile technologies” “mobile phones”

RECOUP	4	'mobile'
UNESCO	12	
IADB Impact Evaluation Database	61	'education category'
IDRC	532	'education category'
WB publications	66 838	'ICT category' "mobile phones"
	5	"mobile technologies"
WB infoDev	Hand-searched 52 (4)	N/A
3ie	667 (25)	'education category'
Total	*5476*	

Conference proceedings	*Hits (of interest)*	*Search terms / comments*
eLearning Africa	Hand-searched	N/A
IADIS International Conference Mobile Learning (2005-2011	Hand-searched	N/A
ICTD (2006-2013)	Hand-searched	N/A
INTEL education summit (2011; 2012	Hand-searched	N/A
mEducation symposium (2011, 2012, 2013	Hand-searched	N/A
mLearn (2002-2011	Hand-searched	N/A
UNESCO mobile learning weeks (2011; 2013;2014	Hand-searched	N/A
Wireless, Mobile and Ubiquitous Technologies in Education (WMUTE);)	Hand-searched	N/A
Citation Searches / Reference Searches	*Hits (of interest)*	*Search terms / comments*
Ally (2009) Mobile Learning: Transforming the Delivery of Education and Training	205	N/A
Donner (2008) Research Approaches to Mobile Use in the Developing World: A Review of the Literature.	381	N/A
Frohberg (2009) Mobile learning projects – a	162	N/A

critical analysis of the state of the art		
Kinuthia & Marshal (eds) (2013) On the move: Mobile Learning for Development	0 – Interesting, shows term is not widely used	N/A
Kukulska-Hulme & Traxler (2005) M-learning: A Handbook for Educators and Trainers.	401	N/A
Naismith et al (2004) Literature Review in Mobile Technologies and Learning.	629	N/A
Pachler et al (2010) Mobile learning: structures, agency, practices.	177	N/A
Sharples et al (2007) A Theory of Learning for the Mobile Age.	407	N/A
Traxler (2006) Mobile learning in developing countries	25 – interesting, shows term is not widely used	N/A
Traxler (2009) Learning in a mobile age	129	N/A
Worldreader (2012) iRead Ghana study. Final evaluation report.	0 – interesting, shows term is not widely used	N/A
Total	*2516*	
Contact experts	*Date contacted*	*Response*
Mohamed Ally Marie-Lise Bourcier John Cook Jonathan Donner Richard Heeks Agnes Kukulska-Hulme Dorothea Kleine Tim Unwin Mike Sharples John Traxler Michael Trucano Niall Winters Maggie Verster Steve Vosloo	See separate sheet	
Twitter	*Hits*	*First used*
♯ m4d ♯ ict4d ♯ ict4e ♯ mlearning	43 63 18 32	
Grey literature combined	**7,992**	**Individual sources: 71/71**

Appendix 4.2: Mixed-methods critical appraisal tool

Study type	**Methodological appraisal criteria**	**Response**		
		Yes	No	Comment
Screening questions: assessing 'fatal flaws' (Dixon-Woods 2005) *Aggregative 'fatal flaws' based on Stewart et al (2014)* *Configurative 'fatal flaws' based on Pawson (2003) TAPUS framework*	<u>Aggregative assessment:</u> ✓ Study reports primary data and applied methods ✓ Study reports before and after data[1] ✓ Study features an intervention and control group			
	<u>Configurative assessment:</u> ✓ Study reports primary data and applied methods ✓ Study states clear research questions and objectives ✓ Study states clear research design, which is appropriate to address the stated research question and objectives (*Purposivity*) ✓ The findings of the study are based on collected data, which justify the knowledge claims (*Accuracy*)			
	Screening question based on abstract and/or superficial reading of full-text: ***Further appraisal is not feasible or appropriate when the answer is 'No' to any of the above screening questions!***			
Study type	**Methodological appraisal criteria**	**Response**		
		Yes	No	Comment / Confidence judgment
1. Qualitative *e.g.* *(A) Ethnography* *(B) Phenomenology* *(C) Narrative* *(D) Grounded theory* *(E) Case study*	**I. RESEARCH IS DEFENSIBLE IN DESIGN** (providing a research strategy that addresses the question) <u>Appraisal indicators:</u> ✓ *Is the research design clearly specified and appropriate for aims and objectives of the research?* Consider whether			
	i. there is a discussion of the rationale for the study design			

<table>
<tr><td rowspan="20"></td><td colspan="4">ii. the research question is clear, and suited to qualitative inquiry</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">iii. there are convincing arguments for different features of the study design</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">iv. limitations of the research design and implications for the research evidence are discussed</td><td></td><td></td><td></td></tr>
<tr><td>Defensible</td><td>Arguable</td><td>Critical</td><td>Not defensible</td><td colspan="3">Worth to continue:</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="4">II. RESEARCH FEATURES AN APPROPRIATE SAMPLE
(following an adequate strategy for selection of participants)

<u>Appraisal indicators:</u>

Consider whether</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">i. there is a description of study location and how/why it was chosen</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">ii. the researcher has explained how the participants were selected</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">iii. the selected participants were appropriate to collect rich and relevant data</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">iv. reasons are given why potential participants chose not take part in study</td><td></td><td></td><td></td></tr>
<tr><td>Appropriate sample</td><td>Functional sample</td><td>Critical sample</td><td>Flawed sample</td><td colspan="3">Worth to continue:</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="4">III. RESEARCH IS RIGOROUS IN CONDUCT
(providing a systematic and transparent account of the research process)

<u>Appraisal indicators:</u>

Consider whether</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">i. researchers provide a clear account/description of the process by which data was collected (e.g. for interview method, is there an indication of how interviews were conducted?/procedures for collection or recording of data?)</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">ii. researchers demonstrate that data collection targeted depth, detail and richness of information (e.g. interview/observation schedule)</td><td></td><td></td><td></td></tr>
</table>

<table>
<tr><td rowspan="14"></td><td colspan="4">iii. there is evidence of how descriptive analytical categories, classes, labels, etc. have been generated and used</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">iv. presentation of data distinguishes clearly between the data, the analytical frame used, and the interpretation</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">v. methods were modified during the study; and if so, has the researcher explained how and why?</td><td></td><td></td><td></td></tr>
<tr><td>Rigorous conduct</td><td>Considerate conduct</td><td>Critical conduct</td><td>Flawed conduct</td><td colspan="3">Worth to continue:</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="4">IV. RESEARCH FINDINGS ARE CREDIBLE IN CLAIM/BASED ON DATA
(providing well-founded and plausible arguments based on the evidence generated)

<u>Appraisal indicators:</u>

Consider whether</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">i. there is a clear description of the form of the original data</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">ii. sufficient amount of data are presented to support interpretations and findings/conclusions</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">iii. the researchers explain how the data presented were selected from the original sample to feed into the analysis process (i.e. commentary and cited data relate; there is an analytical context to cited data, not simply repeated description; is there an account of frequency of presented data?)</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">iv. there is a clear and transparent link between data, interpretation, and findings/conclusion</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">v. there is evidence (of attempts) to give attention to negative cases/outliers etc.</td><td></td><td></td><td></td></tr>
<tr><td>Credible claims</td><td>Arguable claims</td><td>Doubtful claims</td><td>Not credible</td><td colspan="3">If findings not credible, can data still be used?</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="4">V. REASEARCH ATTENDS TO CONTEXTS
(describing the contexts and particulars of the study)</td><td></td><td></td><td></td></tr>
</table>

	<u>Appraisal indicators:</u> Consider whether			
	i. there is an adequate description of the contexts of data sources and how they are retained and portrayed?			
	ii. participants' perspectives/observations are placed in personal contexts			
	iii. appropriate consideration is given to how findings relate to the contexts (how findings are influenced by or influence the context)			
	iv. the study makes any claims (implicit or explicit) that infer generalisation (if yes, comment on appropriateness)			
	Context central | **Context considered** | **Context mentioned** | **No context attention**			
	VI. RESEARCH IS REFLEXIVE (assessing what factors might have shaped the form and output of research) <u>Appraisal indicators:</u> Consider whether			
	i. appropriate consideration is given to how findings relate to researchers' influence/own role during analysis and selection of data for presentation			
	ii. researchers have attempted to validate the credibility of findings (e.g. triangulation, respondent validation, more than one analyst)			
	iii. researchers explain their reaction to critical events that occurred during the study			
	iv. researchers discuss ideological perspectives/values/philosophies and their impact on the methodological or other substantive content of the research (implicit/explicit)			
	Reflection | **Consideration** | **Acknowledgement** | **Unreflective research**	*NB: Can override previous exclusion!*		
OVERALL DECISCON – EXLUDE / INCLUDE (study generates new knowledge relevant to the review question and complies with minimum criteria to ensure reliability and empirical grounding of knowledge)				

Sources used in this section (in alphabetical order); Campbell et al (2003); CASP (2006); CRD (2009); Dixon-Woods et al (2004); Dixon-Woods et al (2006)[cited in Gough 2012]; Greenhalgh & Brown (2014); Harden et al (2004)[cited in SCIE & Gough 2012]; Harden et al (2009); Harden & Gough (2012); Mays & Pope (1995); Pluye et al (2011); Spencer et al 2006; Thomas et al (2003); SCIE (2010).

Study type	**Methodological appraisal criteria**				**Response** Yes	No	Comment / risk of bias judgment
2. Quantitative *(non-randomised; Randomised-Controlled)*	**I. Selection bias:** (Are participants recruited in a way that minimizes selection bias?) <u>Appraisal indicators:</u> Consider whether						
	i. there is a clear description of how and why sample was chosen						
Common non-random design include:	*ii. there is adequate sample size to allow for representative and/or statistically significant conclusions*						
	iii. participants recruited in the control group were sampled from the same population as that of the treatment						
(A) Non-randomised CT *(B) Cohort studies*	*iv. group allocation process attempted to control for potential risk of bias*						
(C) Case-control *(D) Cross-sectional analytical studies*	**Low risk of bias**	**Risk of bias**	**High risk of bias**	**Critical risk of bias**	*Worth to continue:*		
Most common ways of controlling for bias due to baseline confounding:	**II. Bias due to baseline confounding:** (Is confounding potentially controllable in the context of this study?) <u>Appraisal indicators:</u> Consider whether						
• Matching attempts to emulate randomization	*i. the treatment and control group are comparable at baseline*						
	ii. matching was applied, and in case, featured sufficient criteria						
• Propensity score matching and	*iii. the authors conducted an appropriate analysis that controlled for all potential critical confounding domains*						

<table>
<tr><td rowspan="14">methods
• Stratification where sub-groups have been compared
• Regression analysis where covariates are adjusted for

Randomised designs:
Randomised Control Trial (RCT)</td><td colspan="4">iv. the authors avoided to adjust for post-intervention variables</td><td></td><td></td><td></td></tr>
<tr><td>Low risk of bias</td><td>Risk of bias</td><td>High risk of bias</td><td>Critical risk of bias</td><td colspan="3">Worth to continue:</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="4">IF RANDOMISED CONTROL TRIAL, SKIP I + II AND START HERE!
Bias due to ineffective randomisation:
(Is allocation of treatment status truly random?)

<u>Appraisal indicators:</u>

Consider whether</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">i. there is a clear description of the randomisation process</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">ii. the unit of randomisation and number of participants is clearly stated (pay special attention to treatment and control locations/ balance)</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">iii. eligibility criteria for study entry are specified</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">iv. characteristics of baseline and endline sample are provided[1]</td><td></td><td></td><td>Preferable condition, see 1</td></tr>
<tr><td>Low risk of bias</td><td>Risk of bias</td><td>High risk of bias</td><td>Critical risk of bias</td><td colspan="3">If critical risk of bias, treat as non-random study</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="4">III. Bias due to departures from intended interventions
(Was the intervention implemented as laid out in the study protocol?)

<u>Appraisal indicators:</u>

Consider whether</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">i. the critical co-interventions were balanced across intervention groups</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">ii. treatment switches were low enough to not threaten the validity of the estimated effect of intervention</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">iii. implementation failure was minor and unlikely to threaten the validity of the outcome estimate</td><td></td><td></td><td></td></tr>
</table>

<table>
<tr><td rowspan="15"></td><td colspan="4">iv. it is possible that intervention was taken by the controls (contamination and possible crossing-over)*</td><td></td><td></td><td>*whilst challenging in terms of estimating impact, spill-overs might be an important finding in itself (eg teachers read to pupils/village/family members)</td></tr>
<tr><td colspan="4">v. it is possible that knowledge of the intervention group affects how the two study groups are treated in course of follow-up by investigators?**</td><td></td><td></td><td>**consider only in extreme cases in which preferential treatment is clearly evident; blinding in general not expected in social interventions</td></tr>
<tr><td>Low risk of bias</td><td>Risk of bias</td><td>High risk of bias</td><td>Critical risk of bias</td><td colspan="3">Worth to continue:</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="4">IV. Bias due to missing data (attrition)
(Are the intervention groups free of critical differences in participants with missing data?)

