Author: Wang, J.
Title: Technology integration in education: policy plans, teacher practices, and student outcomes
Issue Date: 2021-07-06

Technology integration in education

Policy plans, teacher practices, and student outcomes

ICLON, Leiden University Graduate School of Teaching

The research was carried out in the context of the *Dutch Interuniversity Center for Educational Sciences.*

This research was funded by China Scholarship Council (CSC) (Grant no. 201706990025).

Title: Technology integration in education: Policy plans, teacher practices, and student outcomes

Titel: Technologie integratie in het onderwijs: Beleidsplannen, leraren-praktijken en leerlingresultaten

ICLON PhD Dissertation Series

Print: Mostert & van Onderen!
Cover design: Zhiqian Yu
Lay-out: Mostert & van Onderen!
ISBN/EAN: 978-94-90383-34-3

Technology integration in education

Policy plans, teacher practices, and student outcomes

Proefschrift

ter verkrijging van
de graad van doctor aan de Universiteit Leiden,
op gezag van rector magnificus prof. dr. ir. H. Bijl,
volgens besluit van het college voor promoties
te verdedigen op dinsdag 6 juli 2021
klokke 11.15 uur

door

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geboren te Chongqing, China
in 1990

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General introduction

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1.1 Introduction

Since the beginning of the 21st Century, computers and the Internet have spread dramatically worldwide. However, access to technologies varies significantly across countries and individuals around the world. Digital inequity has a significant negative impact on individuals and limits economic and social development (OECD, 2012). In many educational systems, the integration of technology in schools has been recognized as critical to move toward digital equity in education, thus prompting governments to launch particular initiatives and make substantial investments to access and use technology (Pittman, McLaughlin, & Bracey-Sutton, 2008). Technology integration offers new opportunities to enhance teaching and learning and students' motivation, engagement, and achievement in particular (Ainley, Enger, & Searle, 2008; Hinostroza, Labbé, López, & Iost, 2008). Still, we often see that technology is inappropriate or insufficient used in teaching. Many technologies used in primary and secondary education replicate old methods, strategies, and activities that are mainly teacher-centered without functional changes (see e.g., Crompton & Burke, 2020). Successful technology integration in the educational system entails more than just having Internet-connected computers in the classroom (Chauhan, 2017) and using technologies for replicating traditional teaching. For this reason, in this dissertation, we endorsed the definition of technology integration based on Belland (2009), who defined technology integration as "the sustainable and persistent change in the social system of primary and secondary schools caused by the adoption of technology to help students construct knowledge".

However, according to Niederhauser et al. (2018), it is not easy to achieve long-term sustainability and scalability in technical innovation and integration. The gap between policy and practice is regarded as one of the challenges reported by UNESCO (2015), and existing policies are largely oriented towards traditional curriculum paradigms (Kinshuk, Chen, Cheng, & Chew, 2016). Moreover, many barriers prevent primary and secondary school teachers from integrating new technologies into teaching and learning processes (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012; Hew, & Brush, 2007). Among these barriers, teacher-level factors, especially teacher value beliefs toward technology integration, were important factors in classroom technology integration in terms of quantity and quality (Vongkulluksn, Xie, & Bowman, 2018). Apart from the well-known perceived barriers (such as a shortage of hardware, software, technical assistance, and teacher training) (Goktas, Gedik, & Baydas, 2013), new barriers include a lack of quality digital content, time to prepare and implement technology-based lessons, and opportunities to participate in decision-making regarding content development, technology use and professional development (Vrasidas, 2015).

Despite the value of technology integration for educational equity and quality being emphasized by numerous studies, many gaps exist about how technology integration can be approached in policy plans, implemented in pedagogical practices, and embraced by teachers, students, and parents. In the current dissertation, the focus is on teachers' pedagogical practices with technology in primary and secondary education, contributing to a more detailed understanding of what happens to integrate technology into the teaching and learning processes. Given this goal, we examined the different teaching and technology practices considering the concerted efforts of various stakeholders at different levels and contexts. The remainder of the introduction begins with a description of the theoretical background, followed by the context of the study, then research aims, and finally an overview of the following chapters.

1.2 Theoretical background

1.2.1 Determinants of technology integration: what makes teacher practice different?

Although research studies in education show that teachers' pedagogical practices incorporating technologies are important for school improvement, good quality teaching and learning, it is still unclear whether teachers integrating technology sufficiently in their educational practices. Some studies, e.g., Farjon, Smits, and Voogt (2019) indicated that teachers struggle with fully adopting technology for teaching. This technology integration practice has long been regarded as complex and multifaceted (Mumtaz, 2000; Scherer, Siddiq, & Tondeur, 2019). Technology integration in education is explained by a range of social, organizational, personal, contextual, and technological factors which can change over time (Backfisch, Lachner, Stürmer, & Scheiter, 2021). For example, research found that school-level factors influenced the successful integration of tablets in Philippine public schools and further determined the long-term sustainability of this national large-scale technology program (Lumagbas, Smith, Care, & Scoular, 2019). Yet, teachers' role should be stressed after external obstacles have been removed (Tosuntaş, Ubukçu, & Tuba, 2019). A meta-analysis found that contextual factors of learning environments significantly moderate the overall effect of technology-supported instruction on student learning (Hillmayr, Ziernwald, Reinhold, Hofer, & Reiss, 2020).

To fully understand the mechanism for technology integration, many conceptual models to guide educational research and practice have been developed about the factors influencing teachers' technology use. Some conceptual models emerge from practice. One of the commonly used models is the Four in Balance (FIB) Model (Kennisnet, 2013). Given the interconnectedness of personal, pedagogical, and organizational contexts, the FIB model assumes that successful technology integration requires the balanced deployment of four basic elements: vision, expertise, digital content, and information and communications technology (ICT) infrastructure; leadership is a necessary element for ensuring the balance between the key elements through support and collaboration. This model has been applied in different countries, such as Kenya, Chile, and South Africa (Howie, 2010; Tondeur, Krug, Bill, Smulders, & Zhu, 2015).

Other conceptual models emerge from scientific research and have been empirically validated. A theoretical model that is very useful for explaining teacher behavior in terms of technology use is the Technology Acceptance Model (TAM; Davis, 1989), which includes both technological and psychological factors influencing the use of technology, based on the principles of the Theory of Reasoned Action (TRA; Fishbein & Azjen, 1975). As we believe that whether or not teachers use technology in their pedagogical activities is influenced by their dispositions, one limitation of TAM and its updated versions TAM2 (Venkatesh & Davis, 2000) and TAM3 (Venkatesh & Bala, 2008) lies in that they are more technology-oriented and, therefore and less include critical individual psychological processes. Besides, TAM does not distinguish between the different levels in which various individual and environmental factors are involved. Therefore, more recent models appear to incorporate variables from different educational system levels into a multilevel structure (Voogt, Knezek, Christensen, & Lai, 2018). The Integrative Model of Behavior Prediction (IMBP; Fishbein & Ajzen, 2011) is one such model, that considers human psychological mechanisms and integrates various levels (e.g., teachers nested within schools). Based on a review about teachers' technology use, Kreijns, Vermeulen, Kirschner, Van Buuren, and Van Acker (2013) suggested using IMBP as an option and the IMBP appears to be a stable and parsimonious model for explaining teachers' use of various types of technology in educational settings (see, e.g., Admiraal, Lockhorst, Smit, & Weijers, 2013; Vermeulen, Kreijns, Van Buuren, & Van Acker, 2017). In this dissertation, building upon existing models and elaborating on relevant contextual aspects, various factors at different levels that are likely to influence technology integration in education were investigated.

1.2.2 Evaluating the effectiveness of technology integration in teaching and learning

In recent years, technology integration has evolved globally in various educational environments (see e.g., Han, Byun, & Shin, 2018; Pelgrum, 2001; Pelgrum & Voogt, 2009; Tondeur et al., 2015), given the belief rooted in education policy that technology promotes teaching and learning and the resulting expectation that school leaders and teachers should integrate technology into their school and classroom practices (Vanderlinde, Aesaert, & Van Braak, 2014). Governments and organizations worldwide are experimenting with innovative projects designed to providing supporting conditions to improve learning opportunities for all children (UNESCO, 2015) since leaders are seeking evidence to create high-quality, sustainable education systems that can compete globally (Peng et al., 2014). These initiatives are also the focus of the newly emerging economies, such as China, South Korea, Indonesia, and Turkey.

However, knowledge on how educational practitioners respond to a new program or innovation is somewhat fragmented and inconsistent. Some of these inconsistencies may be due to the variation across studies, making it challenging to draw firm conclusions regarding the overall effectiveness of technology integration. For this reason, educational researchers have been interested in comparing the effectiveness of teaching with or without technology, and comparing the different technology-supported learning modes to find more effective learning approaches. Evaluation of current technology integration in education is vital for policymakers, school leaders, and teacher educators to make the decision about infrastructure investments, teacher professional development, and supporting logistics. Systematic reviews allow for a more objective appraisal of the evidence, which can provide the converging 'best evidence' for the overall effects of using technology in education in a given time. In learning scenarios, mobile technology has become a fast-growing research field in the world (Soloway & Norris, 2018). Though there have been several attempts to explain what mobile technology integration might look like and how to influence student learning in basic education in the Asia-Pacific region (UNESCO, 2018), policymakers hesitate to scale up the usage of mobile devices in primary and secondary schools, because of some adverse effects of using mobile devices (Churchill, Pegrum, & Churchill, 2018). Therefore, more research is needed on the best practices for using mobile technology in order to figure out when and how children should use mobile devices (Crompton & Burke, 2020). In addition to uncertainty about the overall effects of mobile technology on different types of the outcome variable, the potential influences of moderators need further exploration, since the main effects of mobile technology are not the same for all student groups and learning contexts.

Many earlier studies tend to rely on technology usage as a key indicator when evaluating technology integration in diverse contexts (Scherer, Siddiq, & Tondeur, 2020). While a usage model for evaluating technology integration is straightforward to implement, it falls short of covering all aspects of teaching and learning processes, and an imbalance of pedagogy and technology will limit the potential of the learning environment (Knezek & Christensen, 2016). Students' perceptions of the learning environment can be used to get more insights into how learners perceive teaching and learning processes (Fraser, 1998), which in turn can help researchers and practitioners to maximize the effectiveness by identifying critical aspects that students in specific settings most prefer (e.g., Chang et al., 2015). Moreover, student learning is improved more by integrating particular educational strategies (e.g., the use of technology in the classroom) with global factors of instructional quality (Decristan et al., 2015). Therefore, there is a need to investigate the underlying mechanisms of learning that can be facilitated by teachers' instructional quality combined with the use of technology in order to gain a more comprehensive picture of the diverse conditions for improving teaching and learning quality. Moreover, both differences within and between classrooms can bring valuable insights into how learners view their learning environments (Göllner, Wagner, Eccles, & Trautwein, 2018). Therefore, to better interpret the results, there is also a need to consider multilevel data structure when examining students' perceptions of their learning process in the learning environments.

1.3 Context of the study

Despite all students in China having equal access to the nine years of compulsory education, the Chinese government faces challenges with ensuring quality education for all students (Peng et al., 2014). In particular, while China' coastal and Eastern areas have undergone massive economic growth in recent decades, the western regions have lagged behind, resulting in significant rural-urban divides. The Chinese government has provided special funding and projects for Western and rural China, hoping that technology can support disadvantaged groups and equalize educational opportunities. Knowledge about education and technology mainly flows from developed eastern regions to the less developed western regions and from the urban areas to the rural areas (Schulte, 2015). The national guideline (MOE, 2010) maintains that the government's aim is to achieve education equity by allocating quality resources to rural, remote and disadvantaged ethnic minority regions, thereby narrowing the education gap. Nevertheless, in these priorities on technology integration in education in rural areas, connectivity was prioritized over potential pedagogical impacts, which might reveal the shortcomings of many past efforts.

To counteract this, in 2012, the first national ten-year ICT plan was released based on the premise that the use of these technologies would renew how knowledge is taught and learned (MOE, 2012). The introduction of the national ICT plan has accelerated the pace of ICT in rural education by connecting schools through the broadband network, connecting classes with quality digital resources, and connecting students in e-learning space. However, until 2015, "some educational administrations and schools still do not fully recognize the revolutionary impact of ICT on education," and technology is used insufficiently and inappropriately in teachers' daily pedagogical practices (MOE, 2016). In order to complete the development tasks determined by the ten-year plan and promote the ICT in education in a comprehensive and in-depth way, the MOE issued "13th Five-year Plan for ICT in Education (2016-2020)" in which the development of technology integration in education shifted to the benefits of technology for teaching and learning integrating a more learner-centered pedagogy. It is worth noting that local governments have formulated and implemented their policy plans under the call of the central government in the national plan. In 2018 alone, about 20 provinces and municipalities have issued official documents to improve the integration level of ICT and education.

Recently, given the potential impact of smart classrooms on the traditional teaching structure, China has made efforts to facilitate smart classrooms reported in "The announcement of the action plan for ICT in education 2.0". The Chinese central government calls teachers to move beyond traditional teaching and embrace innovative pedagogical approaches with emerging technologies (MOE, 2018). In order to respond to the national call and promote the smart classrooms, many local governments have issued their action plans. However, except some economically developed areas where schools have been provided with student personal tablet PCs and interactive desks (Li, Kong, & Chen, 2015), other local governments typically only provide the infrastructure and equipment for classrooms, and it is not possible to equip each student with a mobile device. Under this circumstance, when students hope to study in smart classrooms, their parents need to buy them mobile devices. In the empirical studies of the current dissertation, schools and participants were purposefully selected from Western China where significant investments and supportive projects regarding technology integration in education had been carried out.

1.4 Research aims

The primary aim of this dissertation is to advance knowledge of technology integration in education. In order to obtain a holistic view, research into this issue was approached from several different stakeholders, different technological practices, and different contexts. Organized into three major thematic strands, this dissertation examines the link between ICT policy plans and ICT practices in rural schools, rural teachers' pedagogical practices with digital educational resources, and students' learning with mobile technology.

Specifically, this dissertation has three aims. First, this dissertation aims to examine technology integration in the context of rural schools in China. Our interest in the rural context focuses attention on how these technology integration practices are shaped by broader political, cultural, and social contexts of teaching, especially connecting rural schools to quality education. Since context matters and strategies must be adapted accordingly to the situation, this study emphasizes the importance of understanding why and how to integrate technology in rural schools.

The second aim of this dissertation is to be of practical value for policymakers, school leaders, and teachers. We argue that promoting digital equity and teaching quality at a high level in rural and remote areas in China can be supported by the use and sharing of digital educational resources. As a result, the emphasis of this dissertation is on school and teacher variables that are likely to explain and predict the use and sharing of digital educational resources by rural teachers.

The third aim concerns the effects of using new and emerging mobile technology on student learning. The current dissertation aims to provide a broader perspective and more in-depth understanding of the overall beneficial effects of mobile technology usage in primary and secondary education. Yet it also aims to provide evidence of underlying mechanisms of learning facilitated by teachers' instructional quality combined with the use of technology in secondary education and for the design and implementation of smart classrooms.

1.5 Dissertation outline

This dissertation focuses on the pedagogical use of technology for teaching and learning in primary and secondary education. Chapters 2 to 6 contribute to the main aim of the dissertation, focusing on at least one or more stakeholder perspectives, technological practices, and contexts. Figure 1.1 provides a schematic overview of the dissertation. Five studies were performed in which:

(1) an overview of the link between local ICT policy plans and the ICT practices of rural schools (Chapter 2);
(2) rural teachers' use of digital educational resources aimed at promoting digital equity and education for all (Chapter 3);
(3) rural teachers' sharing of digital educational resources aimed at promoting teacher professional learning opportunities and development (Chapter 4);
(4) a meta-analysis on the effectiveness of various mobile technology usage on cognitive, affective, and behavioral learning outcomes in primary and secondary education was employed (Chapter 5);
(5) the relationships among teacher beliefs, classroom process quality, and student engagement in the smart classroom learning environment in secondary education were examined using teacher and student questionnaires with a multilevel mediation model (Chapter 6).

Chapter 2 describes a mixed-method study on key elements for integrating ICT in rural schools reflected in both local ICT policy plans and practices from a school improvement point of view. This exploratory study aimed to contributing to insights into whether and how local ICT policy plans are linked with the ICT practices of rural schools by examining the content of local ICT policy plans that have been developed and how school leaders and teachers perceive their experience with ICT practices of rural schools. Two research questions guided the study: (1) How are elements of ICT integration in schools represented in local ICT policy plans? (2) What are rural school practices with ICT from the perspectives of both school leaders and teachers? Directed content analysis was used to analyze local policy plans. Within- and cross-case analyses were used to analyze other qualitative sources (i.e., interviews with school leaders, focus groups with teachers, classroom observations, and an ICT inventory). Descriptive statistics were used to analyze the teacher survey.

Chapter 3 describes a quantitative study aimed at providing insight into rural teachers' use of digital educational resources, and teacher- and school-level factors that explain differences in teachers' use of digital educational resources. Research questions were: (1) What types of digital educational resources do rural teachers use for their teaching? (2) Which school-level variables explain differences between rural teachers in their use of digital educational resources in teaching? and (3) Which teacher-level variables explain differences between rural teachers in their use of digital educational resources in teaching? Questionnaire data were collected from 462 rural teachers from 25 primary and secondary schools in three different areas throughout Western China. The teacher-level variables provided information about teachers' perceptions (attitude, self-efficacy, subjective norm, intention, knowledge and skills, and facilitating conditions) toward using digital educational resources and demographic characteristics (gender, age, class size, number of subjects, year of teaching with digital educational resources). The school-level variables provided information about the schools' types and locations. Except for descriptive statistics, multilevel analyses were conducted taking into account the nested structure (teachers within schools).

Since the use of digital resources can merely increase the resources without changing fundamental practices when teachers continue teaching based on direct instruction (Santana Bonilla & Rodríguez Rodríguez, 2019), exchanging teaching-related knowledge and making digital resources available to all students are the strategies to better handle the growing diversity of students. Thus, in **Chapter 4**, the focus moves from rural teachers' use behavior to sharing behavior with the main research question: How is motivation related to sharing behavior regarding digital educational resources within and outside school? Unlike previous studies focusing on only one context of teachers' general knowledge sharing behavior (Akosile & Olatokun, 2020), this study explores the motivation-behavior relationship in the context of sharing behavior regarding digital educational resources both within and outside school. Self-reported questionnaires from 709 rural teachers were collected and analyzed employing the Structural Equation Modeling. To answer the main research question, the following sub-questions were formulated: RQ1 (a-e). Is motivation related to each of the dispositional variables (a) self-efficacy, (b) attitudes, and (c) subjective norm, (d) sharing intention within school, and (e) sharing behavior within school?; RQ2 (a-e). Is motivation related to each of the dispositional variables (a) self-efficacy, (b) attitudes, and (c) subjective norm, (d) sharing intention, and (e) sharing behavior outside school? Moreover, since more research on the link between intention and behavior is needed, the relationships between sharing intention and sharing behavior were examined, together with environmental variables. For this the following research questions were formulated: RQ3 (a-c). Is (a) sharing intention, (b) sharing climate, and (c) work pressure related to sharing behavior within school?; RQ4 (a-c). Is (a) sharing intention, (b) sharing climate, and (c) work pressure related to sharing behavior outside school?; RQ5. Is there an indirect effect of the motivation on the sharing intention within school through the dispositional variables? RQ6. Is there an indirect effect of the motivation on the sharing intention outside school through the dispositional variables?

To reimagine the current mobile-learning practices, **Chapter 5** reports the outcomes of a systematic review with a meta-analysis of experimental and quasi-experimental studies comparing the effects of learning with and without mobile technology. The purpose of this study is to provide new quantitative data that are expected to deepen the knowledge base on various learning outcomes and inform evidence-based decision-making on the use of mobile technology in primary and secondary education. The research questions that guided the study were: (1) When compared with traditional learning, what is the overall effectiveness of using mobile technologies in primary and secondary education on students' learning outcomes in terms of cognitive, affective, and behavioral dimensions? (2) What, if any, factors based on Biggs' 3P learning process model, that is student factors, teaching context and learning process factors, moderate the relationship between mobile technology use and learning outcomes? (3) What, if any, study quality characteristics explain the heterogeneity in results? Meta-analyses, moderator analyses, sensitivity analyses, and publication bias were used to analyze 61 studies of 56 peer-reviewed papers between 2014 and 2020.

The results from the study in Chapter 5 indicated that studies in which students used their own handheld devices with multiple-functions for learning showed a significantly higher effect size in favor of their cognitive learning outcomes than students who shared single-function devices with others. Therefore, students and teachers using 1:1 tablets in smart classrooms were purposefully selected in the study reported in **Chapter 6**, and this study was focused on examining the relationships among teacher beliefs, classroom process quality, and student engagement across the student and class levels in smart classrooms in secondary education. Three research questions were guiding this study: (1) At the classroom level, which variables (i.e., teacher beliefs, teacher and class background variables) explain differences between students' shared perceptions of classroom process quality in the smart classroom learning environment? (2) At the classroom level (i.e., teacher beliefs, teacher and class background variables) and student level (i.e., students' shared and individual perceptions of classroom process quality, student demographic variables), which variables explain differences between student engagement in the smart classroom learning environment? (3) Is there an indirect effect of teacher beliefs, and teacher and class background variables on student engagement in the smart classroom learning environment through students' shared perceptions of classroom process quality? To obtain a comprehensive view of classroom process quality, two digital questionnaires were developed. The student questionnaire was developed to measure classroom process quality and student engagement, and the teacher questionnaire was developed to measure teacher beliefs. Given the sample's stratified nature, students were nested within class. Multilevel regression analyses and a multilevel mediation analysis for a 2-2-1 mediation design were conducted. The final chapter, Chapter 7, provides a summary of the main findings of Chapters 2 to 6, a general discussion about the results, implications for practice and future direction, and the limitation of these studies.

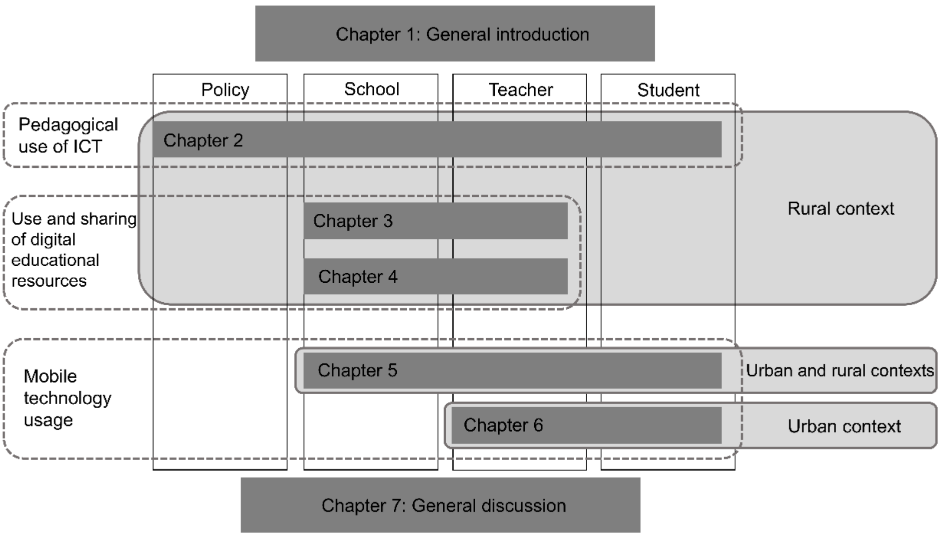

Figure 1.1. Overview of chapters in this dissertation.

From policy to practice: Integrating ICT in Chinese rural schools

2

This chapter was submitted in an adapted form as:
Wang, J., Tigelaar, D. E., & Admiraal, W. From policy to practice: Integrating ICT in Chinese rural schools.

2

Abstract

Research has often ignored the complex systemic nature of ICT integration in education, including the importance of the historical, social, and political context. This study examines the content of local ICT policy plans that have been developed and how school leaders and teachers perceive their experience with ICT practices of rural schools. A mixed-method research approach was applied, involving 25 rural schools in Western China. Data was collected from multiple sources (policy documents, interviews with school leaders, focus groups with teachers, classroom observations, an ICT inventory, and a teacher survey). The results revealed three types of challenges for ICT integration in rural schools: (1) guidance and learning opportunities as a political challenge, (2) sound ICT infrastructure and appropriate digital content as a technical challenge, and (3) teacher training and technical support as a human challenge. These challenges have implications for policymakers and practitioners when improving rural education through ICT integration.

Keywords

Policy plans; ICT integration; Rural education; Pedagogical use of ICT

2.1 Introduction

Researchers and policymakers around the world increasingly acknowledge the importance of developing policy plans to facilitate the integration of information and communication technology (ICT) in education (Goktas, Gedik, & Baydas, 2013; Vanderlinde, Dexter, & Van Braak, 2012). Policymakers recognise that ICT has the power to improve classroom teaching through appropriate pedagogical approaches, especially to connect rural and remote areas to education opportunities (UNESCO, 2015). Many large-scale ICT projects for education started some years ago in developing countries (Blignaut, Hinostroza, Els, & Brun, 2010). The results of these projects often do not meet the high expectations of ICT and investments: while strategic policies at the national level provide a vision of future education enriched by ICT, the operational policies at the local level consider the local budget and constraints to realise the vision (Fishman & Zhang, 2003).