<u>Appraisal indicators:</u>

Consider whether</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">i. outcome data are reasonably complete (80% or above)</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">ii. If ‘no’, are missing data reported?</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">iii. If missing data: are proportion of participants and reasons for missing data similar across groups?</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">iv. If missing data: Were appropriate statistical methods used to account for missing data? (e.g. sensitivity analysis)</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">v. If not possible to control for missing data, are outcomes with missing data excluded from analysis?</td><td></td><td></td><td></td></tr>
<tr><td>Low risk of bias</td><td>Risk of bias</td><td>High risk of bias</td><td>Critical risk of bias</td><td colspan="3">Worth to continue:</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="4">V. Outcome reporting bias
(Are measurements appropriate, e.g. clear origin, or validity known?)</td><td></td><td></td><td></td></tr>
</table>

	<u>Appraisal indicators:</u> Consider whether			
	*i. there was an adequate period for follow up****			****in many social science interventions, follow-up is not required to coincide with the start of the treatment; further, longer period of follow up are often required to measure changes. In the context of education, the question of retention – in particular when dealing with short intervention periods –(< 1 month) is of major interest.*
	ii. the outcome measure was clearly defined and objective			
	iii. outcomes were assessed using standardised instruments and indicators			
	iv. outcome measurements reflect what the experiment set out to measure			
	v. the methods of outcome assessment were comparable across experiential groups			
	Low risk of bias | **Risk of bias** | **High risk of bias** | **Critical risk of bias**	*Worth to continue:*		
	VI. Bias in selection of results reported (Are the reported outcomes consistent with the proposed outcomes at the protocol stage?) <u>Appraisal indicators:</u> Consider whether			
	i. it is unlikely that the reported effect estimate is available primarily because it was a notable finding among numerous exploratory analyses			
	ii. it is unlikely that the reported effect estimate is prone to selective reporting from among multiple outcome measurements within the outcome domain			

	iii. it is unlikely that the reported effect estimate is prone to selective reporting from among multiple analyses of the outcome measurements			
	*iv. the analysis includes an intention to treat analysis? (If so, was this appropriate and were appropriate methods used to account for missing data?)*****			*****usually in clinical RCTs, rare in social science: only rate if conducted*
	Low risk of bias | **Risk of bias** | **High risk of bias** | **Critical risk of bias**			
OVERAL RISK OF BIAS:				
Sources used in this section (in weighted order): Cochrane (2014); Stewart et al (2014); Stewart et al (2012); Higgins et al (2011); Greenhalgh & Brown (2014); Pluye et al (2011); Gough et al (2007)[Weight of evidence thingi]				

Study type	**Methodological appraisal criteria**	**Response** Yes	No	Comment /confidence judgment
3. Mixed-methods[2] <u>*Sequential explanatory design*</u> *The quantitative component is followed by the qualitative. The purpose is to explain quantitative results using qualitative findings. E.g., the quantitative results guide the selection of qualitative data sources and data collection, and the qualitative findings contribute to the interpretation of quantitative results.* <u>*Sequential exploratory design*</u> *The qualitative component is followed by the quantitative. The purpose is to explore, develop and test an instrument (or taxonomy), or a conceptual framework (or theoretical model). E.g., the qualitative findings inform the quantitative data*	**I. RESEARCH INTEGRATION/SYNTHESIS OF METHODS** (assessing the value-added of the mixed-methods approach) Applied mixed-methods design: ○ Sequential explanatory design ○ Sequential explorative design ○ Triangulation design ○ Embedded design <u>Appraisal indicators:</u> Consider whether			
	i. the rationale for integrating qualitative and quantitative methods to answer the research question is explained [DEFENSIBLE]			

collection, and the quantitative results allow a generalization of the qualitative findings. *Triangulation designs* *The qualitative and quantitative components are concomitant. The purpose is to examine the same phenomenon by interpreting qualitative and quantitative results (bringing data analysis together at the interpretation stage), or by integrating qualitative and quantitative datasets (e.g., data on same cases), or by transforming data (e.g., quantization of qualitative data).* *Embedded/convergent design* *The qualitative and quantitative components are concomitant. The purpose is to support a qualitative study with a quantitative sub-study (measures), or to better understand a specific issue of a quantitative study using a qualitative sub-study, e.g., the efficacy or the implementation of an intervention based on the views of participants.*	*ii. the mixed-methods research design is relevant to address the qualitative and quantitative research questions, or the qualitative and quantitative aspects of the mixed methods research question [DEFENSIBLE]*			
	iii. there is evidence that data gathered by both research methods was brought together to inform new findings to answer the mixed-methods research question (e.g. form a complete picture, synthesise findings, configuration) [CREDIBLE]			
	iv. the approach to data integration is transparent and rigorous in considering all findings from both the qualitative and quantitative module (danger of cherry-picking) [RIGOROUS]			
	v. appropriate consideration is given to the limitations associated with this integration, e.g., the divergence of qualitative and quantitative data (or results)? [REFLEXIVE]			

For mixed-methods research studies, each component undergoes its individual critical appraisal first. Since qualitative studies are either included or excluded, no combined risk of bias assessment is facilitated, and the assigned risk of bias from the quantitative component similarly holds for the mixed-methods research.

The above appraisal indicators only refer to the applied mixed-methods design. If this design is not found to comply with each of the four mixed-methods appraisal criteria below, then the quantitative/qualitative components will individually be included in the review:

Mixed-methods critical appraisal:	Qualitative critical appraisal:	Quantitative critical appraisal:
1. Research is defensible in design 2. Research is rigorous in conduct 3. Research is credible in claim 4. Research is reflective	Include / Exclude	1. Low risk of bias 2. Risk of bias 3. High risk of bias 4. Critical risk of bias

Combined appraisal: Include / Exclude mixed-methods findings judged with _____________________________ risk of bias		
Section based on Pluye et al (2011). Further sources consulted (in alphabetical order): Creswell & Clark (2007); Crow (2013); Long (2005); O'Cathain et al (2008); O'Cathain (2010); Pluye & Hong (2014); Sirriyeh et al (2011).		

[1] Two theoretical exceptions to this rule apply:

i) A RCT with appropriate randomization procedure can be included without showing baseline data, as both experimental groups can be assumed to be equal at baseline by design.

ii) A sophisticated quasi-experimental design such as PSM or RDD in theory could make the same claim to not require baseline data.

In both cases, the advise of an evaluation specialist will be thought as the researcher does not have the capacity to make an informed judgment in such specialist cases.

[2] The mixed-methods Critical Appraisal is facilitated for studies applying an explicit mixed-methods approach. The component is applied in addition to criteria for the qualitative component (I to VI), and appropriate criteria for the quantitative component (I to VI).

Appendix 4.3: Effect size calculations

Corrected SMD and corrected Standard Errors (SE) will be estimated as follows:

$$SMD_{corrected} = SMD_{uncorrected} * \left[1 - \frac{3}{4 * (n_t + n_c - 2) - 1}\right]$$

$$SE(SMD)_{corrected} = SE(SMD)_{uncorrected} * \left[1 - \frac{3}{4 * (n_t + n_c - 2) - 1}\right]$$

For regression-based estimates, we will follow Keef and Roberts (2004: p100-101; p129, equation A9) to correct for potential sample bias in the effect sizes.
Many of the impact evaluation designs that we expect to see in this review are likely to use complex statistical analyses, and there is a lack of standard methods for computing effect sizes from these designs. In most cases we expect our approach for computing effect sizes to be as follows.

Calculating standardised mean differences
For studies reporting matching-based estimates, the following formulae to compute *g* and its standard error will be used, where Y_t and Y_c are the post-intervention mean outcome in the treatment group and control group respectively.

$$SMD = \frac{Y_t - Y_c}{S_p}$$

To calculate S_p, the pooled standard deviation (the standard deviation of the outcome variable for both treated (S_t) and control (S_c) individuals), we will use the Hedges' approach described in Lipsey and Wilson (2001), where n_t and n_c are the sample size of the treatment and the control group.

$$S_p = \sqrt{\frac{(n_t - 1) * S_t^2 + (n_c - 1) * S_c^2}{n_t + n_c - 2}}$$

The standard error of *g* will be computed using the following formula.

$$SE\ (SMD) = \sqrt{\frac{n_t + n_c}{n_t * n_c} + \frac{SMD^2}{2 * (n_c + n_t)}}$$

Alternatively, in the event that the necessary information for calculating SE is not available, we will approximate it as follows, where *t* is the *t* statistic of the treatment effect.

$$SE\ (SMD) = \frac{SMD}{t}$$

For regression-based studies, we intend to use the following formula described in Keef and Roberts (2004), where β is the coefficient of interest (i.e. yielding the impact of the intervention) and σ is the standard deviation of the error term in a regression.

$$SMD = \frac{\beta}{\sigma}$$

Where σ is not reported by the study authors (highly likely), we will use the following formula to compute an equivalent using the sample standard deviation of the dependent variable and the sample size for both treatment and control groups.

$$S_p = \sqrt{\frac{(SD_y^2 * (n_t + n_c - 1) - \frac{(\beta^2 * (n_t * n_c))}{n_t + n_c}}{n_t + n_c}}$$

Standard errors will be approximated using the following formula where *t* is the *t* statistic for the regression coefficient.

$$SE\ (SMD) = \frac{SMD}{t}$$

Conversion of SMDs into percentages

In general, an effect size of 0.10 reflects 1/10 standard deviation improvement for the treatment group (i.e. learners engaged in the mobile learning intervention) compared to the control group (Petrosino et al 2010). In an attempt to make this measurement scale less abstract, Rosenthal and Rubin (1982) convert the SDM to a percentage expression of the change between experimental groups. Based on this approach, a more intuitive translation of effect sizes is presented below. For example, a SDM of 0.10 represents and improvement of 5 per cent in the intervention group.

Effect size (cohen's *d*)	Percentage success Treatment	Percentage Success Control	Difference in success rates
0.00	50.0	50.0	0
0.10	52.5	47.5	5%
0.20	55.0	45.0	10%
0.30	57.4	42.6	14.8%
0.40	59.8	40.2	19.6%
0.50	62.1	37.9	24,2%
0.60	64.4	35.6	28.8%

Translation of effect sizes ***Table adapted and updated from Petrosino et al 2012, based on calculation formula by Rosenthal and Rubin (1982). Note calculation in the meta-analysis are based on*** **g*****, a sample size correct version of*** **d*****. The correction has marginal implications for the above translation.***

Appendix 4.4: Interview guide

1. **Introduction**
   - Provide information sheet and give verbal introduction to myself and research
   - Provide consent form and talk through if needed
   - Survey monkey on basic demographic information together on tablet

2. **Start semi-structured conversation**

2.1 Basic information around ICT4RED (≈5 mins)

Pointers:
- How long have you been a teacher?
- Why did you become a teacher; what do you value about it?
- How long have you been involved in the ICT4RED project?
- How were people chosen for ICT4RED?
- Why did you choose project involvement?
- How has it been received at your school/community?

2.2 Teachers' experiences of using the tablets (≈10 mins)

Pointers:
- In general, what do you value about mobile technology in your normal life?
- What was your experience of learning how to teach with the tablet?
- Do you feel like you can use ICTs now? And if so, do you value this, don't you value this?
- What do you value about using mTech in your daily teaching; what don't you value?
- Can you describe how you teach with the tablets?
  - Main functions of using it? What do you do with the mtech?
- Where do you use it most?
- Do you think it is important / not important for a teacher to be able to use and teach with mtech?
  - Would you recommend it?

2.3 Teachers' personal development (≈10 mins)

Pointers:
- Has the experience of using mtech changed from when you started?
- Has experience of using mtech changed you? Do you value these changes; don't you value these changes?
- What was your biggest success/nicest memory of using the tablets?
  - If you feel comfortable sharing it with me, what was a disappointment in using the tablets?
- What do you think other people (colleagues, family, community) think about you using tablets to teach?
- Do you use the tablet at home and with your family?
  - Do you use it for your own or your family's education?

2.4 Teacher's educational experience (≈10 mins)

Pointers:

- Recap on this: *Do you think it is important / not important for a teacher to be able to use and teach with mtech?*
- Can you elaborate on what are things you are able to do now in your teaching that you weren't able to before? Do you value/not value these changes?
- Do you think that the tablets have helped you reach your teaching goals (reformulate as: *reach your goals as a teacher*?) Or have they hindered you?
- In your opinion, is mtech like the tablets an educational tool, or not?
    - o What is the difference between using mobile technology vs. normal ICTs?
- Can you describe the perfect teacher to me?

3. Debrief

- Is there anything else you want to tell me?
- Explain what happens next.

Appendix 4.5: Observation schedule[85]

Classroom set up:	Organisation and state of furniture; Classroom atmosphere (lighting, pictures on the wall, temperature, etc) Number of learners:
Educational material	
ICT material	What devices in use? What educational content is on the tablets?
Lesson content	
Class atmosphere	Greetings, etc
Class interaction	Questions? Encouragement for questions? Praises?
Class participation	Who? On what terms? Who's in control?
What teaching methods?	
Teachers' behaviour	
Learners' behaviour	

[85] Formatting adapted for publication in the thesis.

Technology event teacher:

Event	*Perception/Usage*	*Traditional (substitute)*	*Unique affordance of technology that supported the event*
Event 1: Taking pictures of the school garden to teach a class on botany	E.g. Tech literate; Eagerness to use them; Handle with care	Taking notes / sketches of the plants	Taking pictures and videos

Technology event learner:

	Perception/Usage	*Traditional (substitute)*	*Unique affordance (independent)*
Event 1: Taking pictures of the school garden to teach a class on botany	E.g. Tech literate; Eagerness to use them; Handle with care	Taking notes / sketches of the plants Presenting about the plants to the rest of the class using pictures and videos of the plant	Taking pictures and videos

Learner-centred teaching:

General	*Participatory*	*Interactive*	*Authenticity*	*Personalisation*	*Collaboration*	*Who's in power?*	*Learn on your own?*

Appendix 5.1: List of included studies

Aker, J. C., Ksoll, C., & Lybbert, T. J. (2012). Can mobile phones improve learning? Evidence from a field experiment in Niger. *American Economic Journal: Applied Economics*, 4(4), 94-120.

- Aker, J. C., Ksoll, C., & Lybbert, T. J. (2010). ABC, 123: The impact of a mobile phone literacy program on educational outcomes. CGD Working Paper 223. Washington, D.C.: Center for Global Development.

Aker, J. C., & Ksoll, C. (2015). Call Me Educated: Evidence from a Mobile Monitoring Experiment in Niger. CGD Working Paper 406. Washington, DC: Center for Global Development.

Aladejana, F. Mobile Phones in Higher Education Institutions: A Case Study of a Nigerian University. Currently unavailable online.

Ale, K., & Chib, A. (2011). Community factors in technology adoption in primary education: Perspectives from rural India. *Information Technologies & International Development*, *7*(4), 53-68.

Andersson, A., & Hatakka, M. (2010). Increasing interactivity in distance educations: Case studies Bangladesh and Sri Lanka. *Information Technology for Development*, *16*(1), 16-33.

Balasubramanian, K., Thamizoli, P., Umar, A., & Kanwar, A. (2010). Using mobile phones to promote lifelong learning among rural women in Southern India. *Distance Education*, *31*(2), 193-209.

Bello-Bravo, J., & Baoua, I. (2012). Animated videos as a learning tool in developing nations: A pilot study of three animations in Maradi and surrounding areas in Niger. *The Electronic Journal of Information Systems in Developing Countries*, 55.

Beltramo, T., & Levine, D. (2012). Do SMS Text Messaging and SMS Community Forums improve outcomes of adult and adolescent literacy programs? Accessed 13 October 2017: http://escholarship.org/uc/item/1c31c2m4

Binsaleh, S., & Binsaleh, M. (2013). Mobile learning: What guidelines should we produce in the context of mobile learning implementation in the conflict area of the four southernmost provinces of Thailand. *Asian Social Science*, 9(13), 270-281.

Bridge International Academies. (2013. The Bridge Effect: Comparison of Bridge Pupils to Peers at Nearby Schools EGRA-EGMA Evaluation Programme. Accessed 13 October 2017: http://www.bridgeinternationalacademies.com/wp-content/uploads/2013/01/Bridge-International-Academies_White-Paper_The-Bridge-Effect_Nov-2014_Website.pdf

Chang, A. Y., Ghose, S., Littman-Quinn, R., Anolik, R. B., Kyer, A., Mazhani, L., ... & Kovarik, C. L. (2012). Use of mobile learning by resident physicians in Botswana. *Telemedicine and e-Health*, 18(1), 11-13.

Chen, C. M., & Li, Y. L. (2010). Personalised context-aware ubiquitous learning system for supporting effective English vocabulary learning. *Interactive Learning Environments*, 18(4), 341-364.

Cilliers, J., Kasirye, I., Leaver, C., Serneels, P., & Zeitlin, A. (2014). Improving teacher attendance using a locally managed monitoring scheme: Evidence from Ugandan Primary Schools. Policy note14/0189. London, UK: International Growth Centre Accessed 13 October 2017: https://www.theigc.org/wp-content/uploads/2014/09/Cilliers-Et-Al-2014-Policy-Brief.pdf

Cole, S., & Fernando, A. N. (2012). The value of advice: Evidence from mobile phone-based agricultural extension. Accessed 13 October 2017: http://hbswk.hbs.edu/item/the-value-of-advice-evidence-from-mobile-phone-based-agricultural-extension

Daud, N.M., & Husin, Z. (2013) Mobile Learning: A Quasi-Experiment on Using SMS to Support Reading Comprehension Programme. In Embi, M. A., & Nordin, N. M. (eds).

Mobile learning: Malaysian initiatives and research findings. Malaysia: Centre for Academic Advancement, Universiti Kebangsaan Malaysia.

English in Action. (2011). A qualitative observation study of primary and secondary lessons conducted by teachers participating in EIA. Report 1 synopsis. Dhaka, Bangladesh: EIA.

- English in Action. (2011). Perceptions of English language learning and teaching among primary and secondary school teachers and students participating in EIA. Dhaka, Bangladesh: EIA
- English in Action. (2012). The Classroom Practices of Primary and Secondary School Teachers Participating in English in Action (Study 2a2). Dhaka, Bangladesh: EIA.

Ekanayake, T. M. S. S. K. Y., & Wishart, J. M. (2014). Developing teachers' pedagogical practice in teaching science lessons with mobile phones. *Technology, Pedagogy and Education*, *23*(2), 131-150.

- Ekanayake, S. Y., & Wishart, J. (2014). Mobile phone images and video in science teaching and learning. *Learning, Media and Technology*, 39(2), 229-249.

Enge, K. (2011) Elimu kwa teknolojia. a BridgeIT programme. Summative evaluation. Currently unavailable online.

Frias-Martinez, V., Virseda, J., & Gomero, A. (2012). Mobilizing education: evaluation of a mobile learning tool in a low-income school. In Proceedings of the 14th international conference on Human-computer interaction with mobile devices and services (pp. 441-450). ACM.

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Appendix 5.2: Overview of included studies

Region	Intervention details				Context details			Outcome details
	Technology/ application	*Subject/ educational feature*	*Focus/ Access*	*Pedagogy*	*N*	*Setting*	*Mobile context*	*Outcome & Measures*
Aker 2010 Africa: Niger	Basic/feature phone: SMS	Literacy & numeracy: community based lessons enhanced by SMS quizzes & messages **MALL/MAML**	Learner-centered 1:group	To learn: Additional learning by extending learning to informal context	5014 Adults Education program	Informal: Rural Community Groups	Yes: Community centers & home	Literacy & Numeracy Test Scores Student & Teacher effort Attendance & hotline
Aker 2015 Africa: Niger	Basic/feature phone: Audio: Calls	Literacy & numeracy: community based lessons enhanced by **Mobile Monitoring**	Teacher-centered 1:1	To monitor: Additional teaching and motivation through teacher attendance monitoring	1926 Adults Education program	Informal: Rural Community groups	Yes: Teachers being called in formal and informal contexts	Literacy & Numeracy (test scores) Self-esteem Self-efficacy Teacher attendance Teacher motivation Student attendance Student motivation
Aladejana 2007 Africa: Nigeria	Basic/feature phone: SMS	General perceptions	Learner-centered	To access/record information: Anywhere, any time	413 Tertiary	Formal Urban students	Yes: Anywhere, anytime	Perceptions: Factors of adoption
Ale 2011 Asia: India	Mobile PCs: Educational content (quizzes etc)	All subjects: Educational gaming software	Learner/ teacher-centered	To learn: Game based; more interactive	22 Primary	Formal Rural Community	No: Only usage in classroom	Perceptions: Factors of adoption
Andersson 2010 Asia Bangladesh	Basic/feature phone: SMS, camera	English (FL): Curriculum & content embeds mobiles to make education more interactive **MALL**	Learner/ teacher-centered 1:1	To learn & administer: Interactive learning to yield to social transformation	45 Tertiary	Formal: Distance education	Yes: anytime, anywhere	Changes in pedagogy & learning experience: Qualitative
Balasubramanian 2010 Asia: India	Basic/feature phone: SMS/Audio messages	**Extension** (Agric): Educational messages send to	Learner-centered	To learn & connect: In-context learning for women to	320 Adults Livestock	Informal: Women groups	Yes: In-the field; at home; anywhere,	Empowerment & Social Capital

		newly-owned cellphone	1:1 Females	increase lifelong learning & empowerment, social transformation	extension program		anytime	
Bello-Bravo 2012 Africa: Niger	Smartphones: Educational 3D animations	**Extension** (Agric/health) Educational 3D animations shared among rural communities	Learner-centered 1:group	To learn: In-context learning, more interactive/less literacy requirements	48 Adults Livelihood Extension program	Informal: Rural communities at own will	Yes: Anytime, anywhere, in-context (potential)	Knowledge gains Perceptions: Factors of adoption
Beltramo 2012 Africa: Niger	Basic/feature phone: SMS – quizzes, educational messages, networks	Literacy: community based lessons enhanced by SMS quizzes & messages **MALL**	Learner-centered 1:1	To learn & to connect: Additional learning by extending learning to informal context	800 Adults Education program	Informal: Rural Community Groups	Yes: Anywhere, anytime: community centers & home	Literacy: Test scores
Binsaleh 2013 Asia: Thailand	Tablets: with pre-loaded educational content: e-books, exercises	General educational tool: lessons, content, gaming	Learner/ teacher-centered 1:1	To teach & to learn General educational support by tablets; more student-centered	18 High school	Formal: Rural Community	Yes: Anywhere, anytime; no restrictions	Perceptions: factors of adoption
Bridge International Academies 2013 Africa: Kenya	Tablets: with pre-loaded lesson plans and teacher monitoring	English (FL) / math: scripted lessons for teachers read off + monitoring of teacher practice **MALL/MAML**	Teacher-centered 1:1	To teach: reading off scripted lessons & being monitored	1359 Primary	Formal: urban students	No: restricted to classroom	Literacy & math: Test scores
Chang 2012 Africa: Botswana	Smartphones: mhealth application	**mHealth**: in-context practice tools (drug reference, disease diagnostic)	Learner-centered 1:1	To learn: In-context learning for health trainees	10 Tertiary	Formal: Urban students – hospital	Yes: Anywhere, anytime; no restrictions	Perceptions: factors of adoption
Chen 2010 Asia: Taiwan	PDAs: personalised context-aware ubiquitous learning system	English (FL): context-aware vocabulary lessons & quizzes **MALL**	Learner-centered 1:1	To learn: in-context learning for English vocabulary	36 High school	Formal: Urban students	Yes: context restricted to device recognition (GPS)	English literacy: Test scores
Cilliers 2014 Africa: Uganda	Basic/feature phone: SMS system to monitor teacher attendance	**EMIS:** monitoring teacher attendance	Teacher-centered 1:1	To monitor: increased attendance leads to better education	180 schools High/ Primary	Formal Rural/urban teachers	Yes: parents act as monitors too	Teacher attendance Quality of monitoring reports

Cole 2012 Asia: India	Basic/feature phone: SMS & voice; extension hotline	**Extension** (agric): contextualised information services via audio & SMS	Learner-centered 1:1	To learn & access information: in-context/in-the-field learning for agric workers	766 Adults Extension program	Informal: Rural Community Groups	Yes: Anywhere, anytime; in particular in the field	Knowledge gains: Test scores
Daud 2013 Asia: Malaysia	Basic/feature phone: SMS	English (FL): reminder and information SSM **MALL**	Learner-centered 1:1	To access information: additional learning events created by mobiles	615 Tertiary	Formal: Urban students	Yes: Anywhere, anytime	English literacy: Test scores
EIA 2011 Asia: Bangladesh	i-Pod: audio features, video lessons speakers	English (FL): model lessons, more interactivity & student involvement through mobiles **MALL**	Teacher-centered 1:1 1:class	To teach: lessons to be more student-centered & to encourage interactivity	102 Primary & High School	Formal: Mixed rural/urban teachers	Yes: Anywhere, anytime. Domestic, enroute & in the classroom	Teaching practice: Observation
EIA [Sohel] 2012 Asia: Bangladesh	i-Pod: audio features, video lessons speakers	English (FL): model lessons, more interactivity & student involvement through mobiles **MALL**	Teacher-centered 1:1 1:class	To teach: lessons to be more student-centered & to encourage interactivity	20 High school	Formal Urban teachers	Yes: Anywhere, anytime. Domestic, enroute & in the classroom	Teaching practice: Interviews
Ekanayake 2013 Asia: Sri-Lanka	Smart-phones: Graphics, animations, camera	**Outdoor learning**: learning through more practical examples shown by mobiles	Learner/ teacher-centered 1:1	To learn & to teach: Contextualise information; more practical/ experimental	18 Primary	Formal Urban teachers	Mixed: No as restricted to classroom; yes for potential field trip usage	Learning practice Perceptions & Feasibility
Enge 2011 Africa: Tanzania	Smart-phones: Graphics, animations, multimedia TV	Science & Math: phone-content & TV delivery to increase quality of content/more interactive **MAML**	Teacher-centered 1:1 1:class	To teach: mobile content to make education more interactive & student-centered	18 Primary & High School	Formal Rural teachers	No: Usage restricted to class-room	Science & Math: Test scores Teaching practice Qualitative
Friaz-Martinez 2012 Latin America: Peru	Feature/smart phone: Java-application educational game	Math: math mobile game that teacher creates & administers to	Learner-centered 1:1	To learn: game-based approach to math learning	60 Primary	Formal Urban students	Yes: anytime, anywhere; encouraged to use in schools	Math: Test scores

		students **MAML**						
GSMA 2012b Africa (numerous)	Mobile phones (smart/basic)	General perceptions	Learner-centered 1:1	To learn: mobiles assumed to support education	23 Primary/High School	Mixed Formal /Informal Urban/rural	Not assessed	Perceptions
Hassler 2011 Africa Zambia	Tablet; e-Book: wiki readers: content, and software	Teacher development: math & science **MAML**	Teacher-centered Different models	To teach: mobiles to support teacher to have more participator, interactive and collaborative approach	6 teachers Primary school	Formal: Mixed Student and teachers	No: usage restricted to classroom	Changes in pedagogy & learning experience: Qualitative
He 2008 Asia: India	PicTalk machine: educational software, audio	English (FL): a mobile device with interactive vocab features & quizzes **MALL**	Learner-centered 1:1	To learn: game-based	5317 Primary	Formal: Urban Student	No: usage restricted to classroom	English literacy: test-scores Attendance
Hwang 2013 Asia: Taiwan	PDAs: Voice/camera	**Outdoor learning**: Inquiry-based mobile learning during outdoor visit	Learner-centered 1:1	To learn: contextualised learning; more practical/ experimental	26 High School	Formal: Urban Students	Mixed: semi-formal context during field trips	Learning gains: Test scores Perceptions
Iqubal 2012 Asia: Pakistan	Mobile phones (Basic/Smart)	General perceptions	Learner-centered	To learn: potential of mobile technologies	250 Tertiary	Formal: Urban students	Not assessed	Perceptions
Ismail 2013 Asia: Malaysia	Mobile phones (Basic/Smart)	General perceptions	Teacher-centered	To teach: potential of mobile technologies	38 Tertiary	Formal: Urban teachers	Not assessed	Perceptions
Jantjies 2015 Africa: South Africa	Smart-phone: educational gaming	English (FL)/math: using mobile phone game-based learning **MALL/MAMM**	Learner-centered 1:1	To learn: game-based	90 High-school	Formal: Urban Students	No: usage restricted to classroom	Learning gains: Test scores Perceptions
Jere-Folotiya 2014 Africa: Zambia	Feature/smart phone: educational games	Literacy: game-based learning	Learner-centered	To learn: game-based	573 Primary	Formal: Urban Students	No: usage restricted to classroom	Literacy gains: test scores

			1:1					
Kafyulio 2012 Africa: Tanzania	Mobile phones (Basic/Smart)	General perceptions	Learner/ teacher-centered	To learn & teach: potential of mobile technologies	85 High School	Formal: Urban Teachers & learners	Not assessed	Perceptions
Kaleebu 2013 Oceania: Papua New Guinea	Basic/feature phones: SMS	English (FL): lesson plans & content delivered to teachers via SMS **MALL**	Teacher-centered 1:1 1:class	To teach & learn: lesson plans & content to increase interactivity & quality of lessons	2274 Primary	Formal: Rural teachers	Yes: anywhere, anytime	English literacy: test-scores Teaching practice
Kim 2009 Latin America	PDA (teacher mate): Educational software/gaming; voice/video	Literacy: mobile to support language learning with interactive features **MALL**	Learner-centered 1:1	To learn: contextualised learning to support poor – social transformation	270 Informal education program (Children)	Informal: Rural/ peri-urban community	Yes: anywhere, anytime	Perceptions/ Feasibility
Kim 2011 Latin America: Mexico	PDA (teacher mate): educational games & books with audio	Literacy: gaming features & audio e-books **MALL**	Learner-centered 1:1	To learn: Game-based learning to become more interactive & student centered	80 Primary	Formal: Mixed – urban & rural	No: Restricted to class-room use	Literacy gains: Test scores
Kim 2012 Asia: India	PDA (teacher mate): educational games & books with audio	Math: gaming features & audio e-books **MAML**	Learner-centered 1:1	To learn: Game-based learning to become more interactive & student centered	40 Informal education program (Children)	Informal: Rural/ peri-urban community	Yes: anytime, anywhere	Math gains: Test scores Perceptions
Korkmaz 2010 Asia: Turkey	Basic phone/smart phone: SMS quizzes & reminders	English: educational messages, quizzes, reminders **MALL**	Learner-centered 1:1	To learn: additional learning by extending learning into informal contexts	50 Tertiary	Formal: Urban students	Yes: anytime, anywhere	English literacy: Test scores Perceptions
Kumar 2010 Asia: India	Smart phone: educational gaming feature	English: educational game **MALL**	Learner-centered 1:1	To learn: educational games to extend & improve learning in rural areas	20 Informal education 10-14	Informal: Rural children	Yes: anytime, anywhere	English literacy: Test scores
Kumar 2012	Smart phone:	English: educational	Learner-	To learn: educational	21	Formal:	No: restricted to	English literacy:

Asia: India	Educational gaming feature	game, including speech recognition **MALL**	centered 1:1	games to extend & improve learning in rural areas	Primary	Rural students	class-room setting	Test scores
Lai 2007 Asia: Taiwan	PDAs: Camera, wikis, internet, note taking	**Outdoor learning:** embedding mobiles into an experimental learning flow	Learner-centered 1:1	To learn & access, record information: in context; experimental leaning while in the field	68 Primary	Formal: Urban students	Mixed: semi-formal context during field trips	Science learning: Test scores Perceptions
Leach 2005 Africa: South Africa & Egypt	Netbooks & PDA: far reaching educational support – lexica, camera, e-books, etc.	General educational support for teachers	Teacher-centered 1:1 PDAs 1:2 PCs	To teach: improve teaching in general	52 Primary	Formal Rural teachers	Yes: anytime, anywhere	Teaching practice: Qualitative Perceptions
Liu 2010 Asia: China	Basic/feature phones	General perceptions	Learner-centered	To learn: potential of mobile technologies	230 Tertiary	Formal: Urban students	Not assessed	Perceptions
Liu 2009 Asia: Tawian	PDAs: camera, connectivity, connected with context-aware system	**Outdoor learning:** immersive ubiquitous learning environments for outdoor teaching	Learner-centered 1:1	To learn & access information: contextualised, ubiquitous learning environment	72 High School	Formal: Urban students	Mixed: semi-formal context during field trips	Knowledge gains Perceptions
Lui 2008 Asia: Taiwan	Feature/Smart Phone: SMS reminders	General support: SMS reminders for collaborative programme	Learner-centered 1:1	To administer & connect: SMS to support collaboration	48 Tertiary	Formal: Urban students	Yes: anytime, anywhere	Knowledge gains
Lu 2008 Asia: Taiwan	Feature/Smart Phone: SMS messages	English (FL): SMS messages to learn new words and test knowledge **MALL**	Learner-centered 1:1	To access information: additional learning events to support retention	30 High school	Formal Urban students	Yes: anytime, anywhere*	English gains: Test scores Perceptions
Majid 2013 Asia: Malaysia	Feature/Smart phone: internet access	General perceptions	Learner-centered	To learn: potential of mobile technologies	3 Tertiary	Formal Urban students	Not assessed	Perceptions
Makoe 2010 Africa: South Africa	Basic/feature phone: MxIT chats	General distance education support: collaborative online study/chat groups	Learner-centered 1:1	To learn & connect: Collaborative learning via mXIT to support distance education	12 Tertiary	Formal: Mixed: Rural/Urban	Yes: anytime, anywhere	Perceptions

Masika 2015 Africa: Kenya	Smart-phone; tablets	General perceptions	Learner-centered 1:1	To learn: mobiles assumed to support education	292 Tertiary	Formal Under-graduate students	Not assessed	Perceptions
Masperi 2008 Africa: Malawi	PDAs (TeacherMate): educational software, audio/video	Literacy & English Quizzes, e-books, lesson design **MALL**	Learner-centered 1:1	To learn: gaming-features to make education more interactive	112 Primary	Formal: Urban students	No: restricted to class-room setting	Learning outcomes: Test scores Perceptions
Mruz 2011 Africa: South Africa	PDAs (teacherMate): educational software, audio/video	English (FL): Literacy & English Quizzes, e-books, lesson design **MALL**	Learner-centered 1:1	To learn: gaming-features to make education more interactive	250 Primary	Formal: Urban students & teachers	No: restricted to class-room setting	English literacy: Test scores Teaching practice
Ongoku 2013 Africa: Kenya	Tablets: educational software & recording features	**Outdoor learning:** to design apps that allow for a blended learning experience	Teacher-centered 1:1	To teach: Use mobile apps to facilitate Blended learning for learners	10 Primary	Formal: Rural teachers	Mixed: semi-formal context during field trips	Perceptions
Osman 2011 Asia: Malaysia	Basic/feature phone: SMS & online wiki	English (FL): SMS messages with reminders & quizzes **MALL**	Learner-centered 1:1	To learn & administer: Additional learning through receiving info in informal context	61 Tertiary	Formal Urban students	Yes: anytime, anywhere	English literacy: Test scores
Pamuk 2013 Asia: Turkey	Tablets: e-books and software	General educational support: textbooks & content	Learner-centered 1:1	To learn: General educational support through tablet devices	Provincial High School	Formal: Mixed – rural Urban students	No: restricted to class-room setting	Learning gains: Test scores
Pimmer 2013 Asia: Nepal	Smartphones/ netbooks: general educational support	**mHealth**: Google, Facebook, communication, note taking	Learner-centered 1:1	To learn: general support by mobile technologies	43 Tertiary	Formal: Urban students	Mixed: use of device in work setting only	Perceptions
Piper 2015 Africa: Kenya	Tablets & eReaders: New pedagogies + more access to books	Reading: Structured, learner-centered lessons **MALL**	Teacher-centered Learner-centered 1:1	To teacher: more learner-centered lesson plans & materials To learn: access to	1560 Primary	Formal: Mixed: Urban/rural students	Mixed: use of device in work setting only	Reading gains: Test scores Cost-effectiveness

				more e-books				
Pitchford 2014 Africa: Malawi	Tablets (apple): Euro talk educational software	Math: educational games, quizzes, lessons, etc. **MAML**	Learner-centered 1:1	To learn: game-based learning in a resource poor context	88 Primary	Formal: Urban students	No: restricted to class-room setting	Math gains: Test scores
Porter 2016 Africa: Ghana, Malawi and South Africa	Feature/smart phone: internet; camera & video	General perception	Learner-centered 1:1	To access information & communicate: potential of mobile technologies	3085 Primary & high school	Formal Mixed: Urban/rural students	Not assessed	Perceptions
Ramos 2009 Asia: Mongolia & Philippines	Basic/feature phone: SMS	English & Math: SMS quizzes and reminders **MALL/MAML**	Learner-centered 1:1	To learn & administer: Additional learning through receiving info in informal context	52/73 Adult education program	Informal: Mixed: Urban/rural students	Yes: anytime, anywhere	English & math gains Test scores
Roberts 2011 Africa: South Africa	Basic/feature phone: SMS via MxIT	Math: Quizzes & game based activities over chat platform **MAML**	Learner-centered 1:1	To learn: Collaborative & game based learning to make math more relevant & fun	512 High school	Formal: Mixed: Urban/rural students	Yes: anytime, anywhere	Math gains: Self reports Perceptions
Rosas 2002 Latin America: Chile	Nintendo device: gaming features	Math & Literacy: educational game to support interaction **MALL/MAML**	Learner-centered 1:1	To learn: game-based learning to support disadvantaged learners	1274 Primary	Formal: Mixed: Urban/rural Students & teachers	No: restricted to class-room setting	Learning gains: Test scores Teaching practice: Observation
Sahni 2008 Asia: India	DVD&TV: multi-media video ability	English: model lessons of peer-teachers streamed to more classes via video **MALL**	Teacher-centered 1:1 1:class	To teach: peer-model lessons to support pedagogic innovation	54 Primary	Formal: Mixed: Urban/rural teachers	No: restricted to class-room setting	English gains: Test scores Teaching practice: Observation
Shraim 2014 Asia: Palestine	e-Reader (kindle): e-books	English: e-books to make for more interactive & authentic learning experience **MALL**	Learner-centered: 1:1	To learn: assumed benefits of e-readers	114 Primary	Formal: Urban students	No: restricted to class-room setting	English gains: test scores

Suki 2011 Asia: Malaysia	Basic/feature phones	General perceptions	Learner-centered: 1:1	To learn: potential of mobile technologies	20 Tertiary	Formal: Urban students	Not assessed	Perceptions
Sung 2013 Asia: Taiwan	PDA: audio/camera, internet note-taking	**Outdoor learning:** collaborative & contextual affordance of PDA	Learner-centered: 1:1	To learn: collaborative & in-context learning experience	53 Primary	Formal: Urban students	Mixed: semi-formal context during field trips	Learning gains: Test scores
Taleb 2012 Asia: Iran	Basic/feature phones	General perceptions	Learner-centered: 1:1	To learn: potential of mobile technologies	289 Tertiary	Formal: Urban students	Not assessed	Perceptions
Turtianinen 2012 Africa: South Africa	Smart phones: UFraction mobile game	Math: an educational game with interactive & relevant features **MAML**	Learner-centered: 1:class	To learn: game-based interactive & relevant learning experience.	34 High school	Formal: Urban students	No: restricted to class-room setting	Perceptions
UNESCO 2014 Africa (various)	Smartphone: World reader app	Literacy: access to a range of e-books **MALL**	Learner-centered 1:1	To access: more access to reading materials	Online survey Youth	Informal: Urban	Yes: anytime, anywhere	Perceptions
USAID 2010 Africa: Somalia	Radio: Interactive Radio programme	Literacy, Numeracy & Teacher development: interactive lesson transmitted via radio	Teacher/ learner-centered 1:class	To learn: more access to education & more interactive lessons	122 Primary	Formal Rural teachers	No: restricted to class-room setting	Learning gains: Test scores
Valderama 2010 Latin America: Panama	Basic/feature phone; Netbooks	General perceptions	Learner/ teacher-centered: 1:1	To learn & teach: potential of mobile technologies	435 High school	Formal Mixed: teachers & students	Not assessed	Perceptions
Velghe 2014 Africa: South Africa	Basic/feature phone: SMS; SNs	Literacy: sending messages and becoming phone-literate **MALL**	Learner-centered 1:1	To learn & connect: learning extended into informal contexts to increase learning events	3 (Adults) Informal Education Program	Informal: Women's groups	Yes: anytime, anywhere	Perceptions Empowerment: Ethnography NOTE: No pedagogies at all

Voigt 2014 Africa: South Africa	Tablets: mobimath software for learners & parents &teachers	Math: educational software with learning support & parental M&E **MAML**	Learner/ teacher-centered: 1:1	To learn: game-based all-round math software; more practical learning	31 High school	Formal: Urban teachers & students	No: restricted to class-room setting	Perceptions
Walton 2009 Africa: South Africa	Smart-phones: internet, multi-media, SMS	Literacy: allowing learners to self-create a mobile story	Learner-centered 1:1	To learn: using social networks for teenagers to create a short story	111 High school	Formal: Urban students	Yes: anytime, anywhere	Literacy gains: Support to indigenous languages
Wennersten 2012 Asia: India	Smart-phones: Graphics, animations, multimedia TV	English (FL) & Science: phone-content & TV delivery to increase quality of content/more interactive **MALL**	Teacher-centered 1:1 1:class	To teach: mobile content to make education more interactive & student-centered	1562 High school	Formal Mixed: Teachers & students	No: restricted to class-room setting	Learning gains: Test scores
Witt 2016 Africa: Botswana	Tablets: Internet, content; apps	**mHealth**: educational software & access to medical information	Learner-centered 1:1	To learn: additional and contextualised access to information	82 Tertiary	Formal: Urban under-graduate students	Yes: anytime, anywhere	Perceptions
Wordreader 2012 Africa: Ghana	Tablets: e-books & working books	English (FL): ebooks & educational materials on tablets to give more educational access to learners	Learner-centered 1:1	To learn: more resources for students to gain literacy exposure/learning events due to tablets	374 Mixed Primary High school	Formal: Rural students	Yes: anytime, anywhere (with temporary restrictions)	Learning gains: Test scores
Worldreader 2015 Africa: Kenya	Tablets: e-books & working books	English (FL): ebooks & educational materials on tablets to give more educational access to learners	Learner-centered Provision to libraries	To learn: more resources for students to gain literacy exposure/learning events due to tablets		Informal: Mixed: Rural/ urban Library users	No: restricted to library facilities	Perceptions and adoption
Wu 2011 Asia: Taiwan	PDAs: GPS, internets, graphics	**mHealth**: context-aware mobile learning system to	Learner-centered	To learn & access info: more practical and experiential	48 Tertiary	Formal: Urban	No: restricted to class-room setting	Learning gains: Test scores

		diagnose minor diseases	1:1	learning to increase relevance of education		students		Perceptions
Yang 2013 Asia: Taiwan	Smartphone: QR scanner, internet, graphics	Natural Science: digital concept map to enhance book reading through diagrams etc	Learner-centered 1:1	To learn & access info: Digital concepts maps to contextualise & visualize learning concepts	59 Primary	Formal: Urban students	No: restricted to class-room setting	Learning gains: Test scores Perceptions
Zelesny-Green 2014 Africa: Kenya	Basic/smart phone	General perception	Learner-centered 1:1	To access information & communicate: mobile tech has potential for girls actively excluded from education	36 High school	Formal: Urban students	Mixed: use not permitted at school	Perceptions
Zurita 2004 Latin America: Chile	PDAs: educational game, quizzes	Math & literacy : a collaborative computer-assisted learning game **MALL/MAML**	Learner-centered 1:1	To learn & connect: collaborative & game-based learning facilitated by mobiles	48 Primary	Formal: Urban students	No: restricted to class-room setting	Math & literacy gains: Test scores Perceptions
Zurita 2004 Latin America: Chile	PDAs: educational game, quizzes	Literacy : a collaborative computer-assisted learning game **MALL**	Learner-centered 1:1	To learn & connect: constructivist learning facilitated by collaborative mtech learning event	24 Primary	Formal: Urban students	No: restricted to class-room setting	Literacy gains: Test scores
Zurita 2007 Latin America: Chile	PDAs: educational game, quizzes	Math: a collaborative computer-assisted math learning game **MALL**	Learner-centered 1:1	To learn & connect: collaborative & game-based learning facilitated by mobiles	24 Primary	Formal: Urban students	No: restricted to class-room setting	Math gains: Test scores Perceptions