In order to support effective teaching and learning in meeting educational goals, more attention needs to be paid to local possibilities (Tan, 2016). This is particularly the case in rural schools where, in general, teaching is found to be less effective, and teachers are less qualified compared to urban areas (Liu & Onwuegbuzie, 2012). Insights into both local ICT policy plans and the experience of rural schools may therefore provide us with a better understanding of teachers' pedagogical use of ICT. In this exploratory study, we aim to contribute to insights into whether and how local ICT policy plans are linked with the ICT practices of rural schools. In particular, the present study examines the content of local ICT policy plans that have been developed and how school leaders and teachers perceive their experience with ICT practices.

2.2 ICT integration in education

2.2.1 ICT integration in the context of rural schools in China

Despite all students in China having equal access to nine years of compulsory education, the Chinese government faces challenges in ensuring educational equity and quality education for all students. In particular, the urban-rural gap and regional inequality are long-standing problems and result in considerable special funding and projects for western and rural China. The situation in 2015, however, was that 'some educational administrations and schools still do not fully recognize the revolutionary impact of ICT on education,' and "'the two skins' phenomenon of ICT and education still exists" (Ministry of Education of the People's Republic of China [MOE], 2016). In order to promote ICT in education in a more in-depth way, the MOE issued the '13th Five-year Plan for ICT in Education (2016-2020)'. Local governments have formulated and implemented their policy plans in response to the call of the MOE. In 2018 alone, some 20 provinces and municipalities have issued official documents to improve the integration of ICT and education.

Taking into account China's national conditions, there is a strong emphasis on shifting from a 'technology focus' to a 'pedagogic focus', and from a traditional 'teacher-centred' pedagogy into a 'student-centred' pedagogy. However, the ICT policy implementation process is complex because it is influenced by different stakeholders at different levels and alignment of different level policies. More importantly, it is necessary to consider the changing contextual conditions of school climate (Tondeur, Krug, Bill, Smulders, & Zhu, 2015) and the relationships and interactions of ICT between school leaders and teachers (Vanderlinde, Van Braak, & Dexter, 2012).

2.2.2 Key elements affecting ICT integration in schools

Given the interconnectedness of personal, pedagogical, and organisational contexts, we used the Four in Balance (FIB) model as a framework to identify various factors that are affecting the success and/or failure of ICT integration in rural schools (Kennisnet, 2013). According to the FIB model (Figure 2.1), successful ICT integration requires the balanced deployment of four basic elements: vision, expertise, digital content, and ICT infrastructure. Leadership is a necessary element for ensuring the balance between the key elements through support and collaboration.

Firstly, the vision of school leaders and teachers determines the success of ICT integration and the design and organisation of teaching. In order to arrive at a shared vision, a school ICT policy plan that 'translates' the national

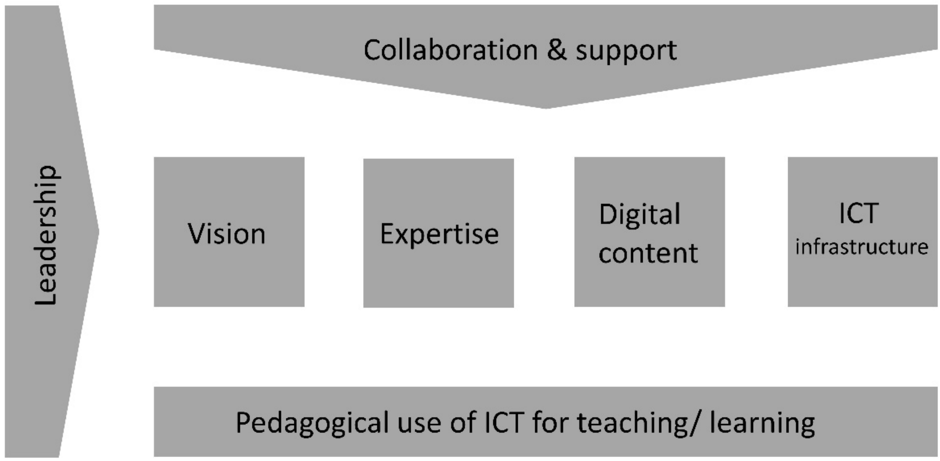

Figure 2.1. Theoretical framework (adapted from Kennisnet, 2013).

ICT policy plans into an ICT plan as part of the overall school policy can act as a possible lever for successful ICT integration (Vanderlinde, Van Braak, & Hermans, 2009). For ICT policy plans to have the best implementation effect, the readiness of teachers needs attention (Akcaoglu, Gumus, Bellibas, & Boyer, 2015). Secondly, as teachers play a crucial role in the implementation process, sufficient expertise is necessary to integrate ICT in the classroom (Wang, Tigelaar, & Admiraal, 2019). It takes time for teachers to learn new technologies and become familiar with using them, which highlights the importance of teacher training being aligned with wider policy interests (Hennessy, Harrison, & Wamakote, 2010). In addition to developing competencies using ICT, Lai and Bower (2019) show that affective elements such as attitudes, beliefs, and motivation toward using ICT are crucial when using in ICT in education. For example, teachers with more positive beliefs and attitudes are more inclined to use technology and adjust their roles, and to enact more student-centred teaching (Lumagbas, Smith, Care, & Scoular, 2019). Thirdly, a teacher's integration of ICT in classrooms is known to be enhanced by facilitating a sound infrastructure, which refers to the availability and quality of computers and internet connections within schools. The unavailability of ICT equipment for instruction and the low density of internet connectivity in classrooms still pose challenges for rural schools (Howie, 2010). Lastly, appropriate digital content encompassing digital learning materials, educational software packages, ICT systems, and management software is vital for meeting the needs and expectations of rural teachers. A lack of quality content that can be easily adapted and used by teachers means that teachers have to spend a lot of time searching for ready-made materials that they can repurpose for their class or developing their resources to better serve their learners (Vrasidas, 2015).

Beyond the importance of the basic elements described above, the role of leadership in managing ICT integration has been identified as a key element related to the level and extent of ICT policy implementation and theorising ICT practices (Hadjithoma-Garstka, 2011). The effective use of ICT requires effort from school leaders when it comes to involving teachers and developing a shared vision (Vanderlinde, Van Braak, et al., 2012). In addition to providing professional development activities, teachers also need readily available technical support in schools to integrate ICT in their teaching (Inan & Lowther, 2010). Meanwhile, the adequate provision of financial support from both the central government and local governments is important for maintaining quality in education, and sometimes school leaders are involved in the purchase of resources (Maher, Phelps, Urane, & Lee, 2012). Another key factor connected to ICT integration is teacher collaboration to share knowledge and experiences and work on pedagogical issues (Shin, 2015). Agyei and Voogt (2012) showed that collaboration with others stimulates teachers to create technology-integrated lesson plans and materials, and develop relevant knowledge.

2.3 Method

2.3.1 Research context

Three regions were purposefully selected using the following criteria: location in Western China, and local ICT policy plans aimed at promoting ICT integration in rural areas. The sample comprised school leaders and teachers from eight or nine schools per region to provide various educational contexts and practices.

2.3.2 Participants

The background characteristics of the rural schools and the number of participants are presented in Table 2.1. A total of 39 school leaders of 25 rural schools were interviewed, 462 teachers completed the survey, and 35 teachers participated in focus group discussions after having completed the survey.

2.3.3 Procedure and instruments

Table 2.2 shows the research questions and connected data sources. One ICT policy plan for each of the three regions was analysed with regard to the first research question based on the following criteria: the plans were published by the local governments, aligned with the national plan, and implemented in 2016-2020 period.

Data from multiple sources was collected to answer the second research question. Interviews and focus group discussions were the main data sources and others provided additional or supplementary informational resources (see Table 2.2).

Data was collected during school site visits. A semi-structured interview with school leaders was first organised in each school. These were individual interviews with school principals; However, in some schools, because the principals were not familiar with the ICT work in their schools, the school principal and an ICT coordinator were interviewed together. In School A-04, no interview was held as the school leaders were unavailable. An interview protocol has been developed, reflecting factors at the school level. The interviews started with an introduction to the research, in which interviewees were informed that their audiotaped interview would be transcribed and anonymised.

The rural schools' background information and ICT inventories were provided by the interviewed school leaders (see Table 2.1 for details). The teachers completed a survey to examine their frequency of use based on a list of ten types of digital content. All of the survey items were rated on a seven-point scale ranging from 1 = never to 7 = always. School policy documents were also collected to gain a comprehensive understanding of school profiles and ICT planning. Teachers' use ICT in class, such as a teacher's use of digital

Table 2.1. Background characteristics (including ICT inventory) of the rural schools and accessible participants.

School number	School location	Grade level	Number of students	Number of teachers	Broad-band speed (Mbps)	Proportion of multimedia classrooms (%)	Student/ PC ratio	Number of computers per 100 students	Number of school leaders interviewed	Number of teacher filled in the survey (valid/ total)	Number of lessons observed	Number of teachers in group
A-01	town	7-9	1742	109	500	100	16:1	17	1	21/24	1	0
A-02	town	1-6	409	21	500	100	10:1	10	1	15/15	1	6
A-03	village	1-6	367	19	500	100	5.4:1	9	3	14/16	1	0
A-04	village	1-6	146	8	100	50	0	0	0	6/7	1	0
A-05	town	1-6	483	23	100	60	9:1	9	2	21/21	1	0
A-06	town	7-9	1200	77	100	100	10:1	10	2	31/32	1	6
A-07	village	1-3	44	4	100	50	0	0	1	4/4	1	0
A-08	village	1-6	239	10	100	100	5.4:1	19	2	10/10	1	0
B-01	town	7-9	725	87	100	100	8:1	12.8	2	22/24	1	0
B-02	town	1-6	306	31	100	100	4:1	16.7	2	15/15	1	0
B-03	town	1-6	756	45	100	100	7.9:1	12.3	1	26/26	1	0
B-04	village	1-6	184	18	100	100	25:1	19.9	1	9/9	1	0
B-05	village	1-6	1284	69	100	100	10:1	9.9	1	25/25	1	6
B-06	village	1	101	4	100	100	11:1	9	1	4/4	1	0
B-07	town	7-9	1275	107	50	100	20:1	9.8	1	20/20	1	6
B-08	town	1-6	2650	133	100	100	12.4:1	8.8	3	18/19	1	0
B-09	town	1-6	1455	87	100	100	11.6:1	9	2	13/14	1	0
C-01	town	7-9	618	55	200	100	8.8:1	11	1	20/21	1	0
C-02	town	1-6	1566	94	10	100	15:1	7	2	31/31	1	0
C-03	town	1-9	4139	262	120	100	12:1	15	1	39/40	1	6
C-04	town	1-9	2396	186	80	100	12.5	8	2	21/22	0	0
C-05	town	1-6	1341	89	100	100	18.6:1	5.2	2	20/22	1	0
C-06	town	7-9	1321	127	100	100	5.7:1	17.6	1	22/22	1	0
C-07	town	1-6	671	43	100	100	7:1	14	2	18/22	1	0
C-08	town	1-9	1832	115	100	100	9:1	10.9	2	17/17	1	

Table 2.2. Research questions and data sources.

Research questions	Categories	Data sources						
		Local ICT policy plans	Interviews with school leaders	Focus groups with teachers	School policy documents	Classroom observations	Teacher survey	ICT inventory
RQ1: ICT integration in local policy plans		×						
RQ2: ICT practices	1. Vision		×	×	×			
	2. Expertise		×	×		×		
	3. Digital content		×	×			×	
	4. ICT infrastructure		×	×				×
	5. Leadership		×	×				
	6. Support		×	×				
	7. Collaboration		×	×				
	8. Pedagogical use of ICT		×	×		×		

Note: × in the table indicates that data source was available content with electronic whiteboards and student use of clickers, was observed and videotaped, and field notes were collected. In total, twenty-four classroom sessions were observed with attention for multimedia classroom type, digital content used, ICT infrastructure used, and the pedagogical approach.

Secondly, data was collected in each region to identify the perceptions of rural teachers of the use of ICT through two focus-group interviews (six in total), each lasting about one hour. The interviews included a total of five statements (e.g., 'I can use ICT in various teaching activities') and probing questions (e.g., 'What training have you received?') built around the key elements of ICT integration. Sessions were videotaped in order to identify and confirm who answered questions, and permissions were approved by the teachers. Our final sample consisted of 35 teachers teaching various subjects at the primary and secondary school level. Teachers ranged from having as little as one year of teaching experience with ICT to more than ten years.

2.3.4 Analysis

Directed content analysis (Hsieh & Shannon, 2005) was conducted to answer the first research question by examining elements for ICT integration presented in the local ICT policy plans. The three policy plans were carefully read and texts were coded using the FIB model as a framework for analysis. Consistent with the elements in the FIB model, relevant parts in local ICT policy plans, such as development goals, objectives, ICT projects, and safeguard measures, were coded in the eight categories (vision, expertise, digital content, ICT infrastructure, leadership, support, collaboration and pedagogical use of ICT), as detailed in Appendix A.

Within- and cross-case analyses as described in Miles and Huberman (1994) were used to answer the second research question. After the first author reading the textual materials several times, a structured coding scheme was used for the analysis containing the main coding areas. The first set of codes focused on the background information about the participants and the schools. The next set contained elements from the FIB model reflecting their ICT practices (see Appendix B for a detailed description of the codes). During the phases of analysis, all data from each school as a case was brought together and a within-case analysis was applied. The results of the previous analysis of each school were then submitted to a cross-case analysis in which the schools were systematically compared for similarities and differences.

In order to improve reliability by measuring agreement between multiple coders, a researcher (not a team member) checked the results matrix and coded two school leader and focus group interviews independently. After discussing each code and identifying areas lacking agreement, three minor changes were made. Firstly, one subcategory of teacher professional development strategies was added in the leadership category. Secondly, a distinction was made between purposes for using ICT in the vision category and attitudes toward using ICT in expertise category. Thirdly, a distinction was made between the prescription in the leadership category and pedagogical support in the support category. The first author then repeated the previous steps to analyse all data. The other two authors reviewed the categories and subcategories, and the final agreement was reached. In the end, all eight categories in the FIB model were identified and twenty-three subcategories emerged from the data, which can be found in Appendix B.

2.3.5 Research purpose

Connecting local ICT policy plans to the pedagogical use of ICT in practice could help rural schools to improve teaching and student learning. This study therefore reports on key elements for integrating ICT in rural schools reflected in both local ICT policy plans and practices. The following research questions guided our study: (1) How are elements of ICT integration in schools represented in local ICT policy plans? (2) What are rural school practices with ICT from the perspectives of both school leaders and teachers?

2.4 Results

The results are structured in eight sections, referring to the model presented in Figure 2.1. More details are included in Appendix A (for the local ICT policy plans) and B (for the school practices). In each section, we first present results for the content of local ICT policy plans, and then the results for the ICT practices of the rural schools.

2

2.4.1 Vision

Development ambitions were presented in all local ICT policy plans. However, these ambitions seemed dependent on local conditions. In terms of the development level, Region B aimed for the highest rank in the western regions, while Region C, which had a better development background, aimed for first-class at national level.

The data on ICT practices reveals that there were no formal written ICT policy plans available in ten schools, although ICT policy plans were presented in other plans (e.g., teaching and research work plan and curriculum reform plan) in nine schools. Although most of the plans were developed by school leaders, the schools involved in the 'Smart School Pilot Project' usually had the most materials (e.g., proposals for applying pilot schools and annual reporting materials) regarding the innovative use of ICT. Specialised ICT policy plans were found in only six schools and the school leader from School C-06 indicated that no updated version had been available since 2010, due to a lack of guidance.

The school leaders and teachers provided further insight into the purpose of ICT use during the interviews. Only leaders and teachers from the 'smart schools' mentioned specific goals that building smart classrooms for smart learning based on the local ICT policy plans, and that they tried to fulfil this purpose. The majority of school leaders indicated that their school's goal was to gradually improve their classroom teaching quality and efficiency, and teachers saw ICT as a means to promote student learning.

2.4.2 Expertise

Improving teaching competences in pedagogical design, content presentation, and assessment to use ICT in everyday teaching practices was regarded as an important objective in three plans. The teacher training programs in Policy C involved the most types of teachers (i.e., general teachers, rural backbone teachers and excellent class teachers) and Policy A was unique for including teachers in teaching sites in remote areas. In addition to teachers' ICT skills improvement, improving students' ICT literacy to help students use ICT for self-directed learning was also presented in both Policy B and C.

According to school practice data, all the school leaders and teachers participated in continuous training. School leaders indicated that the teachers' basic ICT skills (e.g., using an interactive whiteboard) were sufficient, which was confirmed from classroom observations. School leaders worried about the integration of ICT and pedagogy, however, due to a lack of high-level skills (e.g., using an interactive whiteboard to activate students).

In the focus-group interviews, most teachers showed a positive attitude towards ICT, because of the benefits of using ICT in rural schools. However, a small number of teachers worried about the side effects of ICT on students, such as prolonged exposure to digital screens potentially causing eye damage and students paying more attention to animation than the teaching content. Some teachers who had been accustomed to the traditional non-digital teaching method for several decades accepted ICT slowly and hesitated to integrate ICT into their teaching.

2.4.3 Digital content

All ICT policy plans attached importance to quality digital education resources and the educational resources public service platform construction and e-governance improvement. Schools, enterprises, and governments participated in the production of digital content for primary and secondary schools to enable quality education resources construction. To promote the balanced development of urban and rural education, Policy C planned to establish three high-quality online schools sharing digital content nationwide. All three regional plans emphasised the connectivity between the national and local platforms to realise the joint construction and sharing of quality resources.

It was clear from the data on school ICT practices that teachers made considerable use of traditional digital content and used more innovative content less often. The teachers' responses from the survey with regard to how often they use particular digital content are summarised in Table 2.3.

2

Table 2.3. Descriptive statistics of teachers' use of varied types of digital content in teaching practices *(N = 462)*.

Scale	Mean	SD
Multimedia courseware	5.61	1.23
Multimedia material	5.18	1.23
Electronic lesson plans	5.23	1.39
Teaching videos of famous teachers	4.25	1.17
Question bank	4.48	1.37
Microvideo	3.73	1.20
Subject software and tools	3.08	1.54
Online course	3.51	1.35
Website	3.70	1.43
E-books	3.37	1.41

According to the practice data available, digital content was mainly obtained using resources in school, searching the internet, or national or local platforms. In all three regions, school leaders confirmed that the local government had purchased software and promoted the public educational resource service platform by signing agreements with publishers. Although teachers agreed that the amount of digital content available continued to increase, the amount of digital content in different subjects and types varied greatly. Teachers believed that the digital content online was not always compatible with their textbooks, and so they were more enthusiastic about the materials (e.g., the CD-ROM for the teacher's book) that were supplied along with textbooks. Except for a few schools where leaders purchased commercial resources, teachers in most rural schools needed to spend a lot of time and energy in creating or customising digital content.

2.4.4 ICT infrastructure

All subcategories of ICT infrastructure were found in the policy plan, including computers, multimedia devices, and the Internet. As the analysis indicated, there were significantly more schools with access to ICT infrastructure. As formulated in Policy C, all schools were connected with a wired and wireless network, each teacher had one computer, and multimedia equipment was available in every classroom by 2015. Although Policy B has similar indicators, its completion goal was delayed with five years. The indicators in Policy A did not seem as clear as in the other two plans.

According to the ICT inventory data available in Table 2.1, all schools had access to basic infrastructure, but the conditions varied. The data on ICT practices revealed that almost all teachers in Region C had their own laptops, but most other teachers, especially in Region A, had to share computers with two or more colleagues. Except for the 'smart classrooms' (of which two and four were found in two of the schools visited) where students use clickers or tablets in class, student digital devices were mainly available in computer rooms. Two schools located in Region A did not own one single student computer. It was clear that the rural schools closer to the city centre were more likely to be equipped with better electronic whiteboards, and others in remote areas continued to use traditional laser projection or electronic whiteboards purchased many years ago. Both school leaders and teachers believed that outdated multimedia equipment affected the effectiveness of teaching and learning. For example, School C-06 had been damaged by a terrible earthquake in 2008 and most of the school's equipment had been in use since then.

2.4.5 Leadership

In the policy plans, the assessment of the use of ICT in schools was the key to ensuring the implementation of ICT. Setting chief information officer (CIO) positions in primary and secondary schools to guide the ICT development was also highlighted. Based on Policy C, Region C has taken the lead in setting up CIO positions in the primary and secondary schools on a large scale since 2014.

Data on actual practices showed that no one seemed to know about the request to set up CIO positions in their schools. Yet, according to teacher perceptions, the overall participation of school leaders in facilitating ICT use was high. School leaders reported that they set up a leadership team or an information centre and adopted different strategies to promote teachers' professional development. The most commonly mentioned strategies involved in making the training content specific to meet the needs of teachers in different schools, subjects, and teaching skill levels. Some leaders also emphasised the role of supervision and models.

Teachers had the freedom to decide what ICT to use and how to use it, except for some exceptional circumstances (e.g., teaching competitions). All the teachers in Region B were requested by the local government to use multimedia equipment in the 'growth classroom' to achieve the growth of both teachers and students using a student-centred teaching approach and dealing with practical problems.

2.4.6 Support

The pilot school and regional construction had been the focus of pedagogical support in the local ICT policy plans. For example, three hundred 'smart schools' would be built by 2020 in Region B to facilitate the exchange of experiences from good practices. Technical support was rarely presented in these plans and only Policy A emphasised accelerating the construction of a professional technical maintenance team. Financial support was provided through multiple investment mechanisms involving governments, schools, enterprise, and society. Although increasing the public funds per student for ICT in education was included in these plans, only Policy B indicated increasing financial support for schools in rural and remote areas.

According to the practice data, three types of support (pedagogical, technical, and financial) were also found in rural schools. School leaders who had positive attitudes toward ICT use were more likely to attach importance to pedagogical support by encouraging teachers to change their roles in teaching and providing support for the integrated use of ICT. As mentioned above, a small number of school leaders purchased digital content, which cost from 14 to 11,000 dollars to support teaching.

The results of focus-group interviews showed that teachers had access to technical support, but normally only one or two teachers with teaching tasks were responsible for maintenance and simple repairs. Teachers believed that these 'technicians' were unable to give sufficient support and thus hoped that full-time professional staff would carry out the work in the near future. Technical support regarding maintenance and replacement was available outside schools from companies or product suppliers, but satisfaction varied from school to school.

2.4.7 Collaboration

Collaboration in promoting the integration of ICT in education was found in policy plans. While Policy A seemed to ignore the importance of global collaboration, Policy C highlighted implementing the global partnership program and an international collaboration program for teacher capacity improvement. All three plans tried to strengthen school-business partnerships and promote purchase services.

Findings from individual and the focus-group interviews confirmed that teacher collaboration was available within- and across- schools in the form of sharing resources within the design teams, preparing for lessons together, and exchanging ideas for instructional design. Collaboration was mostly used by the teachers to prepare lessons and for different purposes. In Region A, the teaching workload was quite heavy, with 20 lessons each week, and thus they were encouraged to prepare lessons together to reduce the burden. Two secondary schools in Region C, however, collaborated with one famous network school by preparing lessons online twice a month, aiming to improve teaching quality.

A remarkable finding from school-leader interviews was that several schools in Region A collaborated by conducting 1+N synchronous teaching practice to address the digital divide. A 1+N synchronous teaching practice involves a Blended Synchronous Classroom (BSC) that integrates two or more physical classrooms to support online real-time interaction among teachers and students in different locations. During this teaching practice, one teacher in a multimedia classroom in a central school is responsible for preparing and teaching lessons, while teachers in other schools are mainly responsible for preparing lessons and managing the classes. This practice was driven by a provincial project in 2017 aimed at solving the problems of insufficient teachers, and Region A was one of the pilot areas.

2.4.8 Pedagogical use of ICT

Despite the differences above, the content for the pedagogical use of ICT in the three plans was similar, focusing on shifting to ICT use for student-centred teaching. Local governments hoped to use emerging technologies to develop the practical abilities of students in innovative ways. The change in pedagogical approaches was also seen as an important way of improving teaching quality by adopting situational and flipped teaching methods, and using the project-based learning method.

The classroom observations identified six multimedia classroom configurations. In all the lessons observed, teachers used multimedia equipment, but in only two lessons every student used a digital device in class. Besides, only one lesson was observed in the pilot school, involving the use of student clickers, the teacher's mobile phone, and specific software installed in the interactive whiteboard, and where teacher and students interactions and timely feedback were noted. Learning in this technology-rich classroom seemed to provide students with more opportunities to be engaged and meeting personalized learning needs. According to the school leader interview, specific guidance from school leaders and local government was also available.

The general view of the pedagogical use of ICT in rural schools focused on knowledge transfer and the pedagogical approach tended to be teacher-centred. Overall, the observed teachers used multimedia courseware and materials to teach in new lessons, and they used the teaching booth to present student assignments in review lessons. During these lessons, teachers decided what students learned and when, checked that students had mastered the subject matter, and asked numerous questions about it. Although many teachers in Region B used student-driven instruction, there was much more variation in the other schools.

2.5 Discussion and conclusion

This study aimed to examine ICT and education integration in rural schools and the link between local ICT policy plans and the ICT practices of rural schools. The discussion centres on the challenges and opportunities for integrating ICT in rural schools.