Appendix 5.3: Detailed overview of studies included in the meta-analysis

Study	**Design**			**Intervention details**		**Population**	**Outcome**	**Findings & Effect size**
	Risk of Bias	*n*	*Follow-up*	*Programme & technology*	*Context*	*Age/schooling* *Gender*	*Outcome (Measures)*	*ES (SE); [Confidence interval]*
Aker 2010 Niger	Low Randomised Controlled Trial (cluster adjusted)	5014	12 months	SMS-based adult literacy programme Basic/feature phone	Rural Anywhere, anytime	Adults; NGO-adult literacy programme Mixed	Literacy (test scores) Numeracy (test scores) Student effort (attendance) Teacher effort (attendance) Student motivation (paid hotline calls) Cost-effectiveness (cost per student attaining Level 1 proficiency)	+0.18 (0.03); [0.13, 0.24] +0.19 (0.03); [0.13, 0.25] No change No change Increased interest in education For $6.50 per student, 4% more students reach Level 1
Aker 2015 Niger	Low Randomised Controlled Trial	1926	6 months	Mobile teacher monitoring Basic/feature phone	Rural Monitoring conducted in formal and informal settings	Adults; NGO-adult literacy programme Mixed	Literacy (test scores) Numeracy (test scores) Self-esteem Self-efficacy Teacher attendance Teacher motivation Student attendance Student motivation	+0.15 (0.03); [0.07, 0.23] +0.30 (0.04); [0.22, 0.38] 2% Decrease in self-esteem 3% Decrease in self-efficacy 1.27 extra days over 6 months Self-reported motivation increase No change Self-reported motivation increase For $6.50 per village, 0.2 SD in learning
Chen 2010 Taiwan	Moderate Quasi-experimental (random assignment)	36	2 weeks	A personalised context-aware ubiquitous learning system (PCULS) PDAs with GPS capability	Urban Anywhere, anytime	High school Mixed	English vocabulary (test scores) User satisfaction	+0.22 (0.33); [-0.43, 0.88] Not statically significant Not relevant for this module
Cole 2012 India	Low	766	4 months	SMS-based agaric extension programme	Rural Anywhere, anytime	Adults; NGO-agric extension programme	Agricultural knowledge	+0.04 (0.07); [-0.10, 0.19] Not statistically significant Learning outcomes are greater for better-educated

	Randomised Controlled Trial (cluster adjusted)	Basic/feature phone		Mixed	Cost-effectiveness (comparison of input costs)	famers Programme cost: $ 1.13 per famer compared to $8.50 for traditional extension service
Cilliers (2014) Uganda	High 180 schools 14 months Randomized controlled trial	Mobile monitoring of teacher attendance SMS-based	Urban/ Rural Formal: Monitoring took place during school hours	Primary/ High Schools Mixed	Teacher attendance Quality of reporting	11% increase in attendance Large underreporting remains
He 2008 India	Low 5317 10 months Randomised Controlled Trial	PicTalk English & math learning gaming device Educational software/gaming device	Urban Formal: Usage restricted to classroom	Primary school; Mixed	English (test scores) Math (test scores) Student attendance (Observation) Cost-effectiveness (input cost per tenth of SD)	+0.35 SD gain (Experiment 1) +0.36 SD gain (Experiment 2) +0.052 SD gains (Year 1) Not statistically significant +0.36 SD gains (Year 2) Teachers included in implementation in year 2 – found more effective No change Cost-effective compared to other education interventions
Kaleebu 2013 Papua New Guinea	Low 2274 7 months Quasi-experimental (random assignment; matched)	SMS-based, in-practice teacher development programme Basic/feature phone	Rural Anywhere, anytime	Primary school Mixed	English (test scores) 1 Oral fluency* 2 Invented words 3 Sight word fluency 4 Decodable Words Teaching practice (self reports & observation) Cost-effectiveness (input cost per student)	 +0.29 (0.05); [0.20, 0.38] +0.21 (0.05); [0.12, 0.30] +0.14 (0.04); [0.06, 0.23] +0.15 (0.04) [0.07, 0.24] Teacher use more interactive teaching approaches Low input cost, but no comparison made
Kumar 2012 India	High 21 2 weeks Quasi-experimental	Literacy development Using Speech Recognition-	Rural Formal: Usage restricted	Primary school Mixed	English Design 1* (test scores) English Design 2 (test scores)	+1.31 (0.49); [0.35, 2.28] +0.73 (0.45); [-0.16, 1.62] Not statically significant

		Supported Games on Mobile Devices Smart phone	to classroom			
Lai 2007 Taiwan	Moderate 68 1 week Quasi-experimental	Experimental learning through embedding learners via tech into contexts PDAs	Urban Mixed: semi-formal use during field trips	Primary school Mixed	Knowledge gains (test scores) Knowledge acquisition (Text mining) Knowledge created (Text mining) User satisfaction	+0.46 (0.25); [-0.03, 1.00] Not statically significant Critical Risk of Bias - instrument not adequate Critical Risk of Bias - instrument not adequate Not relevant for this module
Liu 2009 Tawian	Moderate 72 1 week Quasi-experimental	Outdoor Natural Science Learning with an RFID-Supported Immersive Ubiquitous Learning Environment PDAs	Urban Mixed: semi-formal use during field trips	High school Mixed	Knowledge gains (test scores) User satisfaction	+1.61 (0.27); [1.08, 2.14] Not relevant for this module
Liu 2008 Taiwan	High 48 2 weeks Quasi-experimental	Web-based collaborative learning scheme based on activity awareness carried out through mobile phones Feature/Smart Phone	Urban Anywhere, anytime	Tertiary Mixed	Knowledge gains (test scores)	+0.54 (0.30); [-0.05, 1.12] Not statically significant
Lu 2008 Taiwan	Moderate 30 2 weeks Quasi-experimental (random assignment)	SMS-based English vocabulary programme Basic/feature phone	Urban Anywhere, anytime	High school Mixed	English vocabulary (test scores) User satisfaction	+0.68 (0.38); [-0.06, 1.42] Not statically significant Not relevant for this module

Piper 2015 Kenya	Moderate 1560 10 months Randomised Controlled Trial (cluster adjusted)	Tablet based PRIMR interventions + e-Reader provision Tablets/e-Readers	Urban/ Rural Formal: Use during work hours at school	Primary Mixed	Tutor tablets: reading Teacher tablets: reading e-Reader: reading Cost-effectiveness Cost of e-reader per student: $40 Cost of teacher tablet per student: $3 Cost of tutor tablet per student: $10	+0.44 (0.06); [0.32, 0.56] +0.47 (0.06); [0.35, 0.59] +0.35 (0.04); [0.27, 0.43] 6 times less cost-effective than no ICT $100 leads to 0.5 students reaching full reading fluency Cost-effective compared to no ICT but not to tutor tablet $100 leads to 4.3 students reaching full reading fluency 2 times more cost-effective than no ICT and teacher tablet; 10 times to e-readers $100 leads to 7.8 students reaching full reading fluency
Pitchford 2014 Malawi	Low 88 2 months Randomised Controlled Trial	Tablet-based math educational gaming programme Tablets (iPads)	Urban Formal: Usage restricted to classroom	Primary school Mixed	Math (test scores) 1 Mathematical concepts 2 Math curriculum knowledge* 3 Math curriculum knowledge generalisation Empowerment (life ambitions & attitudes)	 +0.16 (0.21); [-0.26, 0.58] +1.68 (0.25); [1.19, 2.18] +0.81 (0.22); [0.37, 1.25] Critical Risk of Bias - instrument not adequate
Rosas 2002 Chile	High 1274 3 months Quasi-experimental	Game-based math & literacy learning on Nintendo Gaming device/ educational software	Rural/ Urban Formal: Usage restricted to classroom	Primary school Mixed	Literacy (test scores) 1 Reading comprehension 2 Spelling Math (test scores) Motivation to use video Teacher practice (Observation & Interviews)	 Statistical significant impact. ANOVA estimate +0.06 (0.21) Statistical significant impact ANOVA estimate -0.27 (0.18) Statistical significant impact ANOVA estimate +0.51 (0.43) Critical Risk of Bias - instrument not adequate Critical Risk of Bias - not in both experimental groups

Sung 2013 Taiwan	Moderate	53	2 weeks	Mobile learning system based on a collaborative problem-posing strategy PDAs	Urban Mixed: semi-formal use during field trips	Primary school Mixed	Knowledge gains (test scores) User satisfaction	+0.62 (0.28); [0.06, 1.17] Not relevant for this module
Wu 2011 Taiwan	High Quasi-experimental	48	Instantly	Context-aware mobile learning system for nurse students	Urban Formal: Usage restricted to classroom	Tertiary Mixed	Knowledge gains (test scores) Cognitive load Learner perception User satisfaction	+1.04 (0.31); [0.44, 1.65] +0.58 (0.30); [-0.00, 1.16] Critical Risk of bias: Leading questions Not relevant for this module
Yang 2013 Taiwan	High Quasi-experimental	59	1 week	concept map-oriented ubiquitous learning approach for supporting printed science book reading Smart phones	Urban Formal: Usage restricted to classroom	Primary school Mixed	Knowledge gains (test scores) User satisfaction	+0.45 (0.26); [-0.07, 0.96] Not statistically significant Not relevant for this module
Zurita 2004 Chile	High Quasi-experimental	48	2 months	A Mobile Computer Supported Collaborative Learning math & literacy game PDAs	Urban Formal: Usage restricted to classroom	Primary schools Mixed	Literacy (test scores) Math (test scores) Educational events (Observation)	+0.74 (0.32); [0.12, 1.37] +0.51 (0.28); [-0.04, 1.05] Not statistically significant Critical Risk of Bias - not in both experimental groups
Zurita 2004 Chile	High Quasi-experimental	24	2 months	A Mobile Computer Supported Collaborative Learning math & literacy game PDAs	Urban Formal: Usage restricted to classroom	Primary schools Mixed	Literacy (test scores) User satisfaction	+0.91 (0.43); [0.06, 1.76] Not relevant for this module

Following the risk of bias assessment, I calculated 29 effect sizes of the impact of mobile learning programmes on educational outcomes in LMICs. As explained in chapter 4, section 4.3.4, these effect sizes are expressed as standardised mean differences. To ensure the comparability of the different measurement scales of mobile learning's impact, each individual impact measure is standardised and presented in terms of standard deviations. This allows for a meaningful comparison of the direction and magnitude of impact across all 16 programmes. The 29 effect sizes were derived from 17 studies only. Two studies, He and colleagues (2008), Rosas and peers (2002) applied a regression analysis and only reported regression coefficients, failing to provide either the standard deviation of the error term in the regression, or the sample standard deviation, or the treatment and control standard deviations. I was since unable to calculate SDM for these two studies, but integrate their findings into the analysis narratively where appropriate. Cilliers and peers (2014) did not report any statically information apart from percentage change between experimental groups and I was therefore unable to calculate effect sizes for this study.

I did not calculate any synthetic effect sizes in which I would have statistically pooled multiple treatment or control groups into a single treatment or control. A number of studies featured multiple control or treatment arms (Kumar 2012; Pitchford 2014; Sung 2012; Yang 2013: Piper 2014; Cilliers 2014). Yet, in each case the groups were not regarded as homogenous enough in order to combine their results. I since used the results of the strongest treatment and the plainest control group respectively. Similarly, I did not combine different treatment effects measured at different periods of follow-up. The longest period of follow-up was assumed as the most reliable outcomes indicator and used for effect size calculation. This rule applied to only a single study (Aker 2012). Two studies applied multiple outcome measures to assess the same effect (Kaleebu et al 2013; Pitchford et al 2014). For example, Kaleebu and colleagues used four different indicators of literacy. In both cases, we decided on the outcome measure most closely related to the measured phenomenon. This translated into the usage of oral fluency (Kaleebu 2013) and mathematical curriculum knowledge (Pitchford 2014) as relevant outcomes measures. Lastly, I adjusted standard errors and sample sizes from two cluster-randomisation trials as suggested by Higgins and Green (2011).

I calculated effect sizes for a number of different outcome constructs. All effect sizes were based on the means and standard deviations of test scores of two experimental groups. Test scores assessed knowledge gains in six pedagogical mobile learning experiments; learners' mathematical proficiency in five studies; literacy acquisition of participants in four mobile learning programmes; the effectiveness of mobile-assisted English as a foreign language learning in four studies; and lastly, in one study, test scores assessed changes in agricultural knowledge. The calculated effect sizes since all measured the impact of mobile learning programmes on learning outcomes in developing countries.

Appendix 5.4: More detailed analysis of mobile learning pedagogies

Mobile learning pedagogy as a moderator
The last potential moderator I analysed referred to the specific pedagogies which mobile devices were assumed to produce. Of the different underlying pedagogies described in section 5.1.3, only three types were prevailing in the included studies for meta-analysis (game-based n=4; context-aware/experiential n=7; collaborative n=4). First, I found that pedagogy served as an effective moderating variable that highly reduced heterogeneity across the studies combined in each sub-group. Each of the three pedagogic sub-groups presents a homogenous sample (see Table 5.4) and I since describe each sub-group in more detail before formally comparing their effect sizes.

Collaborative learning was a pedagogic approach in four mobile learning programmes implemented in diverse settings. Two programmes were conducted in urban Chile using a learning game in which learners had to solve a collaborative task (Zurita & Nussbaum 2004a; Zurita & Nussbaum 2004b). Learners were allocated into groups and each learner in the group had to contribute to the collaborative learning task. The mobile technology assumed a guiding role ensuring each player contributed equally to the group task as it was found that during a traditional collaborative learning game individual learners dominated group work. The mobile technology served as a mechanism for each learner in the group to express her consent with the group's solution before engaging in the next task. Both studies found this approach to be effective in improving true collaboration (i.e. involving all learners in the group task) and improving learning outcomes, arguably through the inclusion of all learners in the group work.

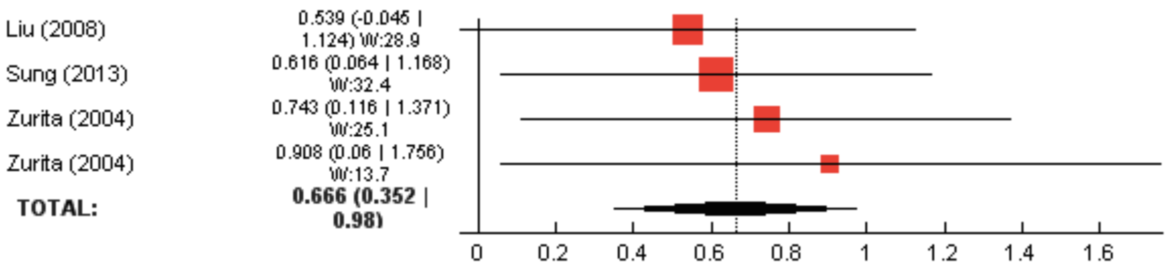

Figure: Effectiveness of collaborative mobile learning approaches
Heterogeneity: Q = 0.581; df = 3; p = 0.901; I-squared = 0%; tau-squared = 0

Two studies were conducted in urban Taiwan. Liu and colleagues (2008) added a SMS module to an existing online collaborative learning task. Learner groups had to collaborate in a competition with other groups to create a Wiki on a given topic. Liu and peers assessed whether using SMS technology to inform group members about each other's online activities would motivate them to improve their own contribution to the Wiki. This information was delivered via SMS and each learner was informed if a group member had updated the Wiki or if a competing group had successfully completed a task on their Wiki. The experiment found positive results on learners' activities and subsequent grading of the Wiki when informed about each other's progress through SMS. Due to the small sample size, however, this finding was not statistically significant. The combined meta-analysis was then able to show that despite the effect's statistical insignificance it seemed, nevertheless, to present an adequate reflection of the true impact of the mobile learning module.

Sung and colleagues (2013) assessed the effectiveness of mobile collaborative learning during a local heritage project. Learners were equipped with PDAs during the visit of a local temple and guided by the device to explore and learn about the connection of the temple to their heritage. The device produced animations and extra information based on a GPS and QR-code system to determine the learner's position. The experiment was delivered in a traditional mobile learning approach in which learners individually explored the temple using their device; and in a collaborative mobile learning approach, in which learners collaboratively explored the temple as each learner's device only had access to a limited set of information. Both mobile learning approaches were found to be more effective than a conventional learning approach (guided tour through the temple by a teacher). The collaborative approach in particular had the largest impact on learning outcomes.

Game-based mobile learning presented the programme approach in four mobile learning interventions. In the above-mentioned studies from Chile (Zurita & Nussbaum 2004a; Zurita & Nussbaum 2004b), the educational game was paired with a collaborative learning approach. The learning game was designed on a Nintendo device and featured a number of syllabi that learners had to group together in order to form words. The device facilitated the correct matching of syllabi and ensured instant feedback and hints to learners. The evaluation found that children learning with the mobile devices had significantly larger learning gains and language acquisition than learners in the control group.

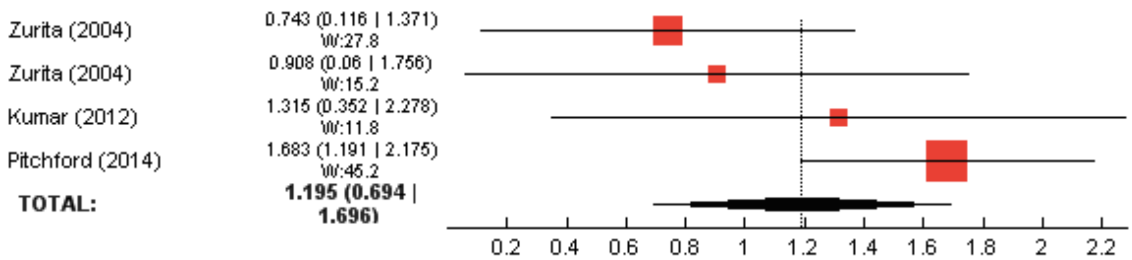

Figure: Effectiveness of game-based mobile learning programmes
Heterogeneity: Q = 6.12; df = 3; p = 0.106; I-squared = 51%; tau-squared = 0.13.

Kumar and colleagues (2012) used a related programme approach in rural India. The research team designed an English learning game based on PDA speech-recognition. Children in rural schools were exposed in the game to familiar situations, e.g. purchasing groceries at the local market, and had to correctly identify and pronounce English words in order to proceed in the game. Learning English with the mobile technology increased post-test English scores significantly.

Lastly, Pitchford and peers (2014) applied a math learning application delivered on iPads to learners in urban Malawi. The application presented a sophisticated learning game with numerous levels and variations. It was found to improve learning outcomes by 1.20 standard deviations (0.70-1.70). This effect size was surprisingly large and would have translated into a difference in success rates of 52.2 per cent—or more simply put: almost every learner using the tablets will achieve a higher test score in math than learners in the control group.

Despite this unconventional effect, the study was based on a randomised-controlled design judged of low risk of bias. The applied mobile application has further been found effective in a HIC setting in the United Kingdom (Guardian 2014). However, I caution to assume that such a large effect size can be replicated across contexts and our understanding of the programme would gain from a replication of the study and application of the intervention in additional schools.

Context-aware mobile learning programmes were evaluated by seven studies. Again, these studies presented a homogenous set and each exploited the ability of mobile technologies to facilitate learning across contexts. Context-aware mobile learning programmes applied the most sophisticated interplay of mobile technologies' particular affordances and educational approaches. Chen and colleagues 2010, for example, designed a personalised context-aware ubiquitous learning system to support effective English vocabulary learning. Using PDAs with GPS capabilities, they determined learners' positions and current social context (e.g. at the train station). The mobile system then supplied the learners via the PDAs with context-relevant English vocabulary and exercises. This situated learning approach was found effective to improve English literacies among learners. This applied in respect to two control groups—one using traditional mobile learning without context-awareness, and a second one using conventional classroom learning. Traditional mobile learning was similarly identified as superior to classroom learning. Alas, due to a small sample size the primary findings are not statistically significant—again, a shortcoming the meta-analysis was able to rectify.

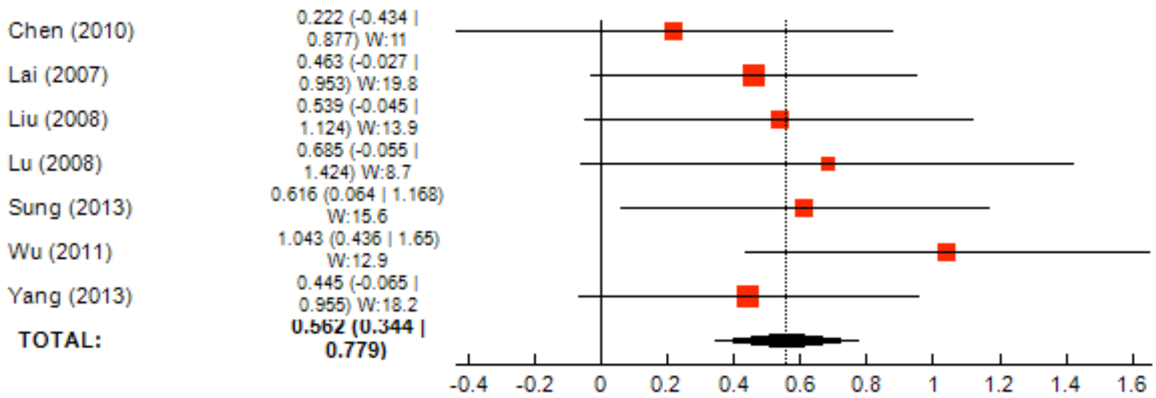

Figure: Effectiveness of context-aware/experiential mobile learning programmes
Heterogeneity: Q = 1.18; df = 5; p = 0.947; I-squared = 0%; tau-squared = 0.

A direct combination of conventional learning practice and mobile learning was investigated by Yang and colleagues (2013). The researchers complemented traditional science textbooks with digital concept maps of complex systems such as the solar systems. Relevant sections in the textbook were linked via QR codes and PDAs to digital concept maps. These concepts maps were interactive and learners could since experience and investigate the solar system (e.g. move planets around, experience a 3D vision) more authentically. This mobile learning approach was found effective in improving learning outcomes, albeit not at a statistical significant level.

Each of the seven context-aware mobile learning programmes was evaluated on a small scale. This came as a result to the high level of control the sophisticated mobile learning systems required. For example, the studies using GPS technology to determine learners' context needed to keep the GPS maps up-to date. Studies assessing context-aware mobile learning in informal contexts (e.g. cultural visits) further had to facilitate these visits and synchronize the learning content. As a result, this set of studies could best be described as feasibility experiments, which aimed to generate proof of concept rather than statistical significance. This conception explained that five out of seven studies reported positive but statically non-significant findings. Meta-analysis, as a tool designed for such cases, was able to show that the true effect of studies in fact was robust and statistically significant.

Appendix 6.1: Overview of mechanism and context themes

Context themes	Mechanism themes
1. Mobile devices' **particular affordances nurture a general positive perception** of mobile technologies among educational stakeholders in LMICs. [Positive perception]	**1.** The usage of mobile technologies in LMICs **can change the way education is practiced,** leading to a number of more **learner-centered** educational approaches. [Pedagogy and practice]
1.1 Mobile devices' **ubiquity** supports the familiarity of the technology among educators, students, and parents.	1.1 The affordances of mobiles (connectivity, information sharing & collection, visualisation, gamification) can support a **more interactive and collaborative** educational approach.
1.2 Mobile devices **conveniently blend** in the daily routines and existing practices of educators and students in LMICs.	1.2 The affordances of mobiles (portability, connectivity, multi-media content; Camera, GPS) can support a more **authentic educational approach** by facilitating contextualisation, real life application, and mobility of learning. This includes codes around situated learning, inquiry-based learning, and real life application of learning. However, the extension of learning to informal contexts often was limited due to contexts.
1.3 Mobile devices ability to produce new and support existing forms of **communication** is a key feature of mobiles' attraction among educators and students in LMICs.	1.3 The affordances of mobiles (access to information; learning software; data collection and analysis; multi-media and multi-format content) can support more **personalised and targeted educational** approaches. An emerging theme is a small number of more recent studies (n=3) highlights the ability of mobiles to track learners' progress as well as the mobile-enabled matching of content levels and students' proficiency to support learning.
1.4 The **affordability** of mobile devices and services shapes the technology's uptake and its usage pattern among educators and students in LMICs.	1.4 A key mechanism through which mobiles influence educational practice is through an **increased access to information**. 1.5 Mobile technologies increase the range of educational tools, thereby increasing **variety in teaching and learning activities**.
2. Mobile devices **are technically able** to serve as	**2.** The usage of mobile technologies in LMICs **can change**

educational tools in LMICs**.** [Feasibility]	**the way education is experienced** by learners facilitating a more engaging, relevant, and open educational experience. [Learner experience]
2.1 Educators and students rapidly develop device literacies. (**ease of use**)	2.1 Students perceive mobile technologies to support a more **engaging and enjoyable** educational experience.
2.2 **Technical queries** relate to breakage and size of the device screen, battery life, and memory capacity.	2.2 Students perceive technologies to allow for a more **personalised and independent** educational experience.
2.3 **Interface design** is central to support the use of mobiles including features that allow for the **personalisation of devices**.	2.3 Students perceive technologies to **enhance the relevance of their educational experience** by allowing for a greater variety and more up-to-date content; more control over the learning process; ability to connect and debate content with peers. 2.4 Students perceive mobile learning to facilitate **a more open educational experience** by supporting more participation and interaction in lessons; more self-direction and control over the learning process; and opportunities to share and debate content/information with peers.
3. While mobile technology as an educational tool is acceptable to teachers, learners, and parents in LMICs, **supporting factors have to be in place to nurture its adoption** as an educational tool. [Factors of adoption]	**3.** Mobile technologies can support **pedagogical and non-pedagogical changes** in teaching. [Teaching practice]
3.1 **User training** is an essential input and requisite for the responsible and adequate use of mobile devices' applications for learners in LMICs (safety, instructions) (partly to reassure communities and partly to indicate to learners the changed function of the phone). **Teacher training,** too, is an essential input and requisite for the use of mobile devices in LMICs.	3.1 Change towards a more **learner-centered approach**, i.e. less frontal delivery of content/lecture style and more learner-led activities, more interaction (e.g. asking questions/debate), wider range of activities. 3.2 Increased **subject knowledge** through access to more information, greater variety of content and greater collaboration and peer-support.
3.2 The introduction of mobile devices and mobile content needs to be in line with and **integrated in the existing curriculum**.	3.3 More **opportunities for collaboration, peer-support, and social learning** in general (linked to content, pedagogy, and administration) through connectivity, communication, and networking abilities of mobiles.

		3.4 Technologies often **reinforce or trigger existing practices** rather than establishing new practices.
3.3 **Power issues on domination** and control of mobile technology that shape group dynamics and technology usage among both educators and students in LMICs.		
3.4 In deprived settings, an **intrinsic economic motivation** supports the adoption of mobile devices as an educational tool.		
4. Mobile devices are intrinsically associated with **status and professionalism leading to higher perceptions** of schools/teachers who possess the devices. [Tech as a social and professional status symbol]		**4.** Mobile devices **facilitate the act of teaching** leading to a better perception of, and satisfaction with, the teaching profession (in return increasing the motivation to teach). [Teaching experience]
4.1 Teachers who master mobile technologies **receive respect and recognition** from peers **and function as peer educators**.		4.1 Teachers report teaching as more **enjoyable and less stressful** as learners are easier to handle, more attentive, and motivated. In addition, they have greater variety of ready-to-go content to choose from.
4.2 Parents and community members experience **pride** of being part of mobile learning programmes and access educational services more strongly that incorporate mobile devices. They also have **higher perceptions of teachers and schools** that use mobile technologies.		4.2 Teachers feel **more efficient and better organised**
4.3 Teachers **feel more professional and valued** in their role in society. Their self-perception and job satisfaction increases.		4.3 Teacher feel more **connected and,** in rural areas, **less isolated**.
4.4 Teachers express **higher opinions of students** who are learning with the mobile devices.		4.4 Teachers feel more **recognised and valued** in their work and taken serious as professionals with an increased social status and respect from the community and learners
5. The **mobile and contextualised use** of technologies is determined and **limited by formal educational actors and social structures.** [Informal use limited for learners]		**5.** **Mastery of technology** is large motivation for learning with technology and a source of **pride, confidence, self-efficiency** (both teachers/adult learners) [Self-efficacy]
5.1 **Teachers** report a range of mobile and contextualised technology usages.		5.1 Mastering technology use improved teachers and learners' **self-perceptions (pride)**.
5.2 **Students rarely** are allowed to use mobile technologies unsupervised during formal educational activities.		5.2 Acquiring a skill considered as advanced, increased teachers and learners' **self-efficacy and aspiration**.