2.5.1 Key challenges for translating policy plans to ICT practices in schools

2.5.1.1 Political challenge in local ICT policy plans

Regarding the first research question, all elements in the FIB model were represented in the local ICT policy plans, but the vision of local ICT policy plans was not shared by all school leaders and teachers. The three plans seek to integrate ICT into the process of innovation in teaching and learning and focus on ICT integration within a learner-centred pedagogy. Data analysis regarding rural school practices revealed that practitioners in most rural schools seemed to have no ideas about whether or how to develop or update their plans, and teachers used ICT based on their personal teaching beliefs. The disconnect between policy goals and practical reality in this study showed that a national or local policy plan alone would not easily result in pedagogical changes in schools. These results were in line with the findings of another study, in which providing 'how-to' guidance at the local level and having chances to learn policy-related materials were important pre-conditions for teachers to integrate ICT into their daily practice, and for sustainable implementation (Fishman & Zhang, 2003).

2.5.1.2 Technical and human challenges for ICT practices in rural schools

With respect to the second research question in this study as a reference, two technical and human challenges for ICT practitioners in rural schools refer to the lack of a sound ICT infrastructure and appropriate digital content, and inadequate teacher training and technical support, respectively. Firstly, in contrast to the earlier findings of Howie (2010), that physical access posed challenges in rural schools, the ICT practices found in rural schools suggests that a lack of sound ICT infrastructure in terms of wireless internet, sufficient computers and updated equipment will be a new technical challenge in such settings in addressing the urban-rural gap. A second technical challenge is that the lack of contextually appropriate digital content needs to be addressed, although a large amount of digital content was available. This finding supports Vrasidas's (2015) claim that implementing an ICT-based lesson plan in the classroom required much more planning than a traditional lesson. Similarly, the current study concurs with findings that alignment between available digital content and course content affected the degree of congruence with a teacher's previous practices, and therefore teachers were willing to let go of their traditional practices whenever able to find the 'right fit' between the digital and course content (Pareja Roblin et al., 2018).

Furthermore, the results indicate that the majority of teachers had positive attitudes toward ICT use and teachers gained basic ICT skills from continuous training programs, but teachers used ICT teacher-centered. These results could be explained by other findings that ICT merely allowed teachers to continue to fulfil their traditional roles and teacher professional development programs needed to be aligned with wider national and local policy interests (Hennessy et al., 2010). Another important human challenge was that the majority of schools revealed a poor supportive school environment for ICT integration and therefore recruitment or the appointment of professional and technical staff for rural schools was needed. The findings are in accordance with earlier research that stressed the important role of the ICT coordinators acting as curriculum managers and change agents to facilitate the integration process of ICT (Vanderlinde, et al., 2009).

2.5.2 Implications for policymakers and practitioners

Based on present evidence, there are implications for policymakers and practitioner to consider. First, to address the political challenge mentioned above, in several studies it has been suggested that integrating research knowledge (e.g., learning theory) directly with practical guidance about the pedagogical use of ICT is the most useful approach to advancing education reform in general and prompting shifts in pedagogy in particular (Fishman & Zhang, 2003). It is also important to stress that the schools that were most successful in integrating innovative ICT were those pilot schools where proposals regarding the innovative use of ICT were available. This is similar to what was found in an earlier study conducted in Chile, in which schools had to take ownership for implementing ICT by submitting proposals to the government before receiving the equipment and training (Howie, 2010). The results of the current study thus suggest that an iterative process of planning and implementation of ICT integration in rural schools, for example, developing evidence-use ICT policy plans and conducting evidence-use practices (Rickinson, de Bruin, Walsh, & Hall, 2017), should be considered.

Also, school ICT policy plans are needed that are multifaceted and related to the school's culture to maximise the impact of ICT policy plans for school practices (Vanderlinde, Van Braak, et al., 2012). That is, there is a strong need for school leaders to involve teachers developing a school ICT policy plan. For example, in a multiple case study conducted by Vanderlinde, Van Braak, and Tondeur (2010) the process of developing a school ICT policy plan and the supportive role of school leaders within this process is being illustrated, and this example can be inspiring for other schools especially in developing countries where few school ICT policy plans are found.

Finally, to enable teachers to be successful in ICT integration in rural schools, a collaboration that is based on teachers' needs and their geographical settings at the school level and local level may be an effective approach to explore. At the school level, sharing digital content and exchanging ideas with colleagues could be beneficial for addressing technical and human challenges. For example, engaging teachers in collaborative design teams might help them to obtain contextually appropriate digital content, and acquire ICT integration skills (Agyei & Voogt, 2012). The exploration of across-school collaboration (e.g., BSC) is also promising as an innovation practice that offers the potential for promoting education quality, especially in mountainous areas. Evidence that BSC could significantly improve the academic performance and study efficiency of rural students is available in China (Yang, Yu, & Chen, 2019).

2.5.3 Limitations and suggestions for future research

Firstly, a limitation to the current study is that the number of rural schools participating in this exploratory study was small considering the huge geographical and social differences in rural China and their ICT practices were measured during one visit. In order to maximise the impact of ICT policy plans and realise educational change, future research is needed to explore whether or not the opportunities we emphasised here would be effective to improve rural education. Secondly, the results regarding pedagogical use were mainly based on a single lesson observation in each school. Future studies could build on a longitudinal approach to explore the long-term effect of these elements on ICT integration in rural schools.

Connecting rural schools to quality education: Rural teachers' use of digital educational resources

3

This chapter was published in an adapted form as:
Wang, J., Tigelaar, D. E., & Admiraal, W. (2019). Connecting rural schools to quality education: Rural teachers' use of digital educational resources. *Computers in Human Behavior*, *101*, 68-76. https://doi.org/10.1016/j.chb.2019.07.009

3

Abstract

Maintaining teaching quality at a high level in rural and remote areas in China can be supported by the use of digital educational resources. This study examined which factors explain differences in rural teachers' use of digital educational resources in their teaching practice in Western China. Data were collected from 462 teachers from 25 primary and secondary schools in rural areas via a questionnaire to gather information about teachers' use of digital educational resources, and school- and teacher-level factors that might influence this. Although various digital educational resources were utilized, electronic lesson plans and multimedia courseware played a dominant role in delivery of lessons. Results from a multilevel regression analysis revealed that no school-level factors seem to be associated with the use of digital educational resources. In contrast, at the teacher level, higher levels of attitudes, knowledge and skills, better facilitating conditions, and teachers' age and teaching experience significantly explained teachers' use of digital educational resources. However, other key factors such as the intention to use, self-efficacy, and subjective norm did not explain differences in use in the rural school context. The article concludes with some practical implications and recommendations for further research.

Keywords

Digital educational resources; Integrative model of behavior prediction; Rural teachers

3.1 Introduction

Recenlty, scholars, educational practitioners, and the public have reached a consensus that high-quality knowledge should be freely, openly, and easily available to promote digital equity between regions, areas, and schools (Harley et al., 2006; Hoosen, 2012; Zhang, Fang, & Ma, 2010). Therefore, almost every country has made significant investments in the production of digital educational resources (DERs) for teachers. The potential of technology has been utilized to ensure education for all, i.e., offering compulsory education of good quality to all children (Burnett, 2008). In terms of educational quality for all, however, teachers in rural and remote areas seem to be less qualified than their urban peers (Liu & Onwuegbuzie, 2012). In addition, the general lack of quality resources has been identified as a pressing concern (Robinson, 2008).

In order to realize the premises of digital equity and education for all, one developing country that is currently facing the challenge of implementing DERs is The *People's Republic of China*. Although children in China have equal rights to education, the increasing social and economic disparities between urban and rural areas have led to an educational gap (Qian & Smyth, 2008). Among the factors that are associated with differences in educational quality, resource disparity is the main reason (Zhou, Peverly, & Lin, 2004). Due to "city-oriented" policies, high-quality educational resources have been mainly allocated to urban schools (Shah, 2016), which has resulted in a tremendous gap between urban and rural compulsory education. Distributing public resources fairly has been regarded as one of the most urgent targets of educational policy (Chuanyou, 2006). Since ICT policies make an important impact on promoting the use of technology and improving educational quality in the rural area, integration of DERs into teachers' pedagogical practices is the main aim of the *National Development Plan for ICT in Education* (MOE, 2012). In compulsory education, serious efforts have been made to construct and allocate DERs, giving priority to rural areas. For instance, a resource pool has been developed to provide free DERs with 160 million students in all rural schools (Wu, 2016). Since 2013, teachers have been encouraged to share high-quality DERs via both national and regional education resource public service of platforms which also aimed to reduce the difficulties of rural schools' DERs construction.

Despite an abundance of information regarding the types of DERs available to be used in education and their potential benefits, few empirical data are available about what resources are actually being used by teachers, particularly those in rural areas. Furthermore, investments in technology do not guarantee more use of these tools among practitioners (Yang & Huang, 2008). Nevertheless, earlier research (e.g., Mumtaz, 2000) showed that teachers' responses to ICT were influenced by the support provided by the school, a positive attitude to ICT from the school principal, and teachers' perceptions toward ICT and related skills. In addition, Tondeur, Valcke, and Van Braak (2008), while investigating teacher and school characteristics in concurrence, found that except for school-level factors, structural teacher factors such as gender and experience were significant predictors of the adoptions of ICT for teachers. Furthermore, recent research concludes that not one factor, but a mix of various factors together, influenced teachers' behavior to use DERs (Vermeulen, Kreijns, Van Buuren, & Van Acker, 2017).

In the present study, we aim to elucidate the degree to which certain teacher- and school-level factors explain rural school teachers' use of DERs. The findings may contribute to teacher professional development initiatives and capacity building in schools with regards to the use of DERs in the classroom. Below, we will elaborate on the theoretical framework that guided the current study.

3.2 Theoretical Framework

In order to gain more insights into factors that explain teachers' DERs usage in rural schools, we used the Integrative Model of Behavior Prediction (IMBP; Fishbein & Ajzen, 2011) as a framework on factors that explain teachers' DERs usage in rural schools. In IMBP, three key constructs (Attitude, Self-efficacy, and Subjective norm) are hypothesized to influence behavioral intention, together with knowledge and skills, and facilitating conditions, which all influence actual behavior (see Figure 3.1).

While many definitions of the six key constructs can be found in the literature, we endorsed the definitions based on Fishbein and Ajzen's IMBP. Attitude is the general feeling of sympathy or antipathy toward behavior.

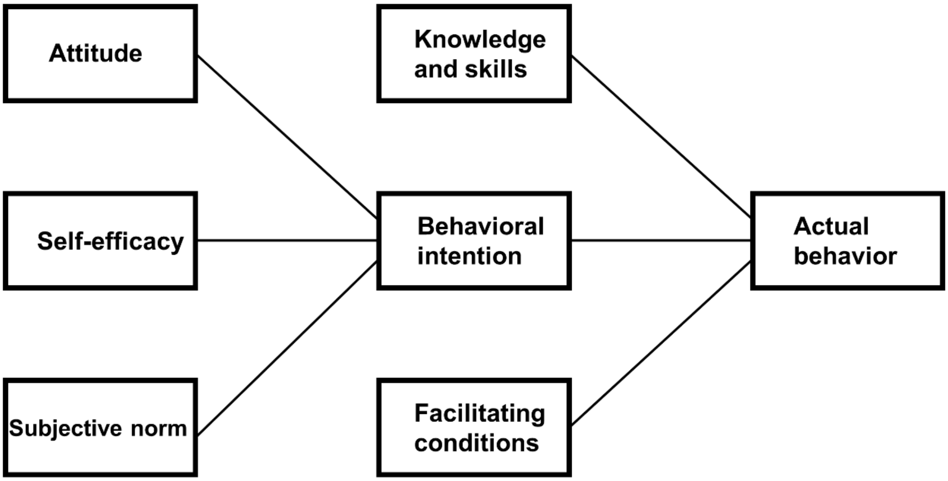

Figure 3.1. The Integrative Model of Behavior Prediction (Fishbein & Ajzen, 2011)

Subjective norm is the perceived peer pressure about whether to perform particular behavior. Self-efficacy refers to the belief in one's capabilities to perform a specific action. Behavioral intention refers to the strength of an individual's willingness to execute particular behavior. Facilitating conditions is defined as external control regarding the environment such that behavior may occur if conditions in the environment promote it. Knowledge and skills reflect the necessary competencies to perform a specific action. Although IMBP was initially conceived of as a theoretical model to predict technology acceptance in the domain of health, it is assumed to identify the factors that determine a particular behavior in any given population (Van Acker, Van Buuren, Kreijns, & Vermeulen, 2013).

Earlier studies show that IMBP is a stable and parsimonious model for explaining teachers' use of different forms of technology in educational contexts (see, e.g., Admiraal, Lockhorst, Smit & Weijers, 2013; Vermeulen et al., 2017). Below, we elaborate on the different elements of IMBP that guided the current study.

3.2.1 Teacher-level factors

3.2.1.1 Behavioral intention to use DERs

Behavioral intention to use technology is one of the proximal measures of actual use of technology. This means that the probability of carrying out a specific behavior increases as an individual's intention to perform that behavior becomes stronger. Previous studies have consistently shown that behavior intention is a suitable proxy for actual behavior (e.g., Ajzen, 1991; Fishbein & Ajzen, 2011; Taylor & Todd, 1995). For example, Armitage and Conner (2001) used a meta-analytic review to analyze the efficacy of the theory of planned behavior (TPB; Ajzen, 1991), which shows a medium correlation between the two constructs. However, Teo (2009) reported doubts about behavior intention as a valid measure of actual behavior. Similarly, Kreijns, Vermeulen, Van Acker, and Van Buuren (2014) indicated that in addition to behavioral intention, environmental variables and teachers' knowledge and skills are supposed to influence actual behavior regarding technology.

3.2.1.2 Facilitating conditions

Facilitating conditions also predict actual behaviors. The study of Groves and Zemel (2000) showed that environmental supports significantly explained differences in teachers' use of technologies in teaching. For instance, ICT training was a significant predictor of technology use; therefore, it is necessary for a school to keep professional development at the center of its ICT policy (Tondeur et al., 2008). Moreover, a recent study indicated that Turkish pre-service teachers' use of ICT is significantly predicted by training programs, especially courses related to ICT (Aslan & Zhu, 2017). Furthermore, Farjon, Smits, and Voogt (2019) discussed that access to different technologies plays a crucial role in successful technology integration. However, research on the level and variety of software and hardware conditions showed that only the level of presence of software applications was significantly related to the use, but no effects were found with other three conditions (Admiraal et al., 2013).

3.2.1.3 Knowledge and skills

Many theoretical models have been used to show the essential qualities of teacher professional knowledge required for technology integration in teaching. The most cited model is the TPACK framework, which has been used to examine the effective use of technology (e.g., Baran, Canbazoglu Bilici, Albayrak Sari, & Tondeur, 2019; Voogt & McKenney, 2017). The TPACK model developed by Mishra and Koehler (2006) includes three basic areas of teacher knowledge (Technology, Pedagogy, and Content), three blended areas illustrating the intersection of the basic areas, and finally the integrated knowledge of the interactions of all three basic areas. Previous research indicates that technology use in classrooms, especially in small and often underfunded rural areas, is dependent on teachers' capacity for maintaining infrastructure (Howley & Howley, 2008). A reason for this is that these areas cannot support teachers by having specific ICT staff who look after the maintenance of equipment and troubleshooting of technical issues in the classroom (Howley, Wood, & Hough, 2011). Moreover, technological pedagogical knowledge (TPK) is a particularly important area of knowledge for rural teachers because these teachers need to teach a wide variety of subjects, and therefore, they often do not have in-depth knowledge of each subject (Heitink, Voogt, Fisser, Verplanken, & Van Braak, 2017). In short, if the teacher lacks the appropriate skills and knowledge, even well-selected technology may not be used effectively for instruction by the teacher in the classroom (Hofer, Grandgenett, Harris, & Swan, 2011).

3.2.1.4 Self-efficacy toward using DERs

Although knowledge and skills are essential, it is not enough to use technology in the classroom, because teachers also need to feel confident (Ertmer & Ottenbreit-Leftwich, 2010). When teachers feel both confident and able to use technology, they are indeed more likely to utilize it. Previous studies showed a positive correlation between the actual behavior and self-efficacy in using technology (Barbeite & Weiss, 2004; Rohatgi, Scherer, & Hatlevik, 2016; Lee & Lee, 2014). Results of a study regarding teachers' sharing behavior in relation to open educational resources indicated that knowledge sharing self-efficacy is the only predictor of actual sharing behavior in the online and face-to-face context (Van Acker, Vermeulen, Kreijns, Lutgerink, & Van Buuren, 2014). However, a positive relationship between self-efficacy and classroom technology use of elementary and secondary teachers has not been confirmed (Mueller, Wood, Willoughby, Ross, & Specht, 2008).

3.2.1.5 Attitude toward using DERs

A large number of studies in the literature have reported a strong relationship between teachers' attitudes and technology use in education, showing that the more teachers believe using technology is good, the more they are likely to plan and implement technology in the classroom (Bas, Kubiatko, & Sünbül, 2016; Farjon et al., 2019). By comparing four models predicting technology use, Teo and Van Schaik (2012) found that attitude appeared to be the most important predictor. This highlights the critical role of attitude in predicting teachers' integration of technology into their classrooms. In fact, based on IMPB, Admiraal et al. (2013) found that attitudes seemed to be the only explanatory variable concerning the use of hardware facilities by teacher educators. Similarly, Kreijns, Van Acker, Vermeulen, and Van Buuren (2013) found that using digital learning materials was strongly explained by the teacher' attitude toward using digital learning materials. Albirini (2006) concluded that the challenge of integrating technology into education is more human than it is technological. Therefore, he suggested that policy makers promote positive attitudes for teachers toward these tools to better prepare them for integrating technology in their teaching practices, especially in developing countries.

3.2.1.6 Subjective norm toward using DERs

Subjective norm refers to the perceived pressure exerted by one's important people to perform a specific behavior. In other words, as the subjective norm becomes stronger, the more likely the person will show the particular behavior. In a previous study, the positive relationship between teachers' subjective norm and technology use was confirmed (e.g., Marcinkiewicz & Regstad, 1996; Sugar, Crawley, & Fine, 2004). For example, Teo (2010) extended the technology acceptance model (TAM) by including subjective norm and facilitating conditions, finding that subjective norm significantly predicted the behavioral intention. Research on the relationship between subjective norm and technology use is limited and has yielded mixed results. A study based on IMBP found that experienced teacher educators' subjective norm toward technology was significantly related to their use of software applications (Admiraal et al., 2013). Yet other research showed that subjective norm was an unimportant variable affecting teachers' behavioral intention (Kreijns et al., 2014; Kreijns, Vermeulen, Van Buuren, & Van Acker, 2017).

3.2.2 School-level factors

The model of the structure of concentric circles developed by Veenstra (1999) classified school-level factors that may be of influence on technology use into two categories: 1) contextual characteristics (e.g., ICT infrastructure, software) and 2) cultural characteristics (e.g., school leadership, school ICT policy). Studies indicated that both cultural characteristics such as openness to change and school ICT policy (Tondeur et al., 2008; Vanderlinde, Van Braak, & Dexter, 2012), and contextual variables such as ICT-equipment availability (Akbulut, Kesim, & Odabasi, 2007; K. T. Lee, 2002; Tallent-Runnels et al., 2006) and presence of ICT in the curriculum (Akbulut, 2009) are related to ICT use. For the current study on the usage of DERs in rural schools in China, two school-level variables might be relevant. The first school contextual factor is school location, defined as the remoteness of rural schools (e.g., town, village). Researchers indicate that school location is a very important context variable in China because there are large differences in education between areas (Liu & Teddlie, 2009). The empirical evidence on the relationship between the remoteness of school and technology use is mixed. Although many studies have indicated that the remoteness of schools seem to decrease technology integration (e.g., Page & Hill, 2008; Subramony, 2007), another study found that the remoteness of a rural school had little influence on teachers' technology use (Howley et al., 2011). Yet one could also expect that there is more need in rural schools to use DERs.

The second school factor is school type. In the present study, school type is defined as a primary school (six years) and junior secondary school (three years), which are both compulsory for all children in China. Based on a review of studies regarding the impact of ICT on European schools, the findings showed that teachers from primary schools perceived that ICT had a greater impact on teaching than their peers from secondary schools (Balanskat, Blamire, & Kefala, 2006). Likewise, Wong and Li (2011) indicated that compared to primary school teachers in Hong Kong, secondary school teachers believed that the paradigm shift in learning toward a constructivist paradigm was less efficient.

The present study aims to provide more insights into rural teachers' use of DERs, and teacher- and school-level factors that explain differences in teachers' use of DERs. Therefore, the specific research questions are:

(1) What types of DERs do rural teachers use for their teaching?
(2) Which school-level variables explain differences between rural teachers' in their use of DERs in teaching?
(3) Which teacher-level variables explain differences between rural teachers in their use of DERs in teaching?

3.3 Methods

3.3.1 Research context

China's ICT strategies seem to achieve quality standardization throughout the whole country (Yang, Zhu, & MacLeod, 2018), without specification to the regional contexts. However, different regional plans have been reformulated in order to promote the exchange of experiences and lessons from failures (Duan, Warren, Lang, Lu, & Yang, 2008). According to Meng & Li (2002), the rural areas in China are divided into three categories: 1) eastern developed regions, 2) middle medium-developed regions, and 3) western less-developed regions. In western rural areas, there are 375 poor counties that account for more than 60% of all counties in China.

In the current study, three areas in Western China were selected where significant investments and supportive projects had been carried out. Schools were purposefully selected from about 150 rural schools with about 10,000 rural teachers in these areas based on that they have already integrated DERs into the classroom. The target population in this study was rural teachers in the three areas during the school year of 2018-2019. In this selection, all school types are represented, i.e., teaching sites and primary schools in villages with a small number of teachers, and primary or secondary schools in towns with a larger number of teachers. In addition, class size seems one factor to consider when explaining Chinese rural teachers' use of DERs. There is a national class size standard that the students' number per class should not exceed 45 in primary schools and should not exceed 50 in secondary schools. However, the class size in rural schools varies from small sizes (<30) in villages to large sizes (>55) in towns.

3.3.2 Participants

First, personal visits were made to the department of ICT in education in each area. Then, before the school visit, the rural school principals were contacted and informed about the study by phone. During each school visit, the school principal selected teachers who were available and willing to participate. A total of 462 teachers from 25 rural schools in three different areas throughout Western China completed the voluntarily survey during the period from September 2018 to November 2018. Table 3.1 shows the demographic information of the teachers and school characteristics.

3.3.3 Measures

Based on previous analysis of both teachers' age and teaching years and use of DERs, we recoded age (0 = lower than 55, 1 = higher than 55) and years of teaching with DERs (0 = less than 3 years, 1 = more than 3 years).

Apart from the demographical variables, the questionnaire included the constructs proposed in IMBP. For the actual behavior, we focused on the self-reported pedagogical DERs usage of teachers rather than their general ICT usage. According to McGorry's (2000) back-translation procedures, the initial English version of items was translated into Chinese and then back into English by the first author and an English teacher. Subsequently, eleven teachers

Table 3.1. Demographic information of the teachers and school characteristics *(N = 462).*

Variables	Category	Frequency	Percent
Teacher level			
Gender	Female	300	64.9
	Male	162	35.1
Age	<26	33	7.1
	26-30	35	7.6
	31-35	84	18.2
	36-40	109	23.6
	41-45	83	18
	46-50	54	11.7
	51-55	57	12.3
	>55	7	1.5
Class size	<16	8	1.7
	16-30	38	8.2
	31-45	166	35.9
	46-55	219	47.4
	56-65	28	6.1
	>65	3	0.6
Number of subjects	1	259	56.1
	2	96	20.8
	3	51	11.0
	>3	56	12.1
Years of teaching with DERs	<1	21	4.5
	1-3	65	14.1
	4-5	90	19.5
	6-10	163	35.3
	>10	123	26.6
School level			
School type	Primary school	296	64.1
	Junior high school	166	35.9
School location	Village	47	10.2
	Town	415	89.8

who were not involved in developing measurement participated in a pilot test. Items were further improved using the feedback from the teachers in the pilot with regard to item wording, missing answer options, and the time needed to complete the questionnaire.

Attitude toward using DERs, self-efficacy toward using DERs, and subjective norm toward using DERs were measured by 19 items that were based on the work of Admiraal et al. (2017). Knowledge and skills were measured by the five TPK items of the TPACK questionnaire (Schmidt et al., 2009). Some of these items were modified because they did not match the context of the research. For example, the item "My teacher education program has caused me to think more deeply about how DERs influence the teaching approaches I use in my classroom" was changed to "I think deeply about how digital educational resources influence the teaching approaches I use in my classroom."

After Principal Component Analysis with Oblimin rotation on these 24 items, the measurement of four concepts was extracted: attitude toward using DERs (10 items, Cronbach's $\alpha = 0.934$ with, for example, "I like to use digital educational resources in my teaching"), self-efficacy toward using DERs (2 items, Cronbach's $\alpha = 0.723$ with, for example, "I doubt my ability to use digital educational resources in teaching"), subjective norm toward using DERs (6 items, Cronbach's $\alpha = 0.882$ with, for example, "My colleagues think teaching with digital educational resources is important"), and knowledge and skills (5 items, Cronbach's $\alpha = 0.893$ with, for example, "I can choose digital educational resources that enhance the teaching approaches for a lesson").