5.3 Teachers and parents **are reluctant** to allow the possession of school-owned devices outside school hours (i.e. taking devices home) for social and financial reasons.		5.3 **Community and peer recognition and status** reinforced the above and in return led teachers and student to educate their peers on the use of technology.
		5.4 However, proficiency of using and controlling mobiles in education also served as an **exercise of power** for educators and learners
6. A range of **systemic issue negatively** affected the implementation of ML4D programmes in LMICs. [Systemic challenges]		**6.** The usage of mobile technologies in LMICs can **change the relationship and interaction between students and teachers** [Relationships and interactions]
6.1 The practice of constant **teacher transfers** to different schools challenged the consistent and sustainable use of technologies.		6.1 There was an overall shift towards teachers assuming **a role of facilitating knowledge** rather than being the holder and transmitter of knowledge leading to more student-led interaction and open teacher-student relationships but:
6.2 **Frequent strikes** disrupted mobile learning programmes leaving less time for learners and teachers to apply the devices.		6.2 Teachers preferred **learner-centered methods** that they were still **in control of**, and often adopted learner-centered methods **for the efficacy** in reducing their work burden rather than their pedagogical grounding.
		6.3 While students generally welcomed a more interactive and participatory approach, there was also a theme which d**id not agree with a shift away** from teacher's powers.
6.3 **Absenteeism** and teachers and learners were forced by economic reasons to cut short or miss their educational commitments.		6.4 Technology itself can become an **instrument of power** and both teacher and students used tech to dominate and exercise power.
		6.5 The shift towards more interaction and open relations is not **intrinsically connected** to the use of technology.
6.4 Learners and teachers **rarely spend as much time** with devices as assumed by programme design.		**7. Teacher training** is key to ensure technology adoption and its pedagogic use during teaching [Teacher training]

		7.1 In order to feel in **control of technology use**, teachers need to be explicitly trained for it; and receive the technology before learners. This makes teacher training (or professional development) the ideal vehicle to deliver ML interventions.
		7.2 Training on technology use **to focus on pedagogy** not ICT skills; and about **subject expertise** (i.e. show how tech can (i) support the teaching of the content and (ii) give teacher additional subject knowledge).
		7.3 Collaboration, peer-support, and **role models** are in particular supportive to increase teachers' educational use of mobile technologies.
		7.4 Training delivered via mobile tech can **reduce teachers time away** at professional development courses
		8. The educational use of mobile technology can support the accumulation of **social capital** [Social capital]
		8.1 In case device use is not limited, mobile technology is shared widely and leads to large **spill-over effects**.
		8.2 The **access to information** facilitated by mobile devices is valued beyond the educational sector and is used to **support a range of social and cultural activities.**
		8.3 The **ability to connect** with mobile devices through friends, colleagues, and relatives was highly valued for social reasons.
		8.4 There is a strong theme running across the above that **collaboration and peer-to-peer support is a key value** of mobile technologies increasing social learning, networking, and communities of practice (groups of learning)
		8.5 Possession of technology and mastery of use is associated with **social standing** and allows teachers in particular to serve as role models and local leaders.

		8.6 Parents and community members **experience pride** of being part of mobile learning programmes and access educational services more strongly that incorporate mobile devices. They also have higher perceptions of teachers and schools that use mobile technologies.
		9. The educational use of mobile technology can support the accumulation of **economic capital** [Economic capital]
		9.1 Teachers and learners assume a **direct economic benefit** from their acquisition of **IT skills** (e.g. better employment opportunities; abilities to take part in the information society)
		9.2 Teachers assume that learners can use mobile devices **to look for jobs online.**
		9.3 In rural communities, parents and community members hoped that the provision of mobile technologies would **support the development of the local community and slow the urban migration of youth**.
		9.4 In the context of adult learning, there was an **intrinsic economic motivation** to use mobile phones in order to obtain business and save costs and phone calls.
		10. A theme of using mobile technologies to support **empowerment** ran through a sub-set of studies, but was not focused on the particular role of mobile learning in this process. [Empowerment]
		10.1 General belief that access to information can empower communities and people, but marginal ideas that pedagogies can be built around that to make them aware of their oppression and overcome it akin to Freire's **critical pedagogy**.
		10.2 **Women empowerment** through literacy acquisition mentioned in a small sub-set of studies.
		10.3 There were constant suggestions but few empirical examples of using mobile technologies to support **the co-**

		construction of knowledge (e.g. learners generating content; teacher designing new exercises; local knowledge fed into the educational process)
		10.4 Mastery of mobile technology to support **self-worth and aspiration**
NON-Themes: 1. There is no systematic empirical evidence that **different groups or actors in education are able to exploit or access mobile devices differently** in formal education; gender emerges as a determinant of access in unstructured informal education programmes. 2. There is no systematic empirical evidence that educators and learners **develop dependencies on mobile technologies** in formal education; illiterate learners in informal programmes, however, are at risk of developing device-based literacies. 3. There is no systematic empirical evidence that mobile technologies **distract learners and promote illicit social behaviour**. 4. There is no evidence of **unsustainable cognitive loads** created due to the usage of mobile devices. 5. There is no empirical evidence that the effect and usage of mobile technologies **wears-off over time**. **(novelty effect)**		**NON-themes:** 1. There was no systematic empirical evidence to indicate that mobile technology presents a mechanism **to access otherwise inaccessible education services**. 2. There was no systematic empirical evidence that **access to educational materials** is a key mechanism through which ML4D works. 3. There was no systematic empirical evidence that mobile devices fostered **life-long learning.** 4. There was no systematic empirical evidence to indicate that mobile technologies **caused harm** to educational actors in LMICs. 5. There was no systematic empirical evidence on mobile learning's effects on **systemic change** in education. 6. There was no systematic empirical evidence on the theme of **leadership** in ML4D. 7. There was no systematic empirical evidence on the theme of **management** in ML4D.

Appendix 6.2: Example of analysis in thematic synthesis

This appendix serves to provide an illustration of the detailed process underlying the thematic synthesis. It supplements the description of the methods for thematic synthesis in chapter 4, section 4.3.4 and the recap of these linked to the thematic synthesis findings in chapter 6, section 6.1.3. The below illustration is linked to the analytical theme on mechanism 1: Pedagogy and practice.

Stage 1: Line-by-line coding of research findings reported in included primary studies

Stage 2: Configuration of line-by-line codes into descriptive themes

Stage 3: Configuration of descriptive themes into analytical themes that are unit of analysis

Research finding: Kim 2009
However, for the children in the present context, short story content was highly entertaining since they had not watched television or accessed Internet content. As shown in Fig. 5, the children often shared their screen with siblings and peers, as they found the content entertaining. In some cases, the children often deeply concentrated on various short stories for an incredibly extended time.

Research finding: Makoke 2010

The findings suggest that MXit has the potential to be used to support collaborative learning amongst distance learners

Research finding: Sahni 2008
These analyses suggested first that, at all three DSH schools, teachers adopted more participatory pedagogical practices over time. There was a dramatic shift away from classrooms whose dominant form of pedagogy consisted of a lecturer and an inactive listening audience toward interactions and pedagogies that were more dynamic and collaborative in nature. In some cases, teachers began to interact with their students by asking additional questions that were relevant to the subject material, while in other cases, the teacher learned to ask more sophisticated questions that seemed to require more complex thinking from the students.

Descriptive theme 1

- interactive and collaborative learning

Descriptive theme 2

- authentic educational approach

Descriptive theme 3

- personalised and targeted learning

Descriptive theme 4

- increased access to information

Descriptive theme 5

- variety in teaching and learning activities

Analytical theme

Mechanism 1: Pedagogy and practice

Mobile learning in LMICs can change the way education is practiced, leading to a number of more learner-centred educational approaches

Stage 1: Line-by-line coding of research findings reported in included primary studies

Stage 2: Configuration of line-by-line codes into descriptive themes

Stage 3: Configuration of descriptive themes into analytical themes that are unit of analysis

Research findings: Ekanayake 2013
Mobile phone images supported bringing the outside world into the classroom making use of authentic contexts and students' science learning personally relevant.

Research findings: Pimmer 2013
The interviewees reported accessing information in situ as needed in hospitals to understand a particular case or when they were studying for exams and were unable to find relevant information in their textbooks. In this sense, mobile devices supported learning and sense-making that arose within the immediacy of a situation by linking codified knowledge to situated cognition.

Research findings: Leach 2005
It improves language skills for those [Xhosa speakers] who do not speak English. At the beginning they are stiff, we play games to facilitate their ICT skills! Now they love working and learning. We have made isiXhosa stories that are related to their experience.

Descriptive theme 1

- interactive and collaborative learning

Descriptive theme 2

- authentic educational approach

Descriptive theme 3

- personalised and targeted learning

Descriptive theme 4

- increased access to information

Descriptive theme 5

- variety in teaching and learning activities

Analytical theme

Mechanism 1: Pedagogy and practice

Mobile learning in LMICs can change the way education is practiced, leading to a number of more learner-centred educational approaches

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Research findings: Onguko 2013
We find that PD offered through blended learning on appropriate technologies, provides teachers with personalized learning. Studying through self-directed approaches, teachers are able to pace their study. They adjust their self-directed study to suit their own schedules determined by their workload and other communal engagements.

Research findings: Kim 2011
This enrichment activity (i.e., consists of reading with visual effects, listening narrations and own recorded voices, and reflecting, etc.) was personal and at the individual level because each student freely selected own materials and interacted at own pace.

Research findings: Balasubramanian (2010)
Two aspects are evident from the above analysis: self-directed learning and gender dimensions. The community came together, defined the learning goals based on individual needs, identified the resources and strategies for learning, and are in the process of evaluating the outcomes. The blending of vertical and horizontal transfer of knowledge helped individual learners to learn in their own time and at their own pace.

Descriptive theme 1

- interactive and collaborative learning

Descriptive theme 2

- authentic educational approach

Descriptive theme 3

- personalised and targeted learning

Descriptive theme 4

- increased access to information

Descriptive theme 5

- variety in teaching and learning activities

Analytical theme

Mechanism 1: Pedagogy and practice

Mobile learning in LMICs can change the way education is practiced, leading to a number of more learner-centred educational approaches

Stage 1: Line-by-line coding of research findings reported in included primary studies

Stage 2: Configuration of line-by-line codes into descriptive themes

Stage 3: Configuration of descriptive themes into analytical themes that are unit of analysis

Research findings: Wu 2011
So it's really helpful, not just for us, but also for the doctors. Because most times during ward rounds, they ask us to check on our tablets to look up information to make sure what they are doing is right, so it helps them as well in managing patients.

In summary, undergraduate medical student participants in the focus group discussions felt that the tablets benefitted their medical education as well as patient care during clinical rotations. In particular, they appreciated the constantly available source of information and the opportunities for communication.

Research findings: Zelesny-Green 2014
In other instances of after-school mobile phone use for education and learning, the NDSS learners employed the devices for information-gathering purposes related to both their informal and formal education: I also use the phone to Google and search for various information about the topics…that I learn…I use the mobile phone to access the internet so that I can get information about my education.

Research findings: Bello-Bravo 2012
As for women and girls it is more difficult to obtain information about controversial topics like forced marriage, divorce, the animation approach providing this information could help to solve that gap.

Descriptive theme 1
- interactive and collaborative learning

Descriptive theme 2
- authentic educational approach

Descriptive theme 3
- personalised and targeted learning

Descriptive theme 4
- increased access to information

Descriptive theme 5
- variety in teaching and learning activities

Analytical theme

Mechanism 1: Pedagogy and practice

Mobile learning in LMICs can change the way education is practiced, leading to a number of more learner-centred educational approaches

Stage 1: Line-by-line coding of research findings reported in included primary studies

Stage 2: Configuration of line-by-line codes into descriptive themes

Stage 3: Configuration of descriptive themes into analytical themes that are unit of analysis

Research findings: Sahni 2008
Additionally, we noticed that the instructors over time used a greater variety of representational tools to facilitate learning, such as drawing pictures on the blackboard, or writing verbally spoken questions on the blackboard. The teachers also showed increases in requests that students think critically about the subject material, approach the blackboard, solve equations, answer questions, and assist other students in solving a difficult question through group-work and group-activities.

Research findings: Masperi 2008
The focus on audio and video material and interactive learning techniques offered pedagogical advantages in combining learner-centred and outcome-based activities with continuous assessment. It was also noted that the flexible and diversity in learning approaches allowed for better class management and small group work, supporting the development of social, leadership and interaction skills in the learners. Teachers reported that shy and slower learners were positively affected by the direct interaction with technology and were more willing to engage in learning activities.

Research findings: Leach 2005
ICT use extended the range of teachers' existing pedagogic practices.

Descriptive theme 1

- interactive and collaborative learning

Descriptive theme 2

- authentic educational approach

Descriptive theme 3

- personalised and targeted learning

Descriptive theme 4

- increased access to information

Descriptive theme 5

- variety in teaching and learning activities

Analytical theme

Mechanism 1: Pedagogy and practice

Mobile learning in LMICs can change the way education is practiced, leading to a number of more learner-centred educational approaches

Appendix 6.3: A narrative summary of the best available aggregative evidence

The meta-analysis generated a robust positive effect of mobile learning, which is based on the statistical synthesis of the evaluations of 17 different ML4D programmes. It aggregated the diverse finding of these evaluations into one combined pooled effect size. Having established ML4D overall effectiveness through this analysis, I outline briefly in the following how some of these ML4D interventions achieved their positive impact in practice. This narrative summary is based on the seven studies judged of the lowest risk of bias, which therefore were assumed to present the best available evidence included in the aggregative module. It serves to give the reader a better understanding of mobile learning's effectiveness that is not merely based on a numerical number.

Four of the seven studies were conducted as part of a wider development programme. Aker and colleagues (2012; 2015) added a SMS module to an existing adult literacy campaign (Project ABC) in rural areas in Niger. Similarly, Cole and peers (2012) used mobile phone technology in a rural setting in India. The Avaaj Otalo programme presented a mobile phone-based agricultural extension service aiming to reduce pesticide use and to encourage the adoption of more effective agricultural practices. He and colleagues (2008) worked with an English language training program developed by Pratham, an Indian network of NGOs that aims to change the way that English is taught in Indian classrooms. They introduced PicTalk a mobile gaming device into the ongoing programme approach to facilitate more interactive learning.

The PicTalk device is based on Interactive Paper Technology and rolled out in urban primary school on a 1:1 model of ownership. The device was applied in English and math classes. Learners could access visual and verbal hints on the machine while engaging in the learning games and the device was programmed in local dialect, Marathi. Apart from the mobile learning game the devices also provided additional features to create picture diaries and poems. He and colleagues' (2012) evaluation of PicTalk found gains of about 0.25-0.35 standard deviations in students' knowledge of English. They further identified two important mechanisms that moderate the programmes effectiveness. When the mobile learning intervention was implemented by teacher, who directed the usages of the devices actively, lower performing students benefited more from the mobile learning. On the other hand, in case device use was self-directed, leaving learner at their own will to access the intervention, higher performing students were found to benefit more. Teaches and learners identified the device as an acceptable educational tool and the overall programme appraisal was since positive.

The Avaaj Otalo extension programme allowed farmers access to locally relevant agricultural information through a toll-free hotline, daily SMS messages, and a peer-to-peer support facility. The Avaaj Otalo interface features a touch-tone navigation system with local language prompts, developed specifically for ease of use by semi-literate farmers. The programme in particular encourages farmers to access the service while at work in their fields to allow for a context-relevant learning experience. The programme aimed at improving farming practice and output, as well as improvements in agricultural knowledge.