Facilitating conditions ($\alpha = 0.907$) was measured by five items based on the work of Teo and Van Schaik (2012). A sample item was "Guidance is available to me in selecting digital educational resources to use." Intention to use DERs ($\alpha = 0.848$) was measured by four items such as "I will use digital educational resources in class" that were based on the work of Kreijns et al. (2014).

For measuring the actual behavior ($\alpha = 0.871$), participants rated their use frequency of a list of 10 types of DERs. The teacher's actual behavior was created using the mean scores of 10 questions. DERs included, for example, multimedia courseware, multimedia material, electronic lesson plans, teaching cases, and videos of famous teachers.

All measures used items with 7-point Likert type rating scales. Answers for actual behavior were ranging from 1 = never to 7 = always, while for other measures were ranging from 1 = absolutely inapplicable) to 7 = absolutely applicable). An overview of the scales and their constituting items can be found in Appendix C.

3.3.4 Analysis

To answer research question 1, we used descriptive statistics. To answer research question 2 and 3, we employed multilevel analysis with IBM SPSS 25 to build a two-level model. Teachers represented level 1 and schools represented level 2. The teacher-level variables provided information about teachers' perceptions (attitude, self-efficacy, subjective norm, intention, knowledge and skills, and facilitating conditions) toward using DERs and demographic characteristics (gender, age, class size, number of subjects, year of teaching with DERs). The school-level variables provided information about the schools' types and locations.

The data analysis consisted of two different models:

Model 0: The initial model was the unconditional baseline model to determine whether there was a statistically significant variation in using DERs among the schools we sampled.

Model 1: Both teacher variables (perceptions and demographic variables) and school variables were added to the initial model to explain variance in teachers' use of DERs.

The method of Snijders and Bosker (2012) was used to calculate the proportion of variance explained by the model (R^2).

3.4 Results

This section reports the findings of the study dealing with each research question. The first section presents descriptive statistics about rural teachers' use of DERs. The second section uses multilevel analysis to explore both school- and teacher-level factors explaining teachers' use of DERs in teaching practice.

3.4.1 DERs use in rural schools

Table 3.2 summarizes the teachers' responses with regards to how often they use particular DERs.

One of the most frequent uses of DERs in teaching was "electronic lesson plans," demonstrating that teachers were making significant use of resources to prepare for their lessons (26.4% always use). In their use of DERs for implementing lessons, not surprisingly, multimedia courseware was frequently used (34.0% always use). Subject-specific software and tools are seldom used (18% never use, and 20.6% hardly use) and e-books/ periodicals (which enables a lesson to be played back), also were not used regularly (9.1% never use it; 19.3% hardly use it).

3.4.2 School- and teacher-level factors explaining teachers' use of DERs

Bivariate Pearson Correlations were used to indicate the relationships between the teacher-level variables included in IMBP. Table 3.3 contains the bivariate correlations between the teacher-level variables in the present study. The same table also includes the means, standard deviations, and the Cronbach's alpha for the seven scales.

Table 3.2. Descriptive statistics of teachers' use of varied types of DERs in teaching practices *(N = 462)*.

Scale	Frequency (%)							Mean	SD
	never	hardly	rarely	sometimes	often	almost always	always		
Multimedia Courseware	0(0.0%)	7(1.5%)	13(2.8%)	53(11.5%)	163(35.3%)	69(14.9%)	157(34.0%)	5.61	1.23
Multimedia material (text, pictures, animation, video, audio, etc.)	0(0.0%)	6(1.3%)	27(5.8%)	96(20.8%)	181(39.2%)	53(11.5%)	99(21.4%)	5.18	1.23
Electronic lesson plans	1(0.2%)	13(2.8%)	35(7.6%)	86(18.6%)	143(31.0%)	62(13.4%)	122(26.4%)	5.23	1.39
Teaching cases and videos of famous teachers	5(1.1%)	23(5.0%)	72(15.6%)	190(41.1%)	122(26.4%)	24(5.2%)	26(5.6%)	4.25	1.17
Question bank/ test papers	14(3.0%)	17(3.7%)	59(12.8%)	145(31.4%)	143(31.0%)	37(8.0%)	47(10.2%)	4.48	1.37
Microlecture/ microvideo	14(3.0%)	49(10.6%)	128(27.7%)	167(36.1%)	78(16.9%)	13(2.8%)	13(2.8%)	3.73	1.20
Subject software and tools (Geometry, virtual lab, etc.)	83(18.0%)	95(20.6%)	109(23.6%)	99(21.4%)	48(10.4%)	11(2.4%)	17(3.7%)	3.08	1.54
Online course	37(8.0%)	68(14.7%)	113(24.5%)	145(31.4%)	73(15.8%)	16(3.5%)	10(2.2%)	3.51	1.35
Thematic page/website	38(8.2%)	52(11.3%)	101(21.9%)	148(32.0%)	82(17.7%)	24(5.2%)	17(3.7%)	3.70	1.43
E-books/periodicals	42(9.1%)	89(19.3%)	122(26.4%)	119(25.8%)	60(13.0%)	17(3.7%)	13(2.8%)	3.37	1.41

Table 3.3. Correlations between measured variables; the third and fourth column contains the descriptive statistics for each measure (*N* = *462*).

	Variable	Number of items	*M*	*SD*	α	*Pearson's r*					
					1	2	3	4	5	6	
1	Actual behavior	10	4.214	0.907	0.871						
2	Behavioral intention	4	6.137	0.878	0.848	0.443**					
3	Facilitating conditions	5	5.149	1.326	0.907	0.447**	0.414**				
4	Knowledge and skills	5	5.703	0.988	0.893	0.558**	0.636**	0.686**			
5	Attitude	10	6.021	0.814	0.934	0.538**	0.857**	0.510**	0.771**		
6	Self-efficacy	2	5.193	1.538	0.723	0.300**	0.366**	0.254**	0.406**	0.475**	
7	Subjective norm	6	5.965	0.891	0.882	0.466**	0.669**	0.532**	0.603**	0.735**	0.346**

** Correlation is significant at the 0.01 level (2-tailed).

3

Table 3.4 shows the results from the multilevel analyses with DERs usage as the dependent variable. The results from the fully unconditional model indicated that the teacher-level variance accounted for 87.5% (0.724/0.827 = 87.5%) of the total variance in the outcome variable, whereas 12.5% (0.103/0.827 = 12.5%) of the total variance was at the school level.

As mentioned in the analyses section, in the second stage of the analysis, level 1 (teacher) variables and level 2 (school) variables were integrated into the fixed part of the model. Table 3.4 shows that the variables are centered around their grand mean. In Model 0, the intercept of 4.47 represents the overall mean of actual using DERs.

Next, when all the teacher and school variables were integrated into Model 2, we found that no school-level variables significantly explained variance in teachers' actual use of DERs. The results indicate that Model 1 explains 39.06% of the variance at the teacher level. The relative importance of the coefficients can be compared by standardizing regression coefficients (β). Age seems to have the strongest association with actual behavior (β = 0.559), which means that teachers over the age of 55 have a lower use of DERs. Similarly, attitude toward using DERs has a relatively strong positive association with actual behavior (β = 0.203), and knowledge and skills also make a significant positive contribution (β = 0.196), whereas facilitating conditions are significantly related to actual behavior, but explain little (β = 0.094). The latter means that the actual behavior of using DERs is not substantially more for teachers with a better perception of support from the school. Teachers with a low number of teaching years in general use DERs less compared to teachers with a high number of teaching years (β = -0.259).

Table 3.4. Results from multilevel analysis with DERs usage as dependent variables (*N* = 462 teachers in 25 schools).

	Model 0 (null)	Model 1	
	B (SE)	*B* (SE)	β
Fixed			
Intercept (cons)	4.200 (0.077) ***	4.473 (0.465) ***	
Teacher-level characteristics			
Attitude toward using DERs		0.249 (0.105) *	0.203
Self-efficacy toward using DERs		n.s	
Subjective norm toward using DERs		n.s	
Behavioral intention to use DERs		n.s	
Facilitating conditions		0.071 (0.036) *	0.094
Knowledge and skills		0.199 (0.062) **	0.196
AGE: 0 = ≤55		0.559 (0.277) *	0.559
Gender: 0 = female		n.s	
Class size		n.s	
Number of teaching subjects		n.s	
Years of teaching with DERs: 0 = ≤3		-0.259 (0.092) * *	-0.259
School type		n.s	
School location		n.s	
Random			
School level (between)	0.103 (0.042) * 12.5%	0.035 (0.018)	
Teacher level (within)	0.724 (0.049) *** 87.5%	0.469 (0.032) ***	
Model fit (Deviance (2-log)	1192.696	982.017	
χ^2		210.679	
df		19	
p		< 0.001	
Reference		Model 0 (null)	

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

3.5 Discussion and conclusion

The aim of this study was to explain the degree to which certain teacher- and school-level factors are related to rural school teachers' use of DERs. For this purpose, we used IMBP, which categorizes these factors into DERs-related teacher characteristics (teacher level) and DERs-related school characteristics (school level). In order to allow the nested structure of teachers within schools, multilevel analyses were conducted.

3.5.1 Teachers' DERs use

Regarding the first research question, the descriptive statistics indicate that although a diversity of DERs were being used, the general view of the use of DERs in Chinese rural schools was quite traditional. Traditional DERs, such as electronic lesson plans/ instruction design, and multimedia courseware, were being used frequently, but the more recent and innovative resources, such as micro-teaching videos, subject-specific software, and tools seemed under-utilized. These results are in line with the findings of another study, in which word processors and presentation software are commonly used in primary schools in regional and metropolitan areas (Maher, Phelps, Urane, & Lee, 2012).

3.5.2 School-level variables

The results of the multilevel analysis indicate that rural school teachers' use of DERs should be considered as a teacher-level phenomenon. The unconditional random intercepts model revealed that 87.5% of the variance in rural school teachers' use of DERs was attributed to differences between teachers, whereas only 12.5% was due to differences between schools. Although the difference between schools was small, the results of this study support the use of multilevel analyses to verify the influence of school-level characteristics on teachers' DERs usage in the Chinese context (e.g., Sang, Valcke, Van Braak, Tondeur, & Zhu, 2011).

Using the second research question in this study as a reference, we can affirm similarity to another study (Mumtaz, 2000), which shows that school factors play a very limited role in explaining the teachers' use of DERs. For example, the remoteness of a rural school was not significantly related to teachers' use of DERs. This result is in accordance with the findings of a previous study in which no significant differences with regard to technology integration were found between elementary teachers in more and less remote locations (Howley et al., 2011). Similarly, the current study does not concur with earlier findings (Balanskat et al., 2006; Wong, & Li, 2011) in Europe and Hong Kong, indicating the different impact of ICT on primary and secondary schools.

3.5.3 Teacher-level variables

Regarding the third research question, the effect size (standardized coefficients) indicate that teachers' age, attitude toward using DERs, and knowledge and skills are more strongly related to their use of DERs, compared to facilitating conditions and teaching year with DERs-though they are still significantly related. The finding that rural teachers over the age of 55 are not using DERs as often as their peers, corroborates the previous findings of Scherer, Siddiq, & Teo (2015), who found a negative relationship between perceived usefulness of ICT and teachers' age. The finding that DERs are more intensively used by teachers who have more years of experience in using DERs, is in agreement with the finding of Tondeur et al., (2012), indicating the importance of technological learning experience in technology integration. A remarkable finding in this study was that new teachers also use DERs less than other teachers. An explanation may be found in an earlier study, in which new teachers were found to experience so many challenges in their first few years of teaching that they developed a preference to spend most of their time in familiarizing themselves with school curriculum and classroom management skills (Russell, O'Dwyer, Bebell, & Tao, 2007).

With regard to IMBP-core variables, we only found attitude, knowledge and skills, and facilitating conditions to be significantly related to the use of DERs. Among these, attitude is the variable that most strongly explained the use of DERs. This result is compatible with the findings by Kreijns et al. (2013), who have noted strong links between positive attitudes toward using DERs and a higher probability of frequent DERs use. The finding that an increase in the probability of frequent DER becomes more likely when teachers have a higher level of knowledge and skills regarding DERs is in line with a recent study conducted by Taimalu and Luik (2019), which highlights the important role of knowledge and skills, including how to integrate technology with pedagogy and subject-specific content. The outcome that facilitating conditions exhibited a significant effect, although with explanatory power, is in line with the results of Mei, Brown, and Teo (2018), who showed that timely technical support and administration policy support were found to be important for supporting technology usage and to avoid chaos in the classroom, especially in rural areas of China. However, in contrast to the findings of Kreijns et al. (2013), the current results did not support the crucial role of both self-efficacy and subjective norm for the use of DERs. These findings might be less surprising considering the specific research context. In the process of urbanization, urban schools have a stricter bureaucratic management, more flexible professional title system, and better performance incentives, whereas rural schools are more loose organizations. In rural schools, it is difficult for principals to motivate the teachers, because no matter how hard rural teachers work, there seems no hope for them to get promoted or to transfer to urban schools. Thus, very few rural teachers feel pressures from colleagues or administrators to develop confidence in using DERs. Surprisingly, intention to use did not explain differences in DERs use, although the intention is understood to be a good proxy for actual use. In this regard, this study confirms Van Acker et al. (2014)'s statement that many teachers with reasonably high intentions never conduct the behavior.

3.5.4 Limitations and directions for future research

Although the current study has yielded important insights into factors influencing rural teachers' use of DERs in Western China, some limitations need to be mentioned. First, because a small sample of teachers three different areas in Western China were involved in the study, the results cannot be simply generalized to other educational regions and other countries. Therefore, we suggest conducting similar studies with a larger sample, and to replicate the analysis using multilevel structural equation modeling to test patterns and interrelationships among variables in IMBP. Secondly, the data in this study were obtained via survey instruments gathering self-reported data. In order to gain a broader picture of rural teachers' use of DERs and prevent a common-method bias, other qualitative methods could be used. For instance, observations could be used to obtain information about the actual use of DERs in classrooms. Thirdly, both the intention and actual behavior measures were based on self-perceived measures, which may cause the problem of self-reported bias. As such, future research should explore the stability of the construct of actual behavior for teachers by classroom observations and/or interviews with students. Furthermore, since variation at the school level was small, as was found earlier, future research should predominantly focus on other teacher variables affecting their use of DERs, such as motivation for technology and constructivist beliefs about teaching and learning. Finally, the adoption of a longitudinal approach could be recommended to track changes in teachers' deliberations and related DERs integration levels in their daily practices.

3.5.5 Concluding remarks

The current study contributes to the literature regarding DER usage in many ways. Firstly, from a theoretical perspective, more insights have been gained in the complex interplay of teacher variables affecting their use of DERs. To our knowledge, almost no research has examined teachers' use of DERs through inclusion of all the six key constructs of IMBP. Another contribution regarding the use of DERs is that this paper maps rural teachers' judgment of their own behaviors. In explaining DERs use in Chinese rural schools, teacher characteristics are more significant factors than school characteristics. These findings might indicate an increase in the use of DERs when teacher characteristics are taking into account. From the perspective of ICT policy planning, these characteristics may be more receptive to interventions centered on promoting DERs use in classrooms. This means that policymakers need to realize that teachers should be involved in the ICT policy planning process when considering future ICT policy planning to encourage the use of DERs in rural schools. The findings imply that developing a more positive attitude toward using DERs is a fruitful way to stimulate technology in rural schools. For example, teachers' perceptions of the benefits of using DERs and changes of students are likely to influence their attitudes toward using DERs. Lastly, considering the influence of the knowledge and skills on classroom use of DERs, it seems crucial that teacher training, especially for the new teachers, should focus more on having teachers master technological pedagogical content knowledge.

Hence, we recommend policymakers, school leaders, and developers of teacher training programs to support teachers' use of DERs by helping them developing a more positive attitude toward technology and by increasing their knowledge and skills, so as to see rural teachers' use of DERs grow.

Rural teachers' sharing of digital educational resources: From motivation to behavior

4

This chapter was published in an adapted form as:
Wang, J., Tigelaar, D. E., & Admiraal, W. (2021). Rural teachers' sharing of digital educational resources: From motivation to behavior. *Computers & Education, 161,* 104055. https://doi.org/10.1016/j.compedu.2020.104055

Abstract

Research indicates that knowledge sharing promotes teacher professional learning opportunities and development. However, it is yet to be known what motivates teachers in rural schools in sharing their knowledge as they may face more challenges than teachers in urban areas when sharing. This study examined factors explaining rural teachers' sharing behavior regarding digital educational resources, both within and outside school, as posited by combining motivation theory and the integrative model of behavior prediction. Self-reported questionnaires from 709 rural teachers were collected and analyzed employing the Structural Equation Modeling. Different motivational factors were found to be related to sharing behavior within school and outside school. More specifically, internal motivation was positively and external motivation was negatively related to sharing behavior in both contexts. Moreover, sharing intention and sharing climate significantly explained teachers' sharing behavior, but only outside school. A mediation analysis using a bias-corrected bootstrapping method revealed that the effect of internal motivation on sharing intention within school was mediated through self-efficacy and attitudes whereas the effect of external motivation on sharing intention outside school was only mediated by attitudes. These findings contribute to a better understanding of how to support teachers' sharing behavior in different contexts.

Keywords

Media in education; Teacher professional development; Elementary education; Secondary education; Improving classroom teaching

4.1 Introduction

Knowledge sharing has received significant attention in areas all over the world as it is considered a key activity to improve organizational capabilities, including team performance (Singh, 2019; Zhu, Chiu, & Holguin-Veras, 2018), innovation (Jiang & Chen, 2018; Yang, Nguyen, & Le, 2018), and creativity (X. H. Guan, Xie, & Huan, 2018). Beyond its importance to managers, employees, technology experts and users, knowledge sharing is emerging as a professional learning activity in the online world where teachers not only professionalize themselves but also promote the professional development of colleagues (Oddone, Hughes, & Lupton, 2019; Runhaar & Sanders, 2016). Sharing of teaching-related knowledge will allow teachers across geographical regions to take different perspectives and to solve various problems they face, which in turn contributes to support teachers' learning and functioning (Hood, 2018; Liou & Canrinus, 2020).

With the development of the Internet, a remarkable trend has been the broad distribution of digital resources that have the potential to supersede textbooks and a direct effect on teacher behavior (e.g., Artuso & Graf, 2020; Baron & Zablot, 2015). Massive Open Online Course (MOOC) viewed as both an object and a service is a good example of a higher educational book (Bruillard, 2017). However, the realized didactic potential of digital resources involves bringing more perspectives into play related to a specific digital resource and adapting it to its particular community and school climate (Hansen & Gissel, 2017), in particular the development of didactic materials that meet the needs of rural education and comply with the curriculum content (de Souza & Dias Garcia, 2019). Moreover, since the use of digital resources can merely increase the resources without changing fundamental practices when teachers continue teaching based on direct instruction (Santana Bonilla & Rodríguez Rodríguez, 2019), exchanging teaching-related knowledge and making digital resources available to all students are the strategies to better handle the growing diversity of students, thus providing potentially new methodologies of teaching and learning. In the process of digital transformation, digital educational resources (often referred to as 'DERs') such as teaching materials, software, and tools that are used in pedagogical practices are important sources of teaching-related knowledge that primary and secondary teachers share with others on a daily basis.

However, as has often been documented in the literature, a number of potential obstacles, such as unwillingness to share, lack of time and background knowledge, or the risk of losing their own advantages, may make people hesitant to engage in knowledge sharing (see e.g., Ahmed, Ahmad, Ahmad, & Zakaria, 2019; Xue, Hu, Chi, & Zhang, 2019). In the educational field, teachers seem to be more refrained than enterprise employees to share, when it comes to sharing outside school (Hou, Chang, & Sung, 2010; Van Acker, Vermeulen, Kreijns, Lutgerink, & Van Buuren, 2014), when they are not confident that the resources are of good value or adequately distinctive (Baas, Admiraal, & Van den Berg, 2019). Furthermore, especially situations where primary and secondary school teachers do not fully embrace emerging technologies and cannot contribute and share adequately may impede teacher interactions and communications in community networks (Yang, Song, Zhao, & Yu, 2018). Teachers in rural and remote areas in Oman, for example, often have a relatively lower degree of technology acceptance and face more challenges than teachers in urban areas (Al-Huneini, Walker, & Badger, 2020), and their conventional thoughts and opinions may also discourage knowledge sharing (Charband & Navimipour, 2016). Teachers' active involvement in sharing is crucial, given that knowledge sharers benefit far more than knowledge receivers (Zhu et al., 2018) and gaps exist in teachers' various needs and available resources (Xie, Di Tosto, Chen, & Vongkulluksn, 2018). Therefore, it is important for researchers and policymakers to consider why teachers (especially those in rural settings) share or not share DERs, and thus to establish potential ways to enable teachers to share.

Previous research found that individual and environmental variables such as intrinsic and extrinsic motivation, self-efficacy, attitude, intention, organizational climate, and support were significant predictors of knowledge sharing (Al-Kurdi, El-Haddadeh, & Eldabi, 2018; Safa & Von Solms, 2016; Sedighi, Lukosch, Brazier, Hamedi, & Van Beers, 2018; T. Guan, Wang, Jin, &

Song, 2018; Wang & Hou, 2015). Current knowledge-sharing research within the educational field, however, focuses on higher academic institutions (see e.g., Akosile & Olatokun, 2020; Xue et al., 2019), while lacking empirical research into knowledge sharing in the primary and secondary sectors, particularly in the rural areas. In this regard, school teachers' knowledge sharing is mainly motivated by teachers' professional needs, such as expectations to achieve better education for students, leading to learning being primarily individually rather than socially oriented (Hood, 2017). Based on other knowledge-sharing research, effects of various motivation types influencing knowledge sharing can be argued to be inconsistent and inconclusive, depending on the research contexts (Wang & Hou, 2015). Since understanding school teachers' motivation is essential to knowledge sharing, this study focuses on the process of knowledge sharing, from motivation to behavior.

Furthermore, it is important to note that individual teachers' sharing behavior is better understood when the particular context is considered (Schuwer & Janssen, 2018), as beliefs, values, and culture vary across countries and regions. In this study, sharing DERs in two types of contexts seems relevant: sharing with colleagues at their school (within school sharing) and sharing with others through the Internet (outside school sharing). Sharing DERs within and outside school may differ substantially, because teachers may encounter specific educational challenges in the two different contexts of knowledge sharing. A previous review (Wang & Noe, 2010) revealed important differences in knowledge sharing between a face-to-face and electronic context. Moreover, Van Acker et al. (2014) found that teachers shared a variety of learning materials more often interpersonally than through websites. Although knowledge sharing among teachers in different situations has become a growing research trend, we cannot assume that every teacher shares DERs within and outside school in a similar way.

As outlined above, DERs sharing as a way of promoting teacher professional learning opportunities and development yields great potential as well as significant challenges. The aim of this research is, therefore, to develop a deeper understanding of the motivation-behavior relationship, especially for rural teachers with little experience in sharing DERs. This study pays close attention to factors that influence sharing and distinguishes rural teachers' within school sharing from their outside school sharing. The findings will help advance the identification of teachers' motives and obstacles in the early stages of knowledge sharing in different contexts.

4.2 Factors related to teachers' sharing behavior

To gain insight into variables explaining teachers' sharing behavior, the Integrative Model of Behavior Prediction (IMBP; Fishbein & Ajzen, 2011) has been used in various studies. This model extends the Theory of Planned Behavior (TPB; Ajzen, 1991), by including the construct of self-efficacy (Bandura, 1986) rather than perceived behavior control. In IMBP, three dispositional variables, i.e. attitude, subjective norm, and self-efficacy, predict intention. Furthermore, IMBP has been extended by hypothesizing that except for intention, actual knowledge and skills, current environmental affordances and constraints also influence behavior.

According to IMBP, attitude pertains to the positive or negative stance of an individual towards behavior, which is shaped by assuming that behavioral success contributes to a particular outcome. Subjective norm is characterized as perceived societal expectations from important people for adopting a certain behavior. Self-efficacy is described as the perception of an individual's capability to execute the behavior. Behavioral intention reflects an individual's subjective will to engage in a certain behavior. Environmental affordances and constraints are concerned with external environmental controls. The behavior may occur if the conditions facilitate it. Knowledge and skills show the abilities required to execute a particular action.

Kreijns and colleagues (Kreijns, Vermeulen, Kirschner, Van Buuren, & Van Acker, 2013) proposed to adopt the IMBP to explain ICT integration in educational practices, with a special emphasis on teaching-related knowledge. In the domain of teachers' ICT using behavior, the IMBP has been applied to various educational research settings, such as primary and secondary education (Kreijns, Van Acker, Vermeulen, & Van Buuren, 2013), teacher education

(Admiraal, Lockhorst, Smit, & Weijers, 2013) and rural education (Wang, Tigelaar, & Admiraal, 2019). Although these studies have shown the relevance of the IMBP model, Kreijns, Vermeulen, Van Acker, and Van Buuren, (2014) have argued that adding the concept of motivation potentially provides a more precise picture of teachers' volitional behavior. In the following, we elaborate on motivation as a variable in teachers' sharing behavior.

4.2.1 Motivation

In the available literature, different conceptualizations of motivation have been used. Following the Self-Determination Theory (SDT; Deci & Ryan, 1985), individuals may be both externally (i.e., controlled motivation) and internally (i.e., autonomous motivation) motivated to perform a specific behavior (Cockrell & Stone, 2010). Based on the controlled-to-autonomous continuum, two essential categories associated with motivation are further developed: intrinsic and extrinsic motivation (Deci & Ryan, 1985). The motivation that leads to intrinsically interesting and pleasant behavior is intrinsic motivation. Extrinsic motivation refers to four different types of regulations, involving regulation driven by external expectations (i.e., external regulation), feelings of shame or guiltiness (i.e., introjected regulation), personal importance (i.e., identified regulation), or fully volitional (i.e., integrated regulation).

In cases where teachers refrain from sharing their knowledge, experiences, and ideas, motivation may play a vital role and positive correlations among motivation and knowledge sharing have been reported in empirical studies. Research has reported that intrinsic benefits are more important than extrinsic benefits for exchanging knowledge within organizations (e.g., Akosile & Olatokun, 2020; Sedighi et al., 2018). Moreover, Lai and Chen (2014) compared differences in online knowledge-sharing behavior between community members, by reporting that posters who posted messages in the forum were largely influenced by intrinsic motivation, and instead lurkers who only visited the forum were mainly affected by extrinsic motivation. Yet a recent study found that autonomous motivation was related to teachers' learning performance and engagement positively (Jansen in de Wal, Van den Beemt, Martens, & den Brok, 2020). Park and Gabbard (2018) in a study on scientists' intention to share implicit and explicit knowledge in an online environment, however, did not find a significant impact of intrinsic motivation. Opposed to commonly accepted practices associated with initiatives of sharing knowledge, expectations for rewards have been found more likely to hinder the development of employees' favorable attitudes toward knowledge sharing (Bock, Zmud, Kim, & Lee, 2005). In addition, intrinsic motivation and identified regulation were positively correlated with self-efficacy, while other types of motivation were negatively correlated with self-efficacy (Fernet, Senécal, Guay, Marsh, & Dowson, 2008). These differences in findings suggest that motivators for knowledge sharing may depend heavily on practical circumstances and how these are perceived.

4.2.2 Self-efficacy toward sharing

According to IMBP, two critical and frequently researched constructs are self-efficacy and knowledge and skills, both determining teachers' sharing behavior. The former is associated with teachers' perceived capabilities, and the latter is defined as the essential acquired teacher professional knowledge for knowledge sharing. High correlations between knowledge and skills, and self-efficacy have been found in earlier research (e.g., Instefjord & Munthe, 2017; Teo & Van Schaik, 2012), involving difficulties in examining perceived capabilities (self-efficacy) and actual capabilities (knowledge and skills) at the same time. Recently, more attention has been given to teacher self-efficacy which is a multifaceted affective construct that enhances job performance of primary and secondary teachers. For instance, in about one-third of countries of the Teaching and Learning International Survey (TALIS) 2018, teachers working in challenging schools employed part-time and short-term contracts were the most likely to have lower levels of self-efficacy (OECD, 2020). In this study, we focus on self-efficacy, which reflects teachers' capability to address possible obstacles in their knowledge sharing.

Self-efficacy, i.e., perceived capabilities to share knowledge, has often been found to be critical for understanding teachers' intention to share knowledge (Tseng & Kuo, 2014). Rural teachers who are less educated and trained are relatively in a less advantageous status compared with urban teachers. Gao and Sun (2019) used Social network analysis to study Teaching Design knowledge needs of Chinese rural teachers in the WeChat community, and proposed providing them training and guidance on the application of DERs. This finding implies that rural teachers experience comparatively lower self-efficacy toward sharing. However, teachers with high levels of self-efficacy were found to be able to better cope with the negative consequences, such as being taken advantage of or being criticized, as a result of playing a significant role in knowledge sharing (Runhaar & Sanders, 2016). Furthermore, in research on virtual learning communities (Chen, Chen, & Kinshuk, 2009), positive relationships between college students' web-specific self-efficacy (e.g., the capability of using the website functions, and exploiting or exploring existing knowledge resource), intention to share, and knowledge sharing behavior, have been found. In other studies related to teachers' sharing behavior or innovative behavior, similar findings were reported (Klaeijsen, Vermeulen, & Martens, 2018; Van Acker et al., 2014). In short, the available studies suggest that self-efficacy exerts a strong influence on knowledge-sharing behavior.

4.2.3 Attitude toward sharing

In the IMBP model, attitudes toward knowledge-sharing behavior are described as determining sharing intention. This means, for example, that teachers tend to shy away from contributing to knowledge if they think making such contributions is worthless and unimportant. Karahanna, Straub, and Chervany (1999) indicated that people with innovative characteristics, e.g. early adopters, seldom see new technologies as complex or incompatible with what they do. Rural teachers tend to have a lower level of technology acceptance than urban teachers and may have a very negative attitude to emerging DERs and related sharing behavior. In a study conducted in Taiwan, Chen (2011) found teachers' attitudes toward knowledge sharing to be an important predictor of knowledge-sharing intention. In addition, positive attitudes are seen as significant factors in enhancing teachers' knowledge-sharing behavior. For instance, Zhang and Liu (2019) found that the more valuable online-sharing behavior was perceived by teachers, the more efforts they made towards online learning. However, it is noteworthy that negative attitudes of pursuers have been found to discourage participation in online knowledge sharing (Hew & Hara, 2007).

4.2.4 Subjective norm toward sharing

Subjective norm shapes individuals' intention to conduct a behavior. This means that teachers who feel more pressure from important people will be inclined to have a stronger sharing intention (Ryu, Ho, & Han, 2003). In recent research it has been found that subjective norm predicted college students' intention to share knowledge (Arpaci & Baloğlu, 2016). However in a study conducted by Jolaee, Nor, Khani, and Yusoff (2014) subjective norm toward knowledge-sharing behavior did not influence intention among academic staff in universities. Several studies have considered subjective norm as a direct antecedent of sharing behavior. For example, a study regarding knowledge sharing in online Q&A communities found reciprocity norm to be a vital factor in predicting users' knowledge contribution (T. Guan et al. 2018). However, in many other studies, low contributions of subjective norm with regards to predicting general behavior have been reported (Hagger, Chatzisarantis, & Harris, 2006; Kreijns et al., 2014).

4.2.5 Sharing intention, environmental affordances and constraints

Behavioral intention is considered to be one of the most critical components in research within the domain of sharing behavior. Among rural teachers, teachers with degrees above the undergraduate level were more willing to engage in online knowledge sharing (Gao & Sun, 2019). Based on the percentage of advanced-degree teachers, teacher quality in China is less favorable among rural schools (Yang, Zhu, & MacLeod, 2018), meaning that urban teachers outperform their counterparts in rural schools in terms of sharing intentions. In a study on determinants of sharing knowledge, Chen (2011) found that high school teachers' knowledge-sharing intention affected their actual behavior of sharing their own knowledge. Likewise, the results of Bock and Kim's (2002) study showed that knowledge-sharing behavior was directly explained by an individual's intention, but only 1.4% of the knowledge-sharing behavior was explained. Although the potential impact of behavioral intention on teachers' contributions to knowledge sharing has been identified in the available research, evidence from other studies seem to contradict the impact of behavioral intention. For example, Kuo and Young's (2008) in longitudinal study testing four competing models for studying knowledge-sharing behavior, found that an intention-behavior gap was existing in knowledge-sharing practices and therefore these authors suggested moving beyond the construct of intention when studying sharing behavior. Recently, based on a meta-analytic study involving teachers, it has been argued that the usually unchallenged assumption of a strong significant link between intention and behavior must be reexamined by adding contextual variables as well (cf. Scherer, Siddiq, & Tondeur, 2020). This line of thinking challenges postulations with regards to the intention-behavior link and thus calls for including alternative proxies of teachers' sharing behavior, taking into account that motivated behavior may be for a large part explained by the interaction between individual and environment or situation.

In the IMBP model, environmental affordances and constraints also are considered as factors that influence behavior. With regards to sharing behavior within and outside school two environmental variables might be relevant. The first important environmental variable is sharing climate in schools. According to Bock et al. (2005), climate refers to a specific contextual situation associated with individuals' perceptions. Research has consistently shown that positive relations between organizational climate and effective knowledge sharing exist in organizational climates where embracing new ideas and learning from failure are emphasized (Al-Kurdi, El-Haddadeh, & Eldabi, 2020; Taylor & Wright, 2004). Similarly, it was found that in a professional community where teachers were respectful and responsible with regards to their online behavior, teachers were encouraged to share high-quality resources (Trust, 2017). A similar concept to climate is culture which refers to evolved context and is often delved into qualitative studies (Bock et al., 2005). Teachers in rural schools in many countries faced a significantly much lower collaborative culture than their colleagues in cities (OECD, 2020). Because research has shown that organizational culture alone cannot promote sharing (Hislop, 2009), informal activities or environments may be important to fostering a knowledge-sharing climate (Hou et al., 2010), and such events and atmospheres could be realized by administrators through organizing open discussions, seminars, or workshops (Lee, Shiue, & Chen, 2016).

Another important environmental variable is work pressure. Work pressure is characterized as aspects of a job such as workload and the work pace that are perceived as quantitatively challenging (Jansen in de Wal et al., 2020). TALIS 2018 also reports on the difference in work pressure perceived by teachers who work in different geographical areas and it was found that rural school teachers were less likely to feel stressed than their colleagues in urban schools (OECD, 2020). Many studies have identified that work pressure is an important determinant of teachers' sharing behavior, either by promoting teachers to share teaching materials with colleagues (Kwakman, 2003) or by preventing them from engaging in online knowledge-sharing communities of practice (Hew & Hara, 2007). This raises the question whether work pressure can be regarded as a threat or a challenge for teachers regarding sharing DERs (see e.g., Crawford, LePine, & Rich, 2010; Evers, Van der Heijden, Kreijns, & Vermeulen, 2016).

4.2.6 This study

The current study aims to increase knowledge of factors influencing DER-sharing behavior among rural school teachers. Based on the literature with regards to sharing behavior of teachers, and drawing on the IMBP model, we have developed the research model that guided our study (see Figure 4.1). Within the context of this research, the list of determinants is extended with motivation, since the literature indicates that teachers' sharing behavior cannot be fully understood without taking individuals' underlying motivation into consideration (Leonard, Beauvais, & Scholl, 1999). In addition, inspired by the distinction between interpersonal knowledge sharing and internet-based sharing through a database made in the study of Van Acker et al. (2014), we derive the relative effects of the determining factors for knowledge sharing in two different contexts: sharing with colleagues within their school and sharing

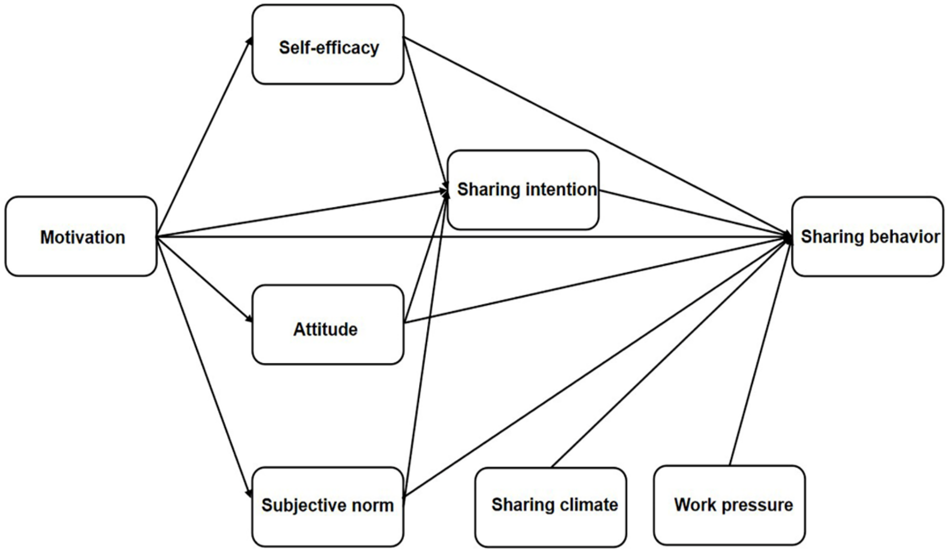

Figure 4.1. The proposed research model.

with others outside their school. As mentioned earlier in the section 2.2, because of the high correlations between knowledge and skills and self-efficacy, we left out knowledge and skills and only included self-efficacy.

Given that motivation and sharing behavior are the main constructs, we have formulated the following main research question: How is motivation related to DERs-sharing behavior within and outside school?

To answer the main research question, in a stepwise approach the following sub-questions were answered.

RQ1 (a-e). Is motivation related to each of the dispositional variables (a) self-efficacy, (b) attitudes, and (c) subjective norm, (d) sharing intention within school, and (e) sharing behavior within school?

RQ2 (a-e). Is motivation related to each of the dispositional variables (a) self-efficacy, (b) attitudes, and (c) subjective norm, (d) sharing intention, and (e) sharing behavior outside school?

Moreover, since the link between intention and behavior remains questionable, the relationships between sharing intention and sharing behavior was examined, together with environmental variables.

RQ3 (a-c). Is (a) sharing intention, (b) sharing climate, and (c) work pressure related to sharing behavior within school?

RQ4 (a-c). Is (a) sharing intention, (b) sharing climate, and (c) work pressure related to sharing behavior outside school?

According to IMBP, distal variables (e.g., motivation) are those variables whose influences on behavioral intention are mediated by the dispositional variables. Therefore, the following research questions were raised:

RQ5. Is there an indirect effect of the motivation on the sharing intention within school through the dispositional variables?

RQ6. Is there an indirect effect of the motivation on the sharing intention outside school through the dispositional variables?

4.3 Methods

4.3.1 Research context

The urban-rural divide in educational access and quality has received much attention in China and is linked to a general disparity between rural and urban socio-economic development led by urbanization and industrialization (Schulte, 2015). The educational gap continues to expand with large differences in regional growth. For example, counties with a "very high" value of rurality index are mainly located in the southwest of China with poor rural, small-town, mountainous, and minority areas (Li, Long, & Liu, 2015). Owing to the failure of rural areas to attract teachers and inadequate local government finances, many rural schools employed substitute or temporary teachers who were typically less educated and paid far less than teachers with permanent contracts. Nonetheless, this poses a significant structural issue in rural schools where there is a mismatch between teacher qualifications and specialist subjects (Peng et al., 2014).

Under these conditions, the national government is making further efforts to optimize the distribution of educational resources. The "Internet Plus" strategy to create ties between rural schools and the wider education system is seen as an effective approach to promoting educational equity and quality for rural compulsory education, in particular to improving the degree of access and integration of digital resources (Qiao, 2018). Teachers in China have been actively encouraged in the last five years to create DERs and share these with others, as a strategy to equip all teachers with the knowledge and skills in the unique contexts of their practice. Ultimately, this would promote a more balanced development of education across regions, particularly between urban and rural areas. However, acquaintance society is still a typical characteristic of Chinese rural societies where everyone is accustomed with others and people do not easily accept new things (Fei, 1992).

For this study, schools located in either a village or remote town were identified as rural schools. Since school leaders (i.e., principals and directors) with teaching obligations are particularly common in rural areas, both school leaders and teachers from rural schools in southwest China were purposefully selected. Within this selection, all types of rural schools were identified, i.e., teaching sites and primary schools in villages, and primary schools, secondary schools, and nine-year schools in towns.

4.3.2 Participants and procedures

The participants were teachers in primary and secondary schools in rural areas in southwest China. First, we develop a new questionnaire by merging existing instruments covering all factors because no such questionnaire existed in previous studies. Some instruments also tested in the Chinese context proved to be effective. Second, a draft questionnaire was pilot tested with eight rural teachers in China to collect feedback on the instruments. The questionnaire has been improved based on their input. Finally, the study adopted a convenient sampling method to collect data with an online survey. Specifically, we recruited participants through sending a hyperlink or QR code via WeChat to teacher educators, rural school leaders, and teachers from the network of the first author and participation was voluntary. We rejected questionnaire data from the same IP address to prevent the same respondents from submitting the questionnaire repeatedly. To allow participants to respond openly and honestly, the online survey using an anonymous link from Qualtrics was sent directly to teachers and school leaders and indirectly through teacher educators to ensure that more participants involved. Completing the questionnaire took about 10-15 minutes.

With the completion of the questionnaire, teachers gave their consent. The data collection period lasted from October 8th to October 30th, 2019. Of the 1047 teachers approached, 709 (67.7%) returned a completed questionnaire, exceeding the suggested sample size of 150 cases (Kline, 2005) or 10 cases per variable (Nunnally, 1978) for the particular analyses (see section 3.3). This sample is close to the main characteristics (age, gender, and degree) of the distribution of the rural teacher population in China (Wu & Qin, 2019). The above demographic data of participants are shown in Table 4.1 and additional information is presented in Table D.1 in Appendix D.

Table 4.1. Demographic statistics of participants (*N* = *709*).

Measures	Items	Frequency	Percent
Gender	Female	478	67.4
	Male	231	32.6
Age	<26	79	11.1
	26-30	123	17.3
	31-35	132	18.6
	36-40	102	14.4
	41-45	125	17.6
	46-50	73	10.3
	51-55	67	9.4
	>55	8	1.1
Degree	Secondary Vocational School Education	18	2.5
	Three-year college Education	121	17.1
	Bachelor	555	78.3
	Master	15	2.1

4.3.3 Measures

Except for the demographic information of respondents, the questionnaire included all the constructs in the proposed model. All measures came from existing instruments (elaborated on below) with good validity and reliability based on earlier studies. In order to fit the current research contexts, we made minor modifications to the items in these instruments. To prevent semantic biases, a Chinese researcher translated the original English instruments into Chinese, then an English and Chinese language teacher did back translations.

In Appendix E, we have included all items for each variable that were kept in the final analyses.

4.3.3.1 Motivation

Motivation for sharing was evaluated with the scale of The Academic Self-Regulation Scale (Vansteenkiste, Soenens, Sierens, Luyckx, & Lens, 2009). The scale includes four regulations, each of which has four items. The subscale of Intrinsic Motivation offers explanations for pleasure and interest in sharing. The subscale of the Identified Regulation provides reasoning for the personal value of sharing behavior. The Introjected Regulation subscale presents reasons for sharing DERs comes with feelings of guilt, shame, anxiety, or pride. The External Regulation subscale assesses reasons for sharing DERs to meet external expectations. The 16 items were included with a 5-point scale scoring from 1 (absolutely inapplicable) to 5 (absolutely applicable).

4.3.3.2 Self-efficacy, attitude, and subjective norm

The teachers' self-efficacy toward sharing DERs was assessed applying an adaptation of the Technology and Teaching scale (Admiraal et al., 2017). This scale assesses teachers' beliefs in their abilities to share DERs. This scale included 5 items which participants rated on a 5-point scale, ranging from 1 (absolutely inapplicable) to 5 (absolutely applicable).

The teachers' attitude toward sharing DERs was adapted from the Attitude toward Knowledge Sharing scale (Ryu et al., 2003). Teachers indicated to what extent they felt a certain attitude if they share DERs. Using a 5-item bipolar scale (unpleasant-pleasant, bad-good, worthless-valuable, harmful-beneficial, and unenjoyable-enjoyable), respondents rated several aspects of sharing DERs on a 5-point rating scale ranging from 1 to 5.

The teachers' subjective norm toward sharing DERs was measured using the scale of Subjective Norm toward Knowledge Sharing (Ryu et al., 2003) including 5 items. This scale assesses teachers' beliefs that most colleagues may think that they should share DERs (e.g., "Most colleagues who are important to me think that I should share digital educational resources"). Participants scored on a 5-point rating scale which ranges from 1 (absolutely inapplicable) to 5 (absolutely applicable).

4.3.3.3 Sharing intention within and outside school

Teachers' intention to share DERs was measured by adapting the Intention scale (Van Acker et al., 2014). This 6-item instrument assesses teachers' intention to share DERs within schools and outside schools. The six items were measured on a 5-point scale, ranging from 1 (extremely unlikely) to 5 (extremely likely).

4.3.3.4 Sharing climate and work pressure

In order to assess sharing climate, Knowledge Sharing (Schenke et al., 2015) including 4 items was applied. This scale assesses sharing climate in schools. Teachers gave responses on a 5-point scale ranging from 1 (absolutely inapplicable) to 5 (absolutely applicable).

Teachers' work pressure was measured by means of subscales from the Dutch Questionnaire Social Psychological Work Demands (Van Veldhoven & Meijman, 1994). This instrument presents 7 items measuring the frequency of experiencing the workload and work pace. All items were scored on a 5-point scale ranging from 0 (never) to 5 (always).

4.3.3.5 Sharing behavior within and outside school

Teachers' sharing behavior scale was developed by two subscales related to sharing within school (8 items) and outside school (8 items). The instrument assesses the frequency that teachers share DERs over the last year in the form of electronic lesson plans, presentations, classroom videos, exercises, tests, digital text, micro lecture/ micro video, and subject software and tools. The sixteen items were scored on a 5-point scale, ranging from 1 (never) to 5 (always).

4.3.4 Data analyses

Four steps were taken for data analysis. Firstly, two exploratory factor analyses (EFA) using IBM SPSS 25 were used to examine the underlying structure of motivation (including four regulations) and dispositional variables (i.e., attitude, subjective norm and self-efficacy). Second, confirmatory factor analyses (CFA) using M*plus* 8.3 (Muthén & Muthén, 1998-2017) was applied to test data for measurement models. Based on these data, we obtained the internal consistency using Cronbach's alpha, two reliability indices of the coefficient of Composite Reliability (CR), and the Average Variance Extracted (AVE) (Fornell & Larcker, 1981), and the discriminant validity using the Pearson correlations between variables. Third, to answer RQ1-RQ4, we employed a structural equation modeling (SEM) with maximum likelihood (ML) estimation. We chose SEM as the main analyses because it is the most suitable approach to test the strength of relationships among latent constructs (Kline, 2005). Finally, to answer RQ5-RQ6, we performed the mediated relations using a bias-corrected bootstrapping of 5000 samples (Preacher & Hayes, 2008).

In the two-step approach to build a SEM model, the following fit indices were used: chi-square (χ^2), chi-square divided by degrees of freedom (χ^2/df), the comparative fit index (CFI), the Tucker-Lewis index (TLI), the root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMR). Value of chi-square divided by degrees of freedom is smaller than 5 is considered an acceptable fit (Carmines & McIver, 1981). For both comparative fit index (CFI) and Tucker-Lewis index (TLI), values greater than 0.90 show good fit for the structural model (Kline, 2005). Values less than 0.08 for RMSEA and SRMR exhibit an acceptable fit (Hu & Bentler, 1999).

4.4 Results

4.4.1 Preliminary analyses

Prior to conducting the EFA, Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity was employed to check the suitability of the analysis. Hutcheson and Sofroniou (1999) suggest that KMO values should be above 0.5. The KMO values for the data sets of motivation and dispositional variables were 0.853 and 0.935 respectively, yielding that the sampling was sufficient. The χ^2 value of Bartlett's sphericity test for the data set of motivation was 4699.02 (p < 0.001, df = 120) and for the data set of dispositional variables was 6844.82 (p < 0.001, df = 120). Both results confirmed the appropriateness of the EFA.

We used principal components analysis (PCA) with Oblimin rotation and looked for eigenvalues greater than 1.0, and items with factor loading values below 0.4 on their own scales or above 0.4 on each of the other scales were removed. 16 motivation items were entered into an EFA, yielding three indicators of motivation: 1) external regulation, 2) introjected regulation, and 3) identified regulation and intrinsic motivation. These factors explained 60.82% of the total variance. In addition, all items from subjective norm were dropped after the PCA on all items from dispositional variables. Thus, subjective norm was removed from the research model and two retained factors of attitude and self-efficacy were extracted explained 65.33% of the total variance.