Avaaj Otalo aimed to not merely tell farmer what to do (e.g. which pesticide not to use) but rather aimed to generate an improved understanding of farming processes and their interaction with the local eco-system. Cole and colleagues (2012) evaluation found a small positive but statistically non-significant impact on agricultural knowledge. As at the same time farming output improved significantly they conclude that farmers trusted and adopted the information received by the mobile phone-based extension. However, learning did not seem to have taken place. The trust placed in mobile phones though is a notable finding. Farmers expressed a preference for mobile extension services over the local extension officers, citing reliability, timeliness/in-context, and quality as main reasons. Avaaj Otalo was since highly accessed and farmers receiving the service turned less often to other farmers and input sellers for agricultural advice.

Jenny Aker and colleagues (2012; 2015) evaluations of the Project ABC programmes arguably presents the most well-known assessment of a ML4D intervention. An existing adult literacy and numeracy campaign was supplemented by a SMS module that entailed training on how to use a mobile phone as well as a subsidised supply of basic phones. As the use of mobile phones, e.g. reading and writing SMS, requires a certain amount of functional literacy, mobile phones training and ownership was assumed to reinforce the existing literacy campaign. This assumption was validated in two large RCTs. The evaluation since showed that mere mobile phone usage supported literacy and numeracy acquisition. These learning gains further were more likely to be retained one year after the programme had ended.

The studies generate a wealth of rigorous evidence on mobile phones impact on informal learning. They identified, among other, that younger learner showed higher learning gains and that the overall impact was not driven by differences in teacher quality or in teacher and student attendance. One study also tried to assess whether learners' overall perception and value of education had increased. This assessment could have potentially served as an indicator of empowerment but due to the poor outcome instrument, it was judged at critical risk of bias in this review. Most importantly, however, it revealed how economic factors provided an intrinsic incentive to obtain functional literacy in order to be able to operate mobile phones. Since SMS in Niger were much more affordable than voice calls, illiterate rural learners were excluded from the financial reward the proficiency of SMS technology offered. This served as a large incentive to obtain the literacy skills required to exploit the financial savings associated with SMS. All in all, the studies produced highly rigorous evidence that simple and relatively cheap mobile technology can serve as an effective vehicle for learning among rural populations.

The studies by Pitchford and colleagues (2014) and Kaleebu and peers (2013) and Piper and peers (2015) were embedded in a formal educational setting rather than in conjunction with an ongoing development programme. They were designed to support formal education systems challenged by widespread poverty in Malawi, Kenya, and Papua New Guinean respectively. Pitchford and colleagues (2014) and Piper and peers (2015) implemented the only tablet-based programmes included in the meta-analysis. Likewise, Kaleebu and peers (2013) and Piper and peers (2015) implemented the only teacher-centered ML4D intervention in the included sample.

The innovative SMS Story project in Papua New Guinean aimed to improve the teaching of reading to learner through the delivery of daily short stories and complementary lesson plans via SMS technology to primary teachers (Kaleebu et al 2013). The programme aimed to increase interactivity and learner inclusion in the learning process. It assumed that teachers' applied pedagogies could be changed through the provision of teaching content and support on mobile phones. The programme was positively received by teacher, who actively took part in its iterations, e.g. calling for a need to deliver SMS a day in advance rather than in the morning prior to the lesson. The intervention was highly effective in increasing English test scores for the involved learners. The evaluation since provided evidence that mobile technologies targeted at teachers could similarly improve learning outcomes. The learners, in this case, experienced academic benefits of the introduction of mobile technologies even though the devices were introduced at teacher level.

Piper and peers (2013) evaluated the Primary Math and Reading Initiative (PRIMR) Kisumu Information and Communication Technology (ICT) intervention in Kenya. The programme aimed to assess different types of technology provision to assess their impact and cost-effectiveness. Three programme approaches were tested: (i) tablet provision with pre-loaded basic educational content to teaching assistants; (ii) tablet provision to teachers themselves with advanced educational content and learning analytics abilities; and (iii) e-readers provided to learners at a 1:1 ratio. The outcomes of the three different treatments were positive on learning gains as follows: The effect size for e-readers, the teacher tablets, and the teaching assistant tablets was .35 SD, .47 SD, and .44 SD, respectively. These effects were not statistically significant from each other, but taking into consideration the cost-effectiveness of each programme arm, large differences are revealed. The teaching assistant tablet programme is by far the most cost-effective approach being almost two times more cost-effective than the teacher tablets, and 10 times more cost-effective than the e-reader learner group. The latter is not cost-effective at all being six times less cost-effective than the control group despite the larger gains in learning outcomes. All in all, this study, too, finds that providing mobile technologies to teachers is an effective approach to achieve positive outcomes at a learner level. What is more, it is also a more cost-effective approach than focusing technology provisions to learners.

Lastly, Pitchford and colleagues' (2014) evaluation of the tablet-based Masamu intervention focused on a tablet-based mobile learning programme in Malawi. As a note of caution it needs to be highlighted that the study was funded and commissioned by EuroTalk, the commercial company who developed the applied mobile learning application. The study also generated an outlying effect size of 1.68, which diverted more than a complete standard deviation from the pooled standardised effect size. Having said that, the study used a highly sophisticated pedagogic application on a high-end device (iPad mini), which might offer an explanation for its large effect size. EuroTalk designed a mobile math learning game that since has been commercially offered in HICs. Evaluations of the application in HICs also identified a significant impact on mathematics learning. In the evaluation, Pitchford and colleagues, moreover, tried to link the improvements in learning gains to increased level of ambition and progressive attitudes, which then could be described as empowerment. However, the outcome instrument was of critical risk of bias and investigating the life ambitions of primary learners, arguably, is unlikely to present a valid indicator of empowerment.

In sum, this short narrative summary underlines the heterogeneity in context and programme approach of the reviewed ML4D interventions. The interventions' impacts are far more nuanced than a single effect size could reflect. From this short juxtaposition of the best available evidence a number of themes and questions arise. For example, He and colleagues found a greater benefit for weaker students if the technology is applied by teachers, whereas Aker and peers establish a larger effect for younger students. However, none of these themes are based on a systematic investigation of the evidence and merely present individual observations. To fully understand these contexts and mechanisms explained the identified effectiveness of ML4D, we require an equally rigorous review and transparent synthesis of a different type of evidence. Understanding contexts and mechanisms subscribes to a configurative mode of analysis rather than an aggregative approach as applied in this meta-analysis.

Appendix 7.1: On the absence of negative case study findings

Lastly, there is also a question whether desirability bias has influenced some of the teachers' responses. There is a curious absence of negative themes in my qualitative case study research and even when probed for what they did not value about using the tablets, teachers reported little feedback that could be seen as a criticism of the ICT4RED.

First, the ICT4RED programme did present a large-scale intervention in teachers' professional lives and the functioning of their schools. It needs to be kept in mind that the rural Eastern Cape is by many measures South Africa's most impoverished region and some of the ICT4RED schools lack basic infrastructure such as built classroom structures. In this context, at an individual level, the ICT4RED provided each educator with a high-end 10-inch tablet, a monthly voice and data allocation, and access to alternative educational content and lesson plans. This was complemented by a certification of becoming an 'ICT champion', bi-weekly trips to the administrative capital including hotel accommodation, travels to ICT-related summits such as the Google summit, and visits by national and district education policy-makers. Professionally as well as socially, ICT4RED therefore did present a major input into teachers' lives. In addition, at a school level, the programme also provided major inputs and changes in infrastructures. The schools gained teaching equipment such as projectors and whiteboards, laptops, and tablets for their pupils, as well as WIFI-connectivity and charging and storage facilities. Schools not connected to the electricity grid gained preferred access to the electricity roll-out in their communities. It could therefore be argued that the ICT4RED presented such a major stimulus in teachers' professional and social contexts to justify the weight of positive data collected. Though, this line of thought assumes a rather naïve conception of technology provision and its application and transformation into social and professional well-being.

Second, the above narrative of ICT4RED as a major intervention into teachers' lives and schools' functioning can be used to set up a situation in which teachers feel compelled to provide a positive account of the programme. This could be in particular the case as the schools' acquisition of technological inputs depended directly on teachers' participation and completion of the professional development course. Teachers therefore had a major responsibility (as well as social reward) for the schools' development of IT capabilities. In this context, teachers might have perceived me as an evaluator of the programme whose findings and recommendations might have affected their own and the schools' continued access to technological inputs. I attempted to counter this assumption by stressing the independence of my research from both the internal and the external evaluation verbally and in the information sheet provided as part of the data collection. However, the introduction of myself to principals was conducted through formal channels involving education district officials and I can therefore not rule out that teachers perceived me and my research as an evaluation of the ICT4RED on which a future access to the programme might have depended.

Third, the manner in which the interview schedule focused around what teachers valued about the technology usage might have influenced the nature of the data. To be clear, exploring valued beings and doings presents an analytical device of the CA and I could not have avoided probing themes in this direction. However, I paired each interview question exploring valued beings and doings with a primer for participants to report beings and doings they did *not* value. I further can cross-reference valued educational and informational beings and doings with the data collected during the classroom observations[86].

In summary, I would argue that all three reasons possibly influenced the content of the data collected. For reasons two and three, I implemented quality assurance measures to the best of my ability, while the scale and nature of the ICT4RED intervention in the context of the Cofimvaba school district is outside my control. When interpreting the results of my qualitative case study, these three caveats should be kept in mind, however.

[86] This is not possible for the functionings related to economic and societal capabilities as these referred to beings and doings that took place outside the school environment.

Appendix 7.2: Exhaustive list of all capabilities and functionings

Capabilities (opportunities)	Valued beings and doings (functionings)
Informational capabilities	
1) To be able to use ICT effectively (be tech champion) [ICT usage]	1. operate a tablet device with its particular apps and affordances (e.g. camera) 2. connect to and use the internet 3. achievement and pride for tech mastery 4. independent usage and curiosity to 'keep trying new things' 5. differentiation of devices and educational application of affordances
2) To be able to find, evaluate, use, and process information [Information literacy]	6. access information instantly, more conveniently 7. access information independently and tailored to personal preferences (choice—get anything I want) 8. stay up-to date 9. translate access to information into teaching relevant knowledge 10. translate access to information into socially relevant knowledge (bible app at church)
3) To be able to connect and communicate [Connectivity]	11. communicate instantly and personal 12. increase and maintain professional networks 13. stay in touch with family and friends 14. stay in touch with learners to follow their path 15. reach out to the world (less isolated/agency)
4) To be able to engage in one's professional identity and practice anywhere, anytime [Mobility]	16. access to device anywhere, anytime 17. more convenient than traditional teaching tools and more dynamic and professional in appearance 18. prepare/gather teaching content anywhere, anytime 19. teach anywhere, anytime (remote instructions, two classes at once) 20. collection of teaching materials all in one place 21. to possess and identify with a personalised and centralized teaching tool (value of tablets/personalisation; cellphone analogy)
5) To be able to extend	22. collect teaching ideas and contexts anywhere

professional being/realities across contexts [Merging realities/contexts]	(take pictures at home eg) 23. provide education across time & space (record lesson for sick children; let children take home videos to study further/revise at night) 24. contextualise students learning experiences across space and time 25. be regarded as a professional in occupational and social domain 26. transfer valued beings across time and space (apartheid deprivation; showing of to former teacher colleagues visiting)
To be able to create, share and use local content [Content generation]	This capability while realised was not valued as it did against the highly top-down fashion of teaching in SA in which teachers did not deem it appropriate to deviate from the Departmental Syllabus.
Educational capabilities	
6) To be able to improve learning achievements [Student success/support]	27. learners are more motivated 28. learners have more fun 29. learners succeed in tests 30. teachers achieve teaching goals
7) To be able to change and explore teaching methods [Pedagogies]	31. increase interaction and participation (ICT4RED methods, group work) 32. provide instant and personal feedback 33. access different and more appropriate content 34. increase subject knowledge 35. 'teach' outside (fieldwork) 36. choose from a variety of methods (creativity)
8) To be able to become a facilitator of knowledge [Role of teacher]	37. co-produce produce knowledge (they are teaching me/do their own research/bring their own information) 38. create room for discovery (learn by themselves /bring their own information/become problem solvers) 39. teach learner-centred 40. deliver more relevant teaching
9) To be able to enjoy teaching more [Occupational satisfaction]	41. organise administration/limits my workload (no need for paper; marking; books; all in one place; content stays) 42. easier to control (tool of power; better behaviour) 43. boost moral 44. pleasure in using tech (ease of use)
10) To be able to innovate	45. changed view about technology as an

[Innovation]	educational tool 46. know how to teach with technology 47. learning by doing 48. make mistakes together/tolerance for failure 49. life-long learning
11) To be able to work in collaboration [Collaboration]	50. exchange teaching content with other teachers 51. gain technological skills through working together 52. extend teaching horizon with international teachers on the internet 53. Observation of after-hours class
Economic capabilities	
12) To be able to be employed [Employment]	54. build IT skills that are in demand 55. train other teachers in IT skills 56. stay employable in a changing time 57. transfer to a different post 58. make learners more employable
13) To be able to build social capital [Social Capital]	59. to be able to guide learners 60. to be able to access & share up-to-date job information 61. to be able to market oneself online
14) To be able to build the brand [Marketing]	62. increased enrolment of learners at ICT4RED schools 63. increase the returns to education at ICT4RED schools 64. train other teachers in IT skills
15) To be able to extend educational opportunities [Online education]	65. further teaching qualifications 66. provide additional teaching services in the community 67. support own children's education
16) To be able to access digital services [Digital services]	68. save costs of going to town 69. use online banking 70. make online appointments 71. use online call rates
Societal capabilities	
17) To be able to be impress [Respectability]	72. being respected by the learners 73. being respected by other teachers 74. being respected by the community 75. impress people

18) To be able to be 'on the same page' [Recognition]	76. have access to same educational inputs/resources 77. attract learners/teachers back to rural schools 78. engage on par with 'reputable' educational institutions 79. be the first to use technology
19) To be able to create a professional teaching identity [Professional identity]	80. appear more professional 81. increase the reputation of the teaching profession 82. attract learners to become teachers 83. be appreciated by the government 84. merging professional and social realities/identities
20) To be able to 'grow' as a person [Self-actualisation]	85. being empowered/enlightened/uplifted 86. become a role model 87. gain confidence and pride (over tech mastery) 88. contribute one's part to society
21) To be able to support the local community [Community development]	89. community excitement (feel important and on the same page) 90. increase community cohesion (no more break-ins) 91. create opportunities (community development; learners take up good jobs)