4.4.2 Measurement model

To simplify the model, we used three sub-constructs as indicators of motivation. However, the CFA did not support a model with three first-order factors linked to a single second-order factor representing overall teachers' motivation, as a negative residual variance was found for the indicator introjected regulation. Moreover, it is difficult to explain the meaning of the higher-order factor (motivation). Therefore, we decided to delete introjected regulation from the model and only include two first-order factors in which external regulation was regarded as external motivation, and intrinsic motivation and identified regulation were seen as internal motivation. The aforementioned relationships were adjusted, resulting in the final model presented in Figure 4.2. The final items and supporting citations appear in Appendix E

For the within school model, the CFA included 8 latent variables and 26 indicators. For the outside school model, the CFA included 8 latent variables and 28 indicators. Table D.2 in Appendix D presents the remaining constructs and items, and the analysis results show acceptable convergent validity and internal reliability of the measurement model. The standardized factor loadings of all the items in the measurement range from 0.645 to 0.919, and all are significant at the $p < 0.001$ level. The composite reliability (CR) values are larger than 0.7, confirming all constructs have good reliability. The average variance extracted (AVE) values for all constructs are above 0.5, supporting the convergent validity

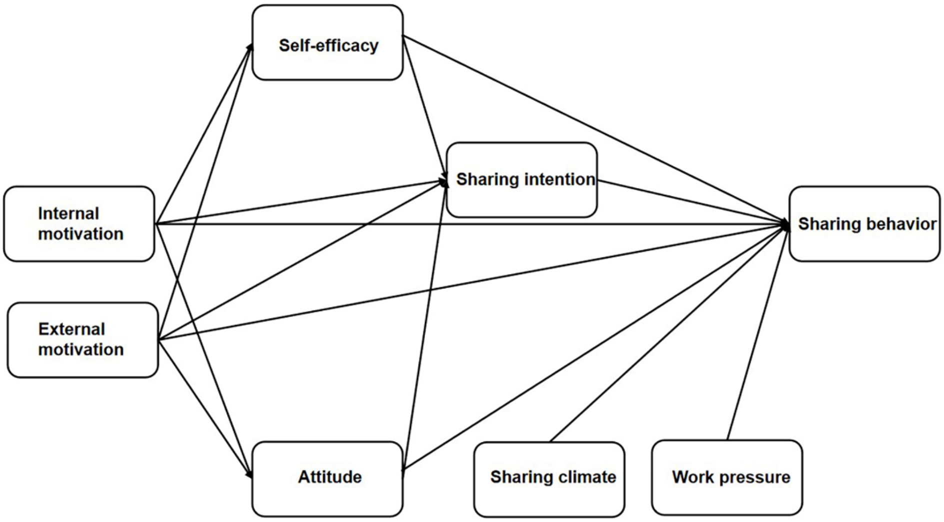

Figure 4.2. The revised research model.

(Hair, Ringle, & Sarstedt, 2011). In addition, all the Cronbach's values are larger than 0.7, indicating all constructs have appropriate internal consistency (Nunnally, 1978).

Table 4.2 lists means, standard deviations, and discriminant validity of constructs. The findings showed that the square roots of the AVEs exceeded the correlations between any two constructs, proving discriminant validity.

4.4.3 Sharing behavior within and outside school

To answer RQ1-RQ4, we performed a SEM to examine the relationships between constructs (Figure 4.2). For the within school model, the indices showed that the model matches the data well, $\chi^2 = 1009.447$, df = 278, $\chi^2/df = 3.631$, CFI = 0.921, TLI = 0.908, RMSEA = 0.061, SRMR = 0.070. In addition, the indices for the outside school model also indicated that the model fits well with the data, $\chi^2 = 1067.695$, df = 329, $\chi^2/df = 3.245$, CFI = 0.934, TLI = 0.924, RMSEA = 0.056, SRMR = 0.064. Table D.3 in Appendix D presents the results of path analysis, and Figure 4.3 and Figure 4.4 show the direct effects between constructs for both within and outside school respectively.

Table 4.2. Descriptive statistics and discriminant validity.

Constructs	Mean	SD	AVE	INT	EXT	SE	ATT	SC	WP	SI	SB
Within school											
INT	3.689	0.783	0.541	**0.736**							
EXT	2.773	1.003	0.559	0.087	**0.748**						
SE	3.450	0.942	0.677	0.425	0.116	**0.823**					
ATT	3.967	0.683	0.678	0.625	-0.078	0.590	**0.823**				
SC	3.755	0.811	0.645	0.506	-0.036	0.650	0.767	**0.803**			
WP	3.992	0.662	0.561	0.082	0.187	0.053	0.178	0.086	**0.749**		
SIIS	3.818	0.765	0.661	0.476	0.007	0.680	0.681	0.677	0.141	**0.813**	
SBIS	2.696	0.882	0.577	0.395	-0.025	0.520	0.396	0.459	0.062	0.443	**0.760**
Outside school											
INT	3.689	0.783	0.541	**0.736**							
EXT	2.773	1.003	0.559	0.087	**0.748**						
SE	3.450	0.942	0.677	0.424	0.116	**0.823**					
ATT	3.967	0.683	0.678	0.625	-0.079	0.588	**0.823**				
SC	3.755	0.811	0.645	0.507	-0.036	0.648	0.766	**0.803**			
WP	3.992	0.662	0.561	0.080	0.187	0.051	0.177	0.085	**0.749**		
SIOS	3.427	0.941	0.722	0.449	0.046	0.693	0.520	0.569	0.055	**0.850**	
SBOS	2.393	0.878	0.674	0.374	-0.014	0.447	0.329	0.415	0.039	0.416	**0.821**

Notes: Boldface numbers on the diagonal are the square root of the average variance extracted. INT = internal motivation, EXT = external motivation, SE = self-efficacy, ATT = attitude, SC = sharing climate, WP = work pressure, SIIS = sharing intention within school, SIOS = sharing intention outside school, SBIS = sharing behavior within school, SBOS = sharing behavior outside school. SI = sharing intention, SB = sharing behavior.

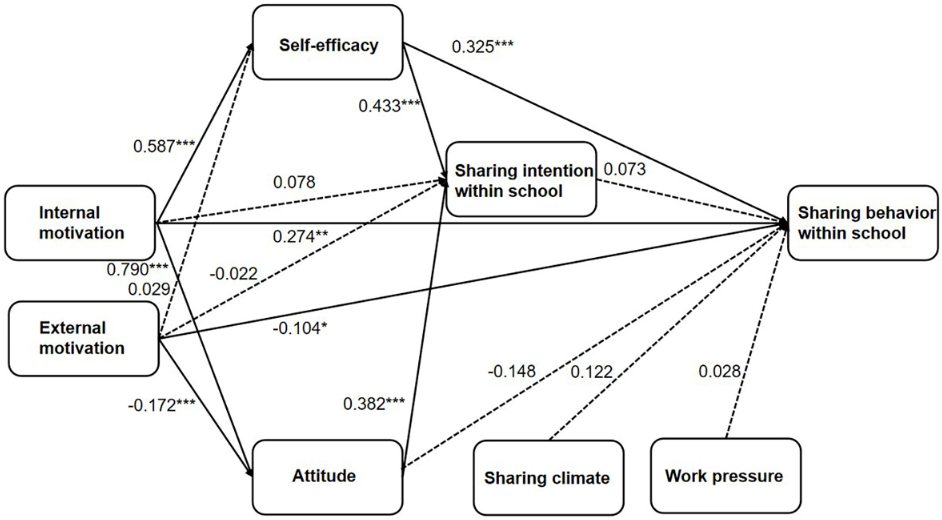

Figure 4.3. Results of the structural model within school. ***$p < 0.001$, **$p < 0.01$, * $p < 0.05$.

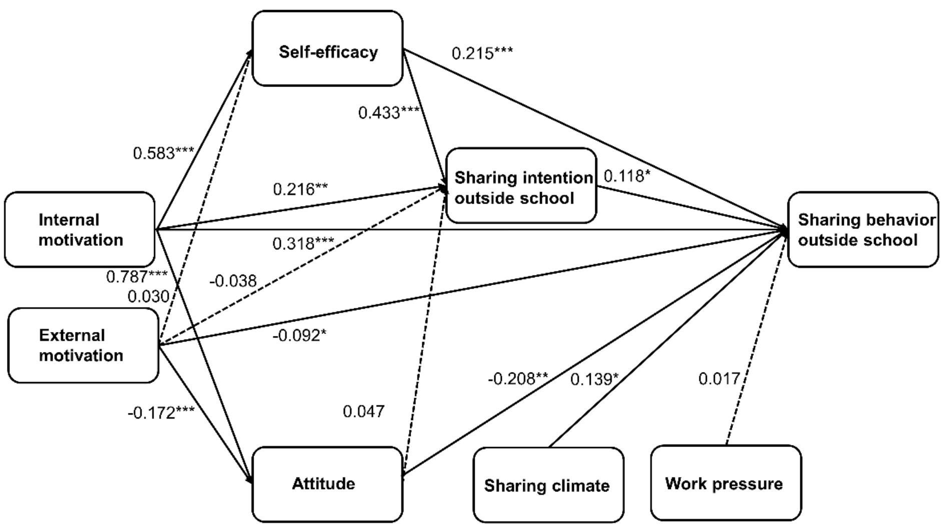

Figure 4.4. Results of the structural model outside school. ***$p < 0.001$, **$p < 0.01$, * $p < 0.05$.

4

4.4.3.1 Sharing behavior within school

Regarding RQ1 of the within school model, internal motivation positively predicted self-efficacy (β = 0.587, $p < 0.001$), attitudes (β = 0.790, $p < 0.001$) and sharing behavior within school (β = 0.274, $p = 0.003$), but had a non-significant effect on sharing intention within school (β = 0.078, $p = 0.282$). In addition, external motivation only negatively predicted attitudes (β = -0.172, $p < 0.001$) and sharing behavior within school (β = -0.104, $p < 0$ .001), but had a non-significant effect on self-efficacy (β = 0.029, $p = 0.494$) and sharing intention within school (β = -0.022, $p = 0.548$). Regarding RQ3 of the within school model, sharing intention (β = 0.073, $p = 0.300$), sharing climate (β = 0.122, $p = 0.070$), and work pressure (β = 0.028, $p = 0.495$) did not significantly predict sharing behavior. The proportions of explained variance for the within school model were 34.9% for self-efficacy, 62.5% for attitude, 57.4% for sharing intention, and 33.1% for sharing behavior.

4.4.3.2 Sharing behavior outside school

Regarding RQ2 of the outside school model, internal motivation positively predicted self-efficacy (β = 0.583, $p < 0.001$), attitudes (β = 0.787, $p < 0.001$), and sharing intention outside school (β = 0.216, $p = 0.003$) and sharing behavior outside school (β = 0.318, $p < 0.001$). Furthermore, external motivation negatively predicted both attitudes (β = -0.172, $p < 0.001$) and sharing behavior outside school (β = -0.092, $p = 0.036$), but had a non-significant effect on self-efficacy (β = 0.030, $p = 0.473$) and sharing intention outside school (β = -0.038, $p = 0.311$). Regarding RQ4 of the outside school model, sharing intention (β = 0.118, $p = 0.043$) and sharing climate (β = 0.139, $p < 0.025$) positively predicted sharing behavior, but work pressure (β = 0.017, $p = 0.668$) did not. The proportions of explained variance for the outside school model were 34.5% for self-efficacy, 62.0% for attitudes, 51.6% for sharing intention, and 28.2% for sharing behavior.

4.4.4 Mediated relations

Lastly, the mediation analysis was applied to answer RQ5 and RQ6. M*plus* 8.3

computed the indirect effects of mediated relations, with a 95% confidence interval using the bias-corrected bootstrap method. The results of the mediating effects within school model and outside school model are summarized in Table D.4 in Appendix D.

4.4.4.1 Mediated relations within school

Regarding RQ5 of the within school model, the results revealed that the indirect effect of internal motivation on sharing intention through two mediators of attitudes and self-efficacy was statistically significant (B = 0.691, 95%CI [0.470, 1.065]). Furthermore, the effect of external motivation on sharing intention within school was significantly mediated only by attitudes (B = -0.060, 95%CI [-0.131, -0.018]).

4.4.4.2 Mediated relations outside school

Regarding RQ6 of the outside school model, the mediating role of self-efficacy between internal motivation and sharing intention outside school (B = 0.496, 95%CI [0.350, 0.721]) was confirmed. However, the data did not support the mediation between internal motivation and sharing intention outside school via attitudes (B = 0.057, 95%CI [-0.362, 0.260]). Moreover, the indirect effect of external motivation on sharing intention outside school through self-efficacy (B = 0.019, 95%CI [-0.057, 0.088]) and attitudes (B = -0.009, 95%CI [-0.051, 0.047]) was not significant.

4.5 Discussion

Motivational factors were introduced into the integrative model of behavior prediction. The findings contribute to our knowledge of the factors for explaining sharing behavior in two contexts: DERs-sharing behavior within school and outside school. Different factors were found to be related to rural teachers' sharing behavior in the two contexts. Self-efficacy had a positive and relatively strong effect on sharing intention and sharing behavior in both contexts. Another important positive predictor of sharing intention within school was found to be attitude, but it was a negative predictor of sharing behavior outside school. One possible explanation may be that without trusting the receiving party, individuals are unlikely to share their hard-earned knowledge (Akosile & Olatokun, 2020; Norulkamar & Hatamleh, 2014).

Since this research's main purpose is to better understand the relationships between motivation and behavior in two contexts, we illustrate the main findings of the study below. First, among the motivational factors, in this study it was found that both internal motivation and external motivation significantly influenced attitudes, as well as sharing behavior within or outside school. However, internal motivation positively influenced whereas external motivation negatively influenced both attitude and sharing behavior. The outcome that internal motivation was significantly and positively related to sharing DERs is in line with the results of Jansen in de Wal et al. (2020). These authors showed that autonomous motivation including intrinsic motivation and identified regulation was significantly and strongly related to Dutch teachers' performance in professional learning activities. The finding that external motivation was negatively rather than positively related to sharing behavior coincides with previous research conducted in 27 companies across 16 industries showing that extrinsic rewards were negatively related to attitude towards knowledge sharing (Bock et al., 2005). Similarly, recent research by Akosile and Olatokun (2020) concluded that external motivation (i.e., reward system) is only a weak incentive for long-term knowledge sharing among academics. Compared with Chinese urban areas, in rural areas with higher avoidance of uncertainty and power distance (Fei, 1992), regulations may contradict the fulfillment of teachers' psychological needs and social rewards might be viewed as empathy rather than autonomy. Therefore, these results suggest that, at least in the Chinese rural school context, favorable individual attitudes toward sharing behavior and actual behavior may be hindered by external expectations but promoted by internal motivation.

Second, intention and sharing climate were only found to be significantly associated with sharing behavior outside school, not with sharing behavior within school. Although intention is believed to be a good determinant of behavior, the result that sharing intention within school was not associated with sharing behavior within school is similar to findings from another study (Wang et al., 2019) conducted in Western China. These authors showed that data from rural teachers' self-reported questionnaires did not support the hypothesized effect of intention on the use of DERs in teaching practices based on IMBP. This direct effect challenges the assumptions of the IMBP with regards to the intention-behavior relationship. More research is necessary to measure the relationship in this regard.

Sharing climate in this study was only found to have a positive relationship with sharing behavior outside school. This finding directly contradicts recent research regarding knowledge sharing among academics, which found that organizational climate was the strongest predictor for knowledge-sharing behavior in higher education (Al-Kurdi et al., 2020). In addition to the different research settings, another possible explanation for this finding may be that due to a rigid hierarchical structure educational system, the Chinese teacher community has a mistake-free culture, which may result in teachers refraining from sharing knowledge with their colleagues (Kuo & Young, 2008). Research also showed that positive organizational culture alone might not promote knowledge sharing (Hislop, 2009). However, the relative autonomy of the teacher regarding sharing outside school may promote teachers' involvement in open sharing DERs. These findings extend the current literature by exploring the effect of sharing climate on knowledge sharing. Although Bock et al. (2005) found that team climate directly affected knowledge sharing, they only used the intention to share knowledge as the dependent variable.

Moreover, and unexpected, the finding that work pressure did not significantly influence sharing behavior in both contexts, is in line with the results of Jansen in de Wal et al. (2020), who have noted that work pressure has no effects on secondary school teachers' performance in professional learning activities. This finding suggests that work pressure is two facets of the same coin in the influence on sharing behavior, for example, some teachers may feel too much workload to engage in other activities while others may appraise job demands as learning opportunities that trigger active actions. Furthermore, work pressure varies with school locations in China, depending on class size and the number of subjects teachers teach. For example, because small rural schools in villages suffering the shortage of teachers teaching minor subjects, teachers in these schools devote more of their time to classroom teaching compared to urban teachers. On the other hand, due to the rapid urbanization, teachers in urban schools with a relatively larger class size normally take on more responsibilities at work than teachers working in towns.

Finally, the mediation results reveal that for sharing within school, teachers who were more internally motivated showed relatively higher sharing intention within school because they had a higher level of self-efficacy and attitudes; teachers who were more externally motivated showed relatively lower sharing intention within school because they experienced more negative attitudes. In addition, for sharing outside school, teachers who were more internally motivated showed relatively higher sharing intention outside school because they had a higher level of self-efficacy. In the IMBP, all relationships between all motivational variables and intention are supposed to be mediated through the dispositional variables. However, this assumption is only supported for the relationships between the internal motivation and sharing intention within school context. Similarly, Hagger et al. (2006) found that attitude and perceived behavioral control to be significant mediators between autonomous motives and intention. Except for different motivation effects, the results of the mediation analysis have significant theoretical implications for the body of knowledge about the different mediating relationships between within and outside school contexts. This research supports Leonard et al.'s (1999) suggestion that self-concept-based motivation should be included when understanding the consistency and variability in individual behavior across contexts. Moreover, both findings from two contexts revealed the relative importance of self-efficacy in promoting sharing intention.

4.6 Limitations and future directions

Although this research has provided valuable insights into factors affecting sharing behavior regarding DERs by rural teachers, there are some limitations in this study. First, we used self-report frequency scales to obtain teachers' actual DERs-sharing behavior, which provides a limited understanding of the quality of the behavior. Future case studies using online monitoring systems to analyze teachers' sharing behavior may provide more in-depth understandings of effective knowledge sharing. Secondly, because the research context was limited to rural areas in China, generalizing the results of this study to larger populations should be done with caution. Future studies could test the research model in other countries or knowledge-sharing contexts to build a more robust conclusion. Third, based on our findings and together with Scherer et al. (2020), we argue that the intention-behavior link may not be positive and significant in all situations, which means that including alternative sources of information about the behavior variable (e.g., log file data) is needed to further investigate sharing behavior. Furthermore, since the effect of different environmental variables varies, future research should include more environmental variables affecting teachers' sharing behavior, such as perceived organizational support for knowledge sharing. Finally, many online sharing platforms exist and each platform has its own characteristics and attributes. Future research should focus on teachers' sharing behavior on different online sharing platforms. This study provides a general analysis of sharing behavior within and outside school which is the first and an important step for differentiating among the various situations where teachers share their DERs.

4.7 Conclusions

This study addresses the gap in the literature on rural teachers' sharing behavior regarding DERs, using the two-step SEM to investigate the motivation-behavior relationship in two contexts. Firstly, both internal motivation and external motivation were related to attitudes and sharing behavior within or outside school but in a different way. Secondly, intention and sharing climate only had a positive relationship with sharing behavior outside school and work pressure was not related to sharing behavior in both contexts. Finally, attitudes mediated the relationships of internal motivation and external motivation with sharing intention within school, and self-efficacy mediated the relationship between internal motivation and sharing intention outside school.

The research provides several contributions to the literature. The unique theoretical contribution is providing a comprehensive understanding of teachers' sharing behavior regarding DERs by introducing the concept of motivation in IMBP. While there are studies taking into account motivational factors for the adoption of technology (see e.g., Fathali & Okada, 2018; Khan et al., 2018; Nikou & Economides, 2017; Safa & Von Solms, 2016), no such study exists in the context of teachers' sharing behavior regarding DERs in primary and secondary education. Our study offers a further explanation for findings by Bock et al. (2005) who found that extrinsic rewards had a negative effect on attitudes toward sharing knowledge. Unlike people in cultures where knowledge sharing is encouraged, external incentives discourage teachers in rural schools with less focus on collaboration and on embracing new things to form a positive attitude and share DERs. Moreover, although several studies adopted motivational factors from interpersonal relationships (Al-Kurdi et al., 2020; Singh, 2019; T. Guan, et al. 2018), we examined the interaction between the individual and the environment that can lead to behavior.

From the empirical perspective, this study helps to identify the key motives and obstacles in the early stages of knowledge sharing based on rural teachers' own perspectives. Unlike previous studies focusing on only one context of teachers' general knowledge sharing behavior (Akosile & Olatokun, 2020), this study explores the motivation-behavior relationship in the context of DERs-sharing both within and outside school. The findings complement the study of Van Acker et al. (2014) in which Open Educational Resources (OER) sharing behaviors of teachers in two situations were compared. This research highlights important reasons why teachers in rural school context share (because of internal motivation) or not share DERs (because of external motivation) as well as identifies two mediators (self-efficacy and attitudes) to improve DERs sharing. This indicates that the higher the internal motivation rural teachers have and the higher level of self-efficacy, the more they contribute their DERs. It is also important to emphasize that the role of variables in the research model might vary from context to context. Comparing these insights to distinguished contexts may contribute to the sharing of DERs in rural schools and to making DERs more contextualized and to enhancing new ways of teaching and learning.

This research offers practical implications to establish conditions that stimulate knowledge sharing in various contexts. Some suggestions are presented below. In schools, adjustments could be made with regards to the types of incentives used for stimulating knowledge sharing, for example, by moving from a focus on high organizational expectations to stimulating individuals' interests in sharing knowledge. Additionally, these conditions should include removing obstacles (e.g., individuals' concerns of losing their unique competitive advantages. As Joo, Lim, and Kim (2016) pointed out, teachers' emotions should be deemed vital to their use of technology. In addition to this, technical and pedagogical support in sharing in the formal training sessions are also needed. Observing others who effectively share is another way to boost teachers' self-efficacy (Instefjord & Munthe, 2017). Efforts aimed at creating a collaborative school climate by communities of practices may also help increase actions, particularly in the outside school setting (Yang, Yu, & Chen, 2019).

The effects of mobile technology usage on cognitive, affective, and behavioral learning outcomes in primary and secondary education: A systematic review with meta-analysis

5

This chapter was submitted in an adapted form as:
Wang, J., Tigelaar, D. E., & Admiraal, W. The effects of mobile technology usage on cognitive, affective, and behavioral learning outcomes in primary and secondary education: A systematic review with meta-analysis.

Abstract

The impact of mobile technology usage on student learning in various educational stages has been continuously studied in empirical and review studies. In the course of researchers' inquiry into the extent of enhancement of learning outcomes, systematic quantitative analyses of mobile devices' effects on both cognitive and non-cognitive learning outcomes, with a particular emphasis on primary and secondary education, are lacking. This study aimed to synthesize the effects of using mobile technology on cognitive, affective, and behavioral learning outcomes in primary and secondary education. Based on our inclusion and exclusion criteria, we found 61 studies of 56 peer-reviewed papers (N = 6406) from electronic databases and major journals in educational technology and mobile learning between 2014 and 2020. We then examined 15 moderators that were expected to affect student learning outcomes. Compared with traditional technology and non-technology groups, using mobile technology produced medium positive and statistically significant effects on primary and secondary students' learning, in terms of cognitive (g = 0.547), affective (g = 0.514), and behavioral (g = 0.543) learning outcomes. Further moderator analyses revealed that student factors (i.e., students' socioeconomic status), learning process (i.e., hardware used, student-to-hardware ratio) and study quality (i.e., learning content/ topic equivalence, software/ tool equivalence, procedure of effect size extraction) were among the variables that moderated the summary effect sizes (ESs) for at least one learning outcome dimension significantly. The findings and their implications for researchers, policymakers, and practitioners are discussed.

5

Keywords

Mobile technologies; Learning outcomes; Primary education; Secondary education; Meta-analysis

5.1 Introduction

Mobile technology is characterized by wireless internet-connected devices, including smartphones, clickers, tablets, and laptops, etc. Considering the rapid growth and affordability of mobile technology, mobile learning, known as "learning across multiple contexts, through social and content interactions using personal electronic devices" (Crompton, 2013, p. 4), has become a fast-growing research field in the world (Soloway & Norris, 2018). The proliferation of mobile technology provides researchers with the opportunity to reimagine teaching and learning with mobile technology (Mayer, 2020). Recent literature has identified the exciting potential of integrating mobile technology in education. For example, instantly gathering student data from mobile devices can help teachers monitor students' learning progress and deliver differentiated instruction in class (Lee, Hao, Lee, Sim, & Huang, 2019), and support teachers plan and orchestrate through reflection on and evaluation of their teaching (Wise, 2019). Beyond the importance to teachers, most mobile technology research reported on increased learning achievement in the language (Alfadil, 2020), science (Chang et al., 2020), mathematics (Zhu & Urhahne, 2018), and social studies (Huang, Chen, & Hsu, 2019), followed by students' perceptions of motivation (Lee et al., 2019) and attitude (Sahin & Yilmaz, 2020). Benefit from the increased learning mobility, mobile learning also facilitates social interaction (Hwang, Lai, Liang, Chu, & Tsai, 2018) and knowledge co-creation (Lim, Shelley, & Heo, 2019). Researchers have pointed out the critical role of self-efficacy in shaping students' behavioral engagement in mobile learning (Xie, Heddy, & Vongkulluksn, 2019). Therefore, mobile technology affords students to learn, both individually and collectively (Koole, 2009). There are some minor concerns on mobile learning, however, regarding distractive effect (Zhai, Zhang, Li, & Zhang, 2019), misuse (Ravizza, Uitvlugt, & Fenn, 2017), self-control challenges (Troll, Friese, & Loschelder, 2020), and heavy cognitive load (Chu, 2014).

To date, because the non-cognitive domains were less reported and seemed less relevant for informal settings, the pooled effects of mobile technology on learning have mainly been limited to cognitive learning. We argue that the targeted learning goals for "21st-century skills" include cognitive goals, affective or intrapersonal goals, and behavioral or interpersonal goals, and research needs to go beyond concentrate on measuring cognitive learning gains (Pellegrino & Hilton, 2013). Recently, highly cited articles on mobile learning have focused more on the affective and behavioral dimensions (Lai, 2020). It is yet to be known what are the overall effects of mobile technology on affective and behavioral learning outcomes, which play a vital role in understanding students' learning from alternative perspectives.

Moreover, given the richness and complexities of mobile learning, it is important to develop a greater understanding of how to optimize the implementation and interpret the different learning outcomes (Rogaten, et al., 2019). Specifically, more research is needed on the best practices for using mobile technology in order to figure out when and how children should use mobile devices (Crompton & Burke, 2020). Because of the numerous, significant differences found in the available studies between primary and secondary education, and post-secondary education (Schmid et al., 2014), one could argue that mobile technologies are more effective for lower education levels. For example, a recent meta-analysis on audience response systems revealed that the effect is much more significant in experiments performed in non-university contexts than in the university context (Castillo-Manzano, Castro-Nuño, López-Valpuesta, Sanz-Díaz, & Yñiguez, 2016). When clickers are integrated into the classroom, students tend to feel more excited, engaged, and less anxious in learning (Lee et al., 2019). While half of the top 100 highly cited articles on mobile learning published from 2012 to 2016 were focused on primary and secondary education (Lai, 2020), the overall quantitative impact on learning outcomes and the factors that play a central role in promoting learning have received relatively little research attention.

To quantify the overall effects of mobile technology usage on cognitive and non-cognitive learning outcomes and close the research gap related to primary and secondary student learning, we employed a meta-analysis to compare mobile learning effects with traditional learning in primary and secondary education. The present study has two aims. First, we aimed to examine the overall effects of mobile technology usage on multidimensional learning outcomes from three aspects, i.e., cognitive, affective, and behavioral learning. Second, it quantifies and explains the amount of variability in the findings in the literature. Our results from an up-to-date meta-analytic synthesis may provide a rich overview of the current mobile-learning practices and their overall effects, which can inform researchers, policymakers and practitioners on how best to integrate mobile technology in teaching and learning.

5.1.1 Previous narrative reviews of learning with mobile technologies

Narrative reviews regarding mobile learning published over the past three years have been performed in various educational contexts (e.g., Chung, Hwang, & Lai, 2019; Diacopoulos & Crompton, 2020; Lai, 2020; Suarez, Specht, Prinsen, Kalz, & Ternier, 2018). These studies have examined various dimensions of learning outcomes such as Bloom's taxonomy of educational objectives (Chung et al., 2019), thinking skills (Diacopoulos & Crompton, 2020), engagement and collaboration (Diacopoulos & Crompton, 2020), and learners' agency (Suarez et al., 2018). As Lai (2020) stated, these previous seldom-discussed learning outcomes like learners' higher-order thinking and behaviors, are potential mobile learning research themes.

Academics also constrained narrative reviews to school-aged students. Crompton, Burke, and Gregory (2017) conducted a systematic review from 2010 to 2015, investigating the general characteristics of 113 mobile-learning studies conducted in PK-12 (students ages 2-18), such as research purposes, methodologies, and outcomes, domains, educational levels, contexts, and learning activities. In 2019, Crompton and his colleagues (Crompton, Burke, & Lin, 2019) published an up-to-date analysis of students' cognitive learning level as measured by Bloom's Taxonomy in PK-12 mobile learning research. They reviewed 101 articles from 2010 to 2016 and found that mobile devices were integrated into more subjects, e.g., multiple subjects and social studies. Similarly, Crompton and Burke (2020) applied the Substitution, Augmentation, Modification, and Redefinition (SAMR) framework to examine PK-12 studies from 2014 to 2019. They found that mobile technologies were sometimes used to replicate activities without functional changes. Besides, Burden, Kearney, Schuck, and Hall (2019) systematically reviewed 57 studies from 2010 to 2017 focused on innovative mobile learning practices in K-12 education. However, these studies were limited as papers were identified through either the top journals or database searches, which may not represent all works published on mobile learning. Also, the included studies were often published before 2015 (Crompton et al., 2017), conducted in a special education settings (Crompton et al., 2019; Crompton & Burke; 2020), or lack comparison groups (Crompton et al., 2017), which means they cannot generally reflect the current mainstream practice or makes it challenging to evaluate the interventions.

5.1.2 Previous meta-analyses of effects of mobile technology usage on learning outcomes

Numerous experimental or quasi-experimental studies have been conducted to investigate the effects of mobile technology usage. The findings of these primary studies as listed in Table 5.1 have been synthesized in at least nine meta-analyses. However, most meta-analyses had a limited scope, either to synthesize a single outcome variable (Castillo-Manzano et al., 2016; Cho, Lee, Joo, & Becker, 2018; Fabian, Topping, & Barron, 2016; Tingir, Cavlazoglu, Caliskan, Koklu, & Intepe-Tingir, 2017; Yang, Sung, & Chang, 2020), or to center on specific subjects (Castillo-Manzano et al., 2016; Cho et al., 2018; Mahdi, 2018; Tingir et al., 2017), or particular mobile devices (Castillo-Manzano et al., 2016; Hunsu, Adesope, & Bayly, 2016).

We found three broader meta-analyses aimed at various mobile technology use for potential benefits of cognitive and non-cognitive learning in all grades and disciplines in the past five years. More specifically, Sung, Chang, and Liu (2016) investigated the effects of integrating mobile devices on learning that cut across all levels of learning stages, school subjects, and mobile technology types, from 1993 to 2013. They found a significant medium average effect size of $g = 0.523$ for learning achievement and $g = 0.433$ for affective outcome variables (e.g., motivation, attitude, participation, and engagement), compassing 110 journal articles and 18749 participants. The authors answered core questions

Table 5.1. Nine meta-analyses of mobile learning research over the last five years, ordered by year of publication.

Meta-analyses (Year)	Inclusive dates	K	Average ES	Education levels	Subjects	Devices	Learning outcomes
Castillo-Manzano, Castro-Nuño, López-Valpuesta, Sanz-Díaz, and Yñiguez (2016)	2008-2012	53	0.48	University, non-university	Various	Audience-response devices	Examination scores
Fabian, Topping, and Barron (2016)	2003-2012	14	0.48	Elementary education	Mathematics	Various	Student scores
Hunsu, Adesope, and Bayly (2016)	2001-2014	86 for cognitive; 25 for non-cognitive	0.05 for cognitive; 0.23 for non-cognitive	K-12, college	Various	Clicker-based technologies	Cognitive and non-cognitive learning outcomes (i.e., Attitudinal and behavioral learning outcome)
Sung, Chang, and Liu (2016)	1993-2013	108 articles for cognitive; 22 for affective	0.523 for cognitive; 0.433 for affective	Kindergarten, elementary school, middle school, high school, college, adults	Various	Various	Cognitive and affective learning outcomes
Tingir, Cavlazoglu, Caliskan, Koklu, and Intepe-Tingir (2017)	2010-2014	14	0.48	K-12	Science, mathematics and reading	Various	Achievement score
Sung, Yang, and Lee (2017)	2000-2015	163	0.516	Kindergarten, elementary school, junior high school, senior high school, college, graduate school, and adults	Various	Various	Learning achievement, learning attitude, and peer interaction for collaborative learning
Cho, Lee, Joo, and Becker (2018)	2008-2017	22	0.51	Primary, secondary, and post-secondary	Language	Various	Tests
Mahdi (2018)	2009-2015	16	0.67	Young and adult learners	Language	Various	Vocabulary tests
Yang, Sung, and Chang (2020)	2001-2017	87	0.803	Various	Various	Various	Cognitive and affective learning outcome for inquiry-based Learning

about cognitive learning outcomes. For example, do students learn academic content better with mobile technology than conventional technology (Mayer, 2020). The authors concluded that students using mobile devices in education performed better than those not. Besides, unlike other reviews, Sung and his colleagues focused on different teaching methods rather than mobile learning in general, for example, inquiry-based learning (Sung, Yang, & Lee, 2017) and collaborative learning (Yang et al., 2020).

Although the above mentioned meta-analyses have added academic understanding to the effects of mobile technology usage, they did not distinguish between affective and behavioral learning outcomes from non-cognitive outcomes, nor consider conducting moderator analyses related to these non-cognitive outcome variables. Moreover, it is hard to determine what happens to primary and secondary students and see how mobile devices boost their learning in various ways. To address these concerns, the current study took a step further by investigating the effects of mobile technology usage on different learning outcomes emphasizing primary and secondary education. In sum, this study differs from previous studies for the following reasons. First, an addition from 2014 on is necessary because of the large number of studies. Secondly, the current study is not limited to cognitive learning outcomes but also includes non-cognitive learning outcomes. We examined the effects of mobile technology usage on three dimensions of outcomes: cognitive learning, affective learning, and behavioral learning. Third, we considered a series of factors from both educational and methodological aspects, which are supposed to moderate the effectiveness of the mobile technology intervention.

5.1.3 Potential moderator variables considered

In addition to uncertainty about the overall effects of mobile technology on different types of the outcome variable, the potential influences of several moderators need further exploration, which were derived from relevant studies conducted earlier. We adopted the 3P (presage - process - product) model (Biggs, 2003) to determine the primary aspects of moderators that could reflect the full picture of teaching and learning within the mobile technology integration context. The 3P model provides us to comprehend the relationships among student and teaching context presage factors, learning process factors, and product factors (learning outcomes) within the context of mobile technology usage. Moreover, higher methodological quality studies could have provided substantially different results than less quality studies (Cheung & Slavin, 2016), thus we chose to study quality factors commonly presented in experimental studies on mobile technology intervention. Therefore, the potential moderators in this meta-analysis have been grouped into four categories: student factors, teaching context, learning process, and study quality.

The following two moderator variables have been considered as student factors: community type and student socioeconomic status (SES). Moreover, teaching context factors include education level, school type, learning environment, school subjects, teacher training on content and technology. Hardware used, student-to-hardware ratio, software used, teaching method and duration of intervention are selected as the learning process factors. Finally, we examine whether the different results between the studies could be explained by research design, instructor equivalence, degree of technology use in the control group, and the procedure of effect size extraction. Although researchers have constantly discussed the significance of the above variables (see e.g., Chauhan, 2017; Schmid et al., 2014; Sung et al., 2016; Zheng, Warschauer, Lin, & Chang, 2016), at this point, we give our special attention to learning process factors which might provide a deeper insight in the implementation and evaluation of the interventions of interest. Below we go into details on our rationale for the selected moderator variables related to the learning process.

In order to guide the decision on instructional designs and keep advancing mobile learning in all different situations, the learning process factors can typically be described by three main aspects: human resources, technological resources and intervention duration. Human resources primarily refer to teachers, especially the type of pedagogy they adopted that supports students to acquire knowledge and their interaction processes, and technological resources primarily relate to the degree of resource access and differences in resource usage that supports educational processes. Intervention duration refers to the duration between time prior intervention and time post intervention.

Regarding technological resources access, the effects of technology on learning retention and joyful learning environment are most likely when each student had access to an individual digital device (Chou, Chang, & Lin, 2017). However, Kay, Benzimra, and Li (2017) found that students were distracted more when using mobile devices on their own. Next, the most common variables with regard to the difference of resource usage are hardware and software used for learning. As an example, Sung et al (2016) found that the effect sizes differed significantly among the various hardware including handheld, laptops and mixed devices, and larger effects were reported for learning-oriented software designed for educational purposes than for general software designed for commercial purposes. More importantly, we believe that the value of mobile technology lays in how it is integrated with pedagogy and curriculum. Several meta-analyses (see e.g., Sung et al., 2017; Yang et al., 2020) have shown that different teaching methods implemented in mobile learning context produce different effects. Furthermore, we included duration of intervention as moderator variable. Empirically, short interventions might not yield effects because students need some time to familiarize with hardware and software (Sung et al., 2017). Nevertheless, if the intervention duration is too long, the effects could decline because students feel less motivated (Lee et al., 2019).

The purpose of this study is to provide new quantitative data that are expected to deepen the knowledge base on various learning outcomes and inform evidence-based decision-making on the use of mobile technology in primary and secondary education. Following the PICO framework, the population is composed of students in primary and secondary education. The intervention is the use of mobile technology for learning. The comparison is made with a non-technology (e.g., pen and paper) or traditional technology group (e.g., desktop computers and whiteboards). The outcomes refer to measurements of cognitive (e.g., attention, memory, and understanding), affective (e.g., motivation, emotions, and attitudes), and behavioral (e.g., self-efficacy, interaction, and engagement) aspects of learning. Specifically, this meta-analysis seeks to answer the following research questions:

RQ1: When compared with traditional learning, what is the overall effectiveness of using mobile technologies in primary and secondary education on students' learning outcomes in terms of cognitive, affective, and behavioral dimensions?

RQ2: What, if any, factors based on 3P model, that is student factors, teaching context and learning process factors, moderate the relationship between mobile technology use and learning outcomes?

RQ3: For RQ1 above, what, if any, study quality characteristics explain the heterogeneity in results?

5.2 Method

5.2.1 Inclusion and exclusion criteria

Our criteria for the determination of coding studies and subsequent meta-analysis were developed based on a preliminary literature review on the use of mobile technology for educational purposes. A pre-defined criterion for identifying research samples was listed below:

(a) The study used an experimental or quasi-experimental research design.
(b) The results of the mobile technology intervention group were compared with non-technology (e.g., pen and paper) or traditional technology (e.g., desktop computers and whiteboards) groups.
(c) Learning outcomes were reported as the dependent variable, measured by either cognitive, affective, or behavioral learning outcomes.
(d) Reported original data and provided sufficient information to calculate effect sizes, such as means, standard deviations, the sample size in each group.
(e) The sample consisted of primary or secondary school students.
(f) Studies were published in peer-reviewed journals, and a full text was available.
(g) Studies were published between 2014 and 2020 and were written in English. The starting year was set in 2014 because we extended Sung et al.'s (2016) study to understand the mobile learning empirical field over recent years.

Several exclusion criteria were used. Conceptual analysis or research reviews, and qualitative research, pre-experimental studies, and editorials were excluded. Moreover, studies on gifted education, special education, or disabilities learning were excluded. Studies involving any children with special educational needs were also excluded because this may have potential impacts on the entire group's performance. In cases where studies met all the inclusion criteria but lacked sufficient descriptive statistics or inferential statistics to calculate effect sizes were excluded.

5.2.2 Literature search and data sources

Studies were identified from two different sources. First, a database search was performed on all databases available at the library of Leiden University, such as Web of Science, Elsevier, ERIC, SAGE journals. Four sets of keywords were combined: (1) population (i.e., student); (2) mobile-technology related terms (i.e., mobile technology, mobile device, personal digital assistant, handheld, iPad, laptop, tablet, smart phone, mobile phone, response system); (3) learning-related keywords (i.e., learning outcome, achievement, performance); and (4) research-design related keywords (i.e., experimental, quasi-experimental). For the search, a Boolean OR operator first linked the keywords within each set; a Boolean AND operator was used to combine keywords across the four sets. The terms of mobile technology were searched within titles, and other terms were searched within any field. 421 peer-reviewed articles were found on 25 May 2020, and twenty duplicate papers were then removed in the Mendeley. In the next step, the title and abstract of each paper were read. Based on our criteria, the first author assessed these 401 studies to determine 'yes', 'maybe', or 'no' (Liberati et al., 2009), and papers in the 'maybe' group were then assigned to other two authors for the final decision. A total of 39 eligible papers were obtained in this stage.

Moreover, we browsed the major educational technology and mobile learning journal online in June 2020, including the British Journal of Educational Technology, Computers & Education, Educational Technology Research and Development, Educational Technology & Society, Journal of Computer Assisted

Learning. After removing the 41 duplicates from the 3318 paper contained in the five journals, additional 196 studies were found after screening abstracts, resulting in 235 articles for full-text review. These articles were not found in the first stage and the main reason is that the terms of mobile technologies were searched within titles and these studies used other related terms (e.g., games, mobile learning, mobile application, online tools, and clickers).

During the final full-text screening step, at least two authors screened the articles applying the inclusion and exclusion criteria to check for eligibility. There were minor disagreements mostly related to whether mobile technologies were used, and these were discussed among the three authors until they were resolved. This step limited these studies to the 61 studies of 56 journal articles that were included in this meta-analysis. Figure 5.1 provides a flowchart describing the inclusion process and describes the reasons why studies were excluded, following the guidance of The PRISMA Group (Moher, Liberati, Tetzlaff, & Altman, 2009).

5.2.3 Coding of potential moderators

First, a coding sheet was developed mainly based on the coding variables in recent meta-analysis articles (Schmid et al., 2014; Sung et al., 2016). Evidence produced by review, however, was used to assess relationships that primary researchers never examined (Cooper & Hedges, 1994). Thus, a strategy we used to adapt the original coding sheet was to search for possible moderators by evaluating a subset of studies (Brown, Upchurch, & Acton, 2003). After the pilot testing on 22 articles, four variables (i.e., student training on technology, student training on content, learning topic/ content equivalence, and software/ tool equivalence) were added to the coding sheet. After completing the code sheet, a codebook was developed to guide the coding process for all eligible studies. All the eligible studies were independently coded by the first and the second or third author. All disagreements produced by the former procedure were addressed in several meetings, and the authors reached consensus on each coding category.

In total, we coded for 21 variables (17 from previous studies and 4 from our new data) that were supposed to be used as moderators. However, not all were included in the moderator analyses. We excluded 6 moderators either because of low variability in the outcome (i.e., school type and software used), or because very few studies reported the relevant information (i.e., student and teacher training on technology/ content). In the end, 15 variables served as moderators (see Table 5.3 for the final moderators and their categories).

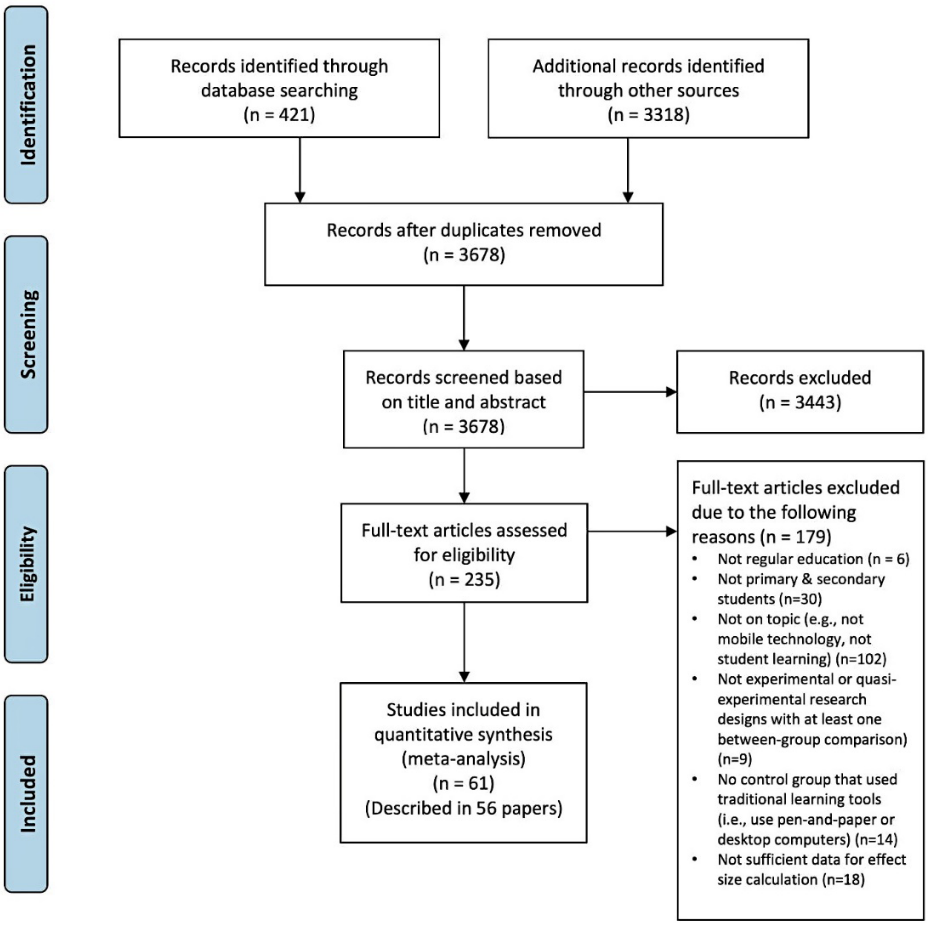

Figure 5.1. Flowchart of the study selection process following the guidelines of The PRISMA Group (Moher et al., 2009).

5.2.4 Effect size calculation

In the present meta-analysis, the standardized mean difference between the intervention and the control conditions on the posttest was the dependent variable. We chose the effect size of Hedges' *g* over Cohen' s *d* because it is more accurate for smaller samples (Borenstein, Hedges, Higgins, & Rothstein, 2009). The intervention group outperformed the control group by showing a positive effect size. Cohen (1992) indicated that the value of any pooled Hedges' *g* was viewed as following: small effect ($g = 0.2$), medium effect ($g = 0.5$), and large effect ($g = 0.8$).

Wherever applicable, the effect sizes were calculated based on the post-baseline means and standard deviations rather than scores reflecting changes from baseline to follow-up, as these are not independent (Cuijpers, Weitz, Cristea, & Twisk, 2017). If they were not available, we used other inferential statistics as long as they represent the difference between the intervention and the control condition on the posttest.

The cognitive learning outcome was the primary outcome and we also coded effect sizes based on affective and behavioral learning outcomes. When more than one appropriate outcome measure was reported in a study, we calculated effect sizes for all of those. The software Comprehensive Meta-Analysis (CMA), Version 3.3.070 was used to calculate the effect size for each contrast.

5.2.5 Statistical dependence of the samples

We included ten studies with multiple comparisons. Since these comparisons are not independent of each other this may yield an artificial reduction of heterogeneity which can affect the pooled effect size, we examined these possible effects by conducting sensitivity analyses in which we included only one of the comparisons per study. However, this did not result in a different result (for more details, see section 3.3). The second case of dependent data was reporting multiple outcomes or time-points per study. A study may involve different measures for the same learning outcome variable. In this case, we created a synthetic effect size for each study, which is a more conservative method for combining dependent outcomes than assuming completely independent outcomes (see Borenstein et al., 2009). When multiple time points of one dependent variable in one study could be calculated, we chose only to include the measurement that is closest to the end of the intervention that causes differences between experimental and control groups to rule out other possible explanations. Additionally, for those studies providing two or more independent experiments, and each experiment contributing independent information, we treated each experiment as a separate study, computed the effect within experiments, and then use these effects as the unit of analysis.

5.2.6 Data analysis

We conducted three meta-analyses: one on the cognitive learning outcome, one on the affective learning outcome, and one on behavioral learning outcome. Because there was a wide range of different participants, interventions and outcome measures between studies, we used the random-effects model to calculate the average effect sizes. The random-effects model allows for between-study variance beyond random error (Borenstein et al., 2009).

The first method to examine heterogeneity is to look carefully at the forest plot. Forest plots were presented to examine effect size distributions, and to assist in identifying outliers. Outliers were defined as studies in which the 95% CI was outside the 95% CI of the pooled studies and excluding outliers from a meta-analysis results in a considerable drop in the level of heterogeneity (Levy Berg, Sandell, & Sandahl, 2009). However, outlier tests are tools that help us to find certain studies that are worth examining in more detail but should not be taken as a justification of removal studies (Viechtbauer & Cheung, 2010).

Additionally, the *Q*-statistics was utilized to calculate the heterogeneity of the average effect sizes. As an indicator of heterogeneity, we calculated the I^2-statistic, which gives heterogeneity in percentages and it is assumed that a percentage of 25% indicates low heterogeneity, 50% moderate and 75% high heterogeneity (Higgins, Thompson, Deeks, & Altman, 2003).

In order to assess the effects of differences between the primary studies that might have an influence on the results we tested the effects of a priori defined variables. Moderator analyses were conducted to compare the contrasts based on categorical moderator variables in all the meta-analyses. Only categorical moderator variables that had at least four contrasts in the categories were used (Bakermans-Kranenburg, Van IJzendoorn, & Juffer, 2003). Because very few studies were found in some categories, we merged these categories. For example, we assumed that the SES of students was not low if it was not reported in the study.

Publication bias was inspected in all sets of studies. Studies with significant results are more likely to be published and thus significant findings may be overrepresented in a meta-analysis which may lead to an overestimation of the average effect size. The visual display of effect sizes against standard errors by a funnel plot is a popular way to evaluate publication bias and an asymmetrical distribution of the studies indicates the risk of missing studies (Card, 2012). In case of an asymmetrical funnel plot, we used Duval and Tweedie's trim and fill procedure to calculate the adjusted effect (Duval & Tweedie, 2000). Furthermore, Rosenthal's fail-safe N was estimated to show the number of missing studies ($5k + 10$) with zero effect to be required to generate non-significant results (Rosenthal, 1979).

5.3 Results

5.3.1 Characteristics of included studies

The final dataset consisted of 61 studies from 56 articles with a total of $N = 6406$ students. Appendix F presents the studies included in the present meta-analysis and Appendix G provides an overview of the studies. The most studied region was Taiwan (n = 26). Community types (i.e., urban, suburban and rural) were only reported in 23% of the studies. In a few studies (n = 5), students came to school with a low SES. More than half of the studies (n = 33) investigated primary school students and less than half of the studies (n = 28) investigated students from the secondary school level. For learning environment, 40 studies implemented in the formal settings. Language arts were the most studied subjects (n = 20), followed by Science (n = 18), Social studies (n =10) and Mathematics (n = 9). Handheld devices with multiple functions (including laptops, tablet PCs, and mobile phones) were the most widely studied hardware (n = 53), followed by handheld devices with one specific function (n = 5, including classroom response systems, e-book readers, PDAs, digital pen, etc.). In about half of the studies (n = 36), students owned and used a mobile device. With regard to teaching method, inquiry-oriented leaning (n = 19, including discovery and exploration, problem-solving, project-based learning, and cooperative learning) was the most frequently researched, followed by game-based learning (n = 11). The studied intervention duration were similar, that is, < 1 day (n = 18), 1 day- 4 weeks (n = 20), and > 4 weeks (n = 19). Only 9 studies utilized a true experimental design. Some studies conducted well on equivalent instructor (n = 28), equivalent learning topic/ content (n = 50), and equivalent software/ tool (n = 35). Finally, pen-and-paper conditions (n = 40) were the most often studied control groups, followed by traditional technology condition (n = 12).

5.3.2 Evaluation of publication bias

Regarding the possibility of publication bias affecting our data, funnel plots for each dependent variable were examined for asymmetry, as presented in Figures 5.2, 5.3, and 4. Duval and Tweedie's trim and fill analyses showed that no studies missing for cognitive and affective learning outcomes, and that 1 extra study for behavioral outcome variable had to be imputed to obtain a symmetric distribution of effects. The adjusted mean effect size on behavioral outcome was still positive, but showed a smaller (and significant) effect of using mobile devices for learning (g = 0.477, 95% CI [0.164, 0.789]). Finally, the fail-safe N was 6508, 607, and 262, with cognitive, affective and behavioral learning outcomes, respectively, which is much larger than the tolerable number of studies with 370, 130, and 80, respectively. Based on these analyses, we concluded that the effects of mobile technology usage on learning in primary and secondary education was reliable and robust.

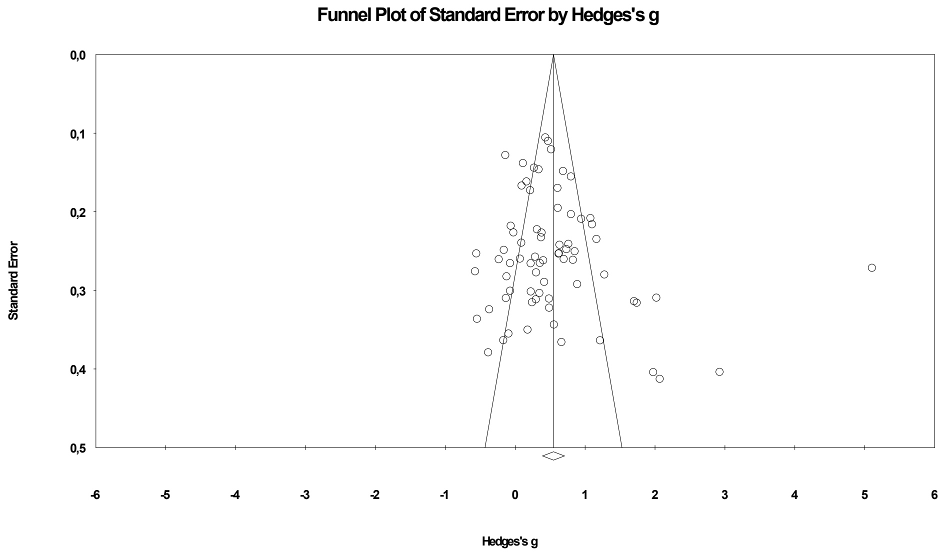

Figure 5.2. Funnel plot of the 72 effect sizes for cognitive outcomes.

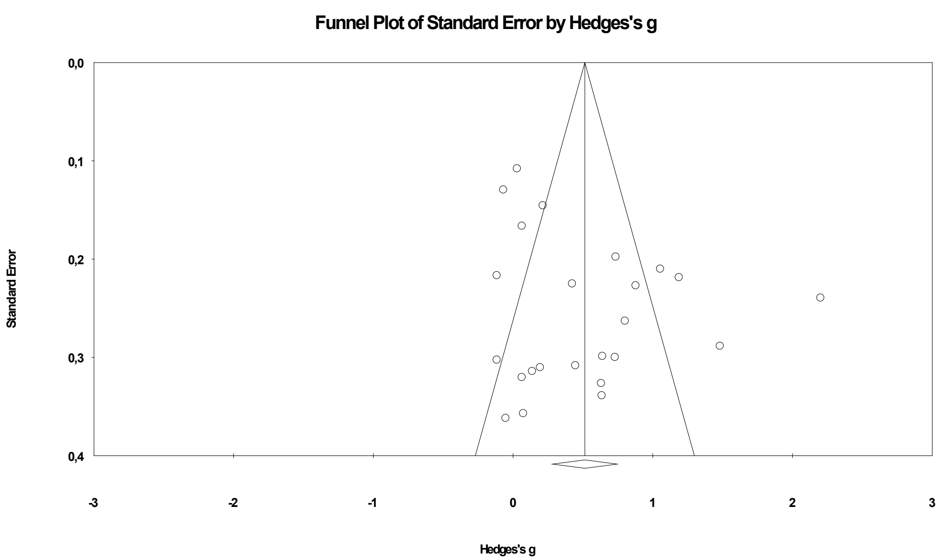

Figure 5.3. Funnel plot of the 24 effect sizes for affective outcomes.

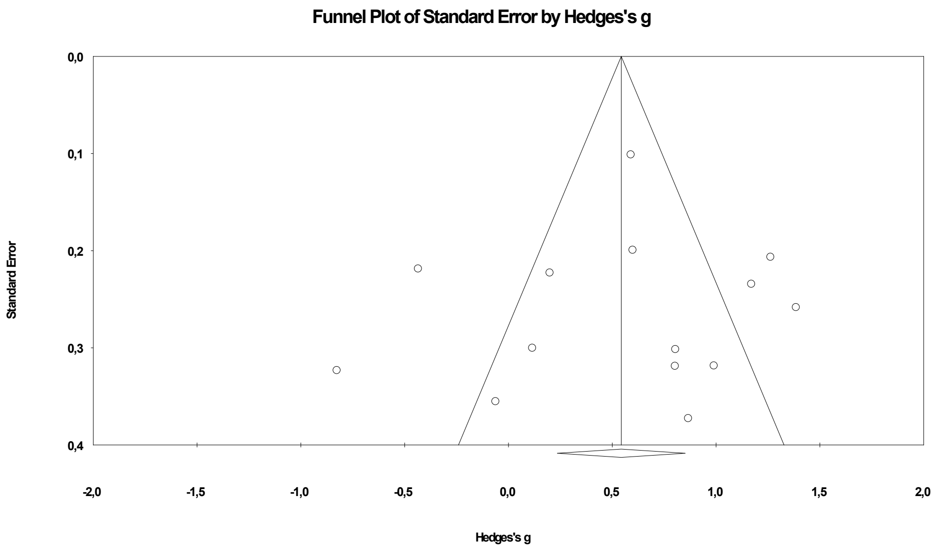

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Figure 5.4. Funnel plot of the 14 effect sizes for behavioral outcomes.

5.3.3 Overall effects of mobile technology usage compared with control groups

The first research question focused on the advantages of using mobile technologies on student learning outcomes correspondingly in comparison to students learning without mobile technologies. We could compare the effects of mobile technologies with control groups on learning outcome in 72 cognitive comparisons from 59 studies, in 24 affective comparisons from 22 studies, and in 14 behavioral comparisons from 13 studies. Within each study set, effect sizes and 95% confidence intervals of each study are presented in Figures 5.5, 5.6 and 5.7.

With regard to the primary outcome variable, the overall effect shows that the use of mobile technologies had a medium positive and significant effect on cognitive learning (g = 0.547, 95% CI [0.392, 0.703]). Similar to the effects on cognitive learning, the combined effect on affective learning was medium (g = 0.514, 95% CI [0.282, 0.745]). For behavioral learning outcomes, a medium positive and significant effect size (g = 0.543, 95% CI [0.235, 0.851]) was also found. Heterogeneity is large (I^2 = 88.694 for the cognitive dimension, I^2 = 84.618 for the affective dimension, I^2 = 83.595 for the behavioral dimension)

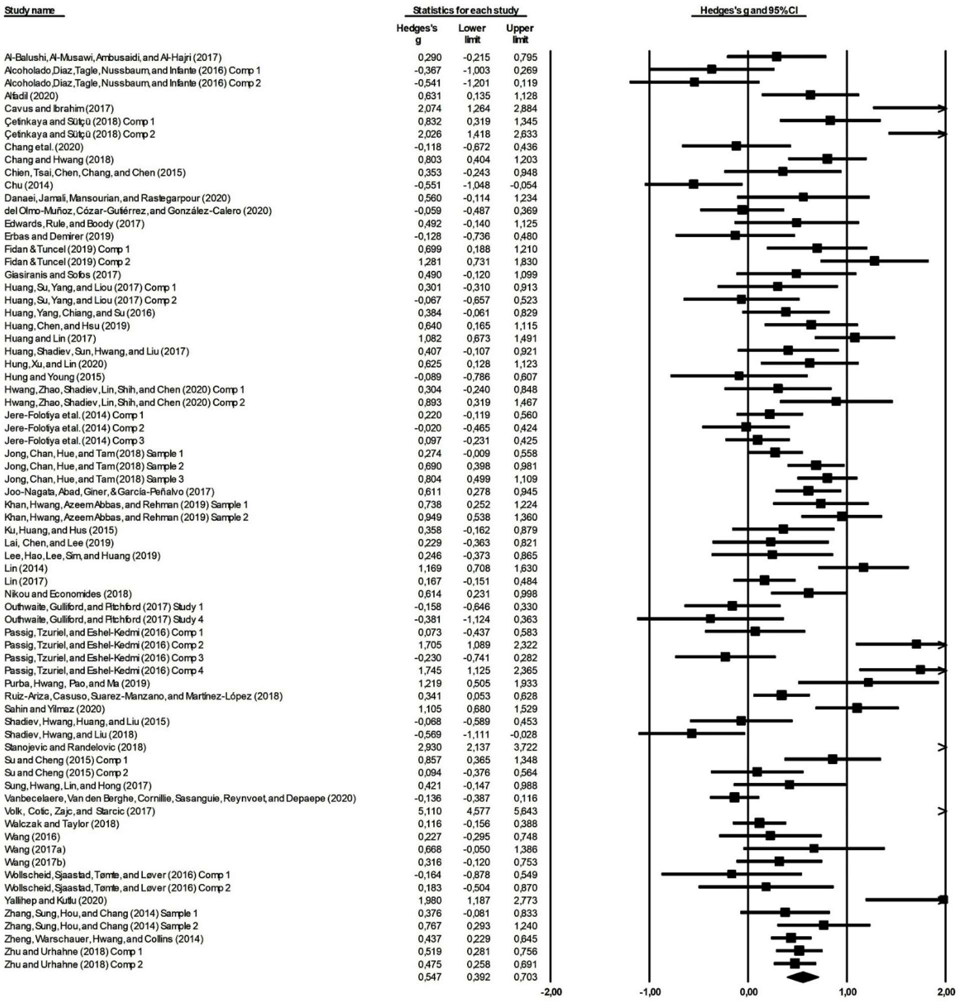

Figure 5.5. Forest plot of the 72 effect sizes for cognitive outcomes. Within one article, when multiple sample or studies were presented, the figure reports the result of each sample (sample 1, sample 2, etc.) or study (study 1, study 2, etc.) separately. Similarly, when studies used multiple comparisons, the figure reports the result of each comparison (comp 1, comp 2, etc.) separately.

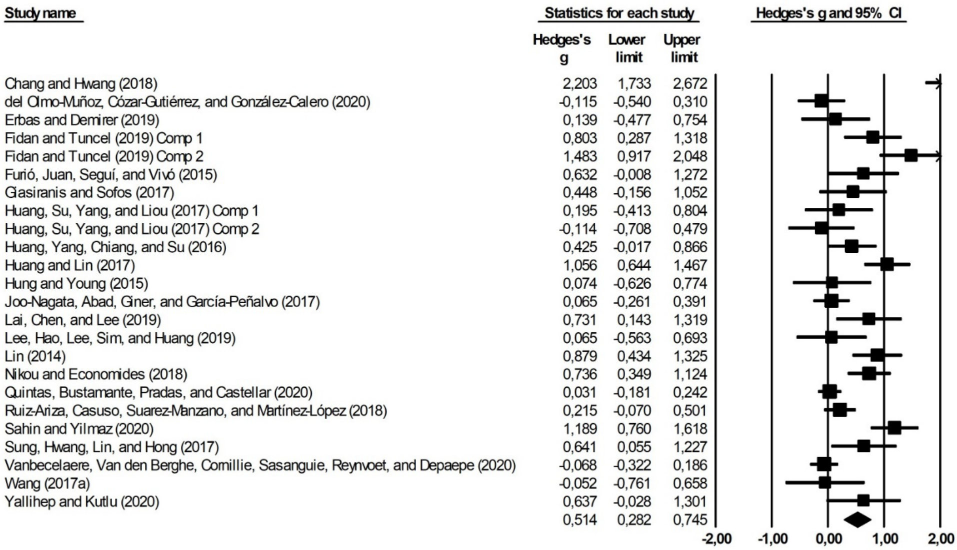

Figure 5.6. Forest plot of the 24 effect sizes for affective outcomes.

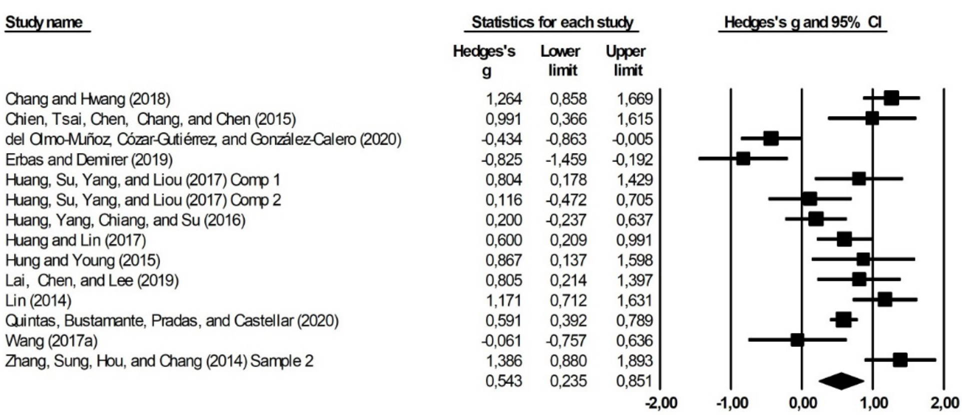

Figure 5.7. Forest plot of the 14 effect sizes for behavioral outcomes.

for the effects on all three learning outcome dimensions and highly significant ($p < 0.001$) in these analyses.

Ten studies were special since they included multiple comparisons. We examined the possible effects of this by conducting analyses with only one effect size (either the largest or the smallest effect size) per study. As Table 5.2 reveals, the resulting effect sizes were roughly the same as in the overall analyses. Heterogeneity test was not significant for cognitive ($I^2 = 9.894$, $p = 0.344$), affective ($I^2 = 0$, $p = 0.826$), and behavioral ($I^2 = 0$, $p = 0.972$) learning outcome, indicating the observed differences might not be important.

5.3.4 Moderator analyses

To answer RQ2 and RQ3, we performed moderator analyses. We calculated effect sizes and 95% CI for each level with at least four studies of all potential moderators. Results for cognitive learning outcomes are presented in Table 5.3, affective and behavioral learning outcome are presented in Table C.1 and Table C.2 respectively in Appendix H, along with all between group heterogeneity tests.

For cognitive learning outcomes, as can be seen in Table 5.3, of all 15 variables tested, 5 moderators were found. We found indications that low SES students had lower ESs than others ($p = 0.001$), that students using handheld device with multiple functions were significantly more effective than using device with one single function ($p = 0.031$), that equivalent learning topic/ content between comparison groups resulted in a higher ESs ($p < 0.001$), that each student having one mobile device was significantly associated with the higher ESs ($p = 0.01$), and that the ESs differed significantly between the two effect size extraction procedures ($p = 0.041$).

In the moderator analyses for affective learning outcomes (see Table H.1 in Appendix H), we only found studies in which the equivalent learning topic/ content resulted in a higher differential effect size than studies in which non-equivalent learning content/ topic were applied ($p = 0.017$). In the series of moderator analyses regarding behavioral learning effects, results in Table H.2 in Appendix H showed that the effects size was only significantly associated with software/ tool equivalence ($p = 0.020$).

Table 5.2. Overall effect sizes of mobile technology usage.

Dependent variable	Effect size and 95% confidence interval				Heterogeneity			
	N	*g*	SE	95% CI	Q(p)	df(Q)	τ^2 (SE)	I^2 (%)
Cognitive learning outcome								
All studies	72	0.547	0.080	[0.392, 0.703]	628.013 (< 0.001)	71	0.386 (0.090)	88.694
Possible outliers removed	53	0.446	0.045	[0.358, 0.533]	107.356 (< 0.001)	52	0.049 (0.020)	51.563
One effect size per study (largest)	59	0.613	0.092	[0.432, 0.794]	570.021 (< 0.001)	58	0.434 (0.110)	89.825
One effect size per study (smallest)	59	0.520	0.090	[0.343,0.697]	548.781 (< 0.001)	58	0.412 (0.105)	89.431
Affective learning outcome								
All studies	24	0.514	0.118	[0.282, 0.745]	149.523 (< 0.001)	23	0.268 (0.113)	84.618
Possible outliers removed	19	0.405	0.089	[0.230, 0.579]	41.112 (0.001)	18	0.079 (0.050)	56.218
One effect size per study (largest)	22	0.527	0.125	[0.282, 0.772]	144.294 (< 0.001)	21	0.277 (0.122)	85.446
One effect size per study (smallest)	22	0.485	0.120	[0.249, 0.721]	134.777 (< 0.001)	21	0.254 (0.112)	84.419
Behavioral learning outcome								
All studies	14	0.543	0.157	[0.235, 0.851]	79.244 (< 0.001)	13	0.274 (0.158)	83.595
Possible outliers removed	10	0.610	0.111	[0.393, 0.827]	18.099 (0.034)	9	0.055(0.056)	50.273
One effect size per study (largest)	13	0.574	0.165	[0.251, 0.897]	76.815 (< 0.001)	12	0.282 (0.167)	84.378
One effect size per study (smallest)	13	0.524	0.166	[0.199, 0.850]	78.713 (< 0.001)	12	0.289 (0.170)	84.755

5.4 Discussion

5.4.1 Overall effects on learning outcomes

We conducted a systematic review with a meta-analysis of experimental and quasi-experimental studies comparing the effects of learning with and without mobile technology. Compared with traditional technology and non-technology groups, mobile technology produced medium positive and statistically significant effects on primary and secondary students' learning in terms of cognitive, affective, and behavioral learning outcomes. The current meta-analysis provides the converging 'best evidence' for the overall beneficial effects of using mobile technology in education.

5.4.2 Moderator variables

The main effects of mobile technology mentioned above are not the same for all student groups and learning contexts. Therefore, moderator analyses have been performed with characteristics of the students and learning contexts as moderators. The results from a series of moderator analyses supported the importance of some variables from three categories, i.e., student factors, learning process, and study quality, that explained differences in learning outcomes between mobile learning and traditional learning. From an educational perspective - as indicated in the 3P model -, effect sizes varied significantly for cognitive learning outcomes according to SES, hardware used, ratio. The mobile technology interventions were more beneficial for students using handheld devices with multiple functions, and using mobile devices on their own, except for students with low socioeconomic status (SES) backgrounds. Moreover, the effect of community type was on the edge of significance for cognitive learning outcomes, $p = 0.055$, favoring urban communities. The effect of teaching method was on the edge of significance for affective learning outcomes, $p = 0.052$, favoring inquiry-oriented learning. Nevertheless, because the number of included studies was small, these effects must be interpreted with caution. Furthermore, the four factors in the teaching context category (education level, school type, learning environment, and school subjects) were not significant moderators for all learning outcomes. From the methodology perspective, the

Table 5.3. Moderator analyses and weighted mean effect sizes for cognitive outcome variables.

Moderator category	Moderator variables	N	*g*	SE	95% CI	Q_B	*p*
Student factor	**Community type**						
	Urban	11	0.647	0.150	[0.352, 0.942]	3.695	0.055
	Not urban	6	0.271	0.125	[0.027, 0.516]		
	SES						
	Low	6	0.031	0.152	[-0.267, 0.329]	10.638	0.001
	Not low	66	0.601	0.086	[0.432, 0.770]		
Teaching context	**Education level**						
	Primary school	41	0.483	0.125	[0.238, 0.728]	0.771	0.380
	Secondary school	31	0.618	0.090	[0.442, 0.794]		
	Learning environment						
	Formal settings	48	0.495	0.114	[0.272, 0.719]	1.656	0.437
	Informal settings	17	0.560	0.066	[0.431, 0.689]		
	Unrestricted	7	0.921	0.312	[0.310, 1.531]		
	School subject						
	Language arts	23	0.466	0.112	[0.247, 0.685]	2.829	0.587
	Social studies	10	0.420	0.120	[0.185, 0.656]		
	Mathematics	14	0.623	0.330	[-0.023, 1.270]		
	Science	19	0.579	0.088	[0.407, 0.752]		
	Professional subjects	4	1.305	0.674	[-0.015, 2.625]		
Learning process	**Hardware used in intervention group**						
	Handheld devices with multiple functions	61	0.582	0.094	[0.399, 0.765]	4.675	0.031
	Handheld devices with one specific function	8	0.247	0.124	[0.005, 0.489]		
	Student-to-hardware ratio						
	Own	43	0.645	0.121	[0.407, 0.883]	6.613	0.010
	Shared	5	0.144	0.152	[-0.154, 0.442]		
	Teaching method						
	Inquiry-oriented learning	22	0.537	0.084	[0.372, 0.701]	0.653	0.884
	Game-based learning	11	0.439	0.136	[0.173, 0.704]		
	Self-directed learning	9	0.655	0.271	[0.125, 1.186]		
	Computer-assisted testing/ assessment	14	0.508	0.173	[0.170, 0.846]		
	Duration of the intervention						
	< 1 day	21	0.475	0.107	[0.264, 0.685]	0.582	0.747
	1 day-4 weeks	23	0.596	0.124	[0.353, 0.839]		
	> 4 weeks	25	0.561	0.173	[0.221, 0.900]		

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Study quality	**Research design**						
	Quasi-experimental	61	0.534	0.087	[0.363, 0.705]	0.161	0.688
	Experimental	11	0.624	0.206	[0.220, 1.027]		
	Instructor equivalence						
	Same	35	0.577	0.118	[0.347, 0.808]	0.032	0.857
	Different	27	0.545	0.136	[0.279, 0.811]		
	Learning topic/ content equivalence						
	Same	57	0.652	0.099	[0.458, 0.846]	14.124	< 0.001
	Different	7	0.188	0.073	[0.045, 0.332]		
	Software/ tool equivalence						
	Same	38	0.603	0.138	[0.333, 0.873]	0.068	0.795
	Different	16	0.551	0.143	[0.272, 0.831]		
	Degree of technology use in the control group						
	Pen-and-paper	47	0.579	0.119	[0.347, 0.812]	0.255	0.614
	Traditional technology	13	0.495	0.118	[0.264, 0.726]		
	Procedure of effect size extraction						
	Calculated from exact descriptive	63	0.580	0.092	[0.399, 0.761]	4.196	0.041
	Calculated from inferential statistics	8	0.321	0.007	[0.152, 0.490]		

results on cognitive learning outcomes identified two moderators (i.e., learning topic/ content equivalence, and procedure of effect size extraction), on affective learning outcomes identified one moderator (i.e., learning topic/ content equivalence), and on behavioral learning outcomes identified one moderator (i.e., tool/ software equivalence).

Although previous research has indicated the influence of socioeconomic status on education equality among children (Li & Ranieri, 2013), previous meta-analyses of mobile technology interventions (see e.g., Tingir et al., 2017) failed to examine this moderator effect due to lacking relevant information. The finding that students with low SES benefited less than their peers is of particular importance in understanding the new digital divide and offering a valuable direction to explore differences amongst subgroups such as ethnicity, migration status, and community types. Furthermore, in line with previous meta-analysis (Sung et al., 2016), handheld devices with multiple functions often induced better cognitive learning outcomes. Handheld devices with diverse functions such as instant-feedback, speech recognition, and peer-assessment enrich learning opportunities and meet students' demands, prompting higher learning achievement. Besides, in contrast to the assumption of Haßler, Major, and Hennessy (2016), the current meta-analysis proved the higher learning gains in a student-device ratio of one-to-one environment than the shared-device learning environment. A possible explanation is that individual student mobile device supported student-centered and individualized learning (Zheng et al., 2016) and enabled teachers or computer systems to provide immediate feedback to individual students (Castillo-Manzano et al., 2016). No significant effects were found in variables in the teaching context category. An important implication of these findings is that mobile technology interventions can have an equally powerful effect on students' learning across teaching contexts. With regard to the research methodology category, the finding that instructor equivalence was not found to be a significant moderator is in accordance with previous meta-analysis on college students' learning outcomes in technology-enabled active learning environments (Shi, Yang, MacLeod, Zhang, & Yang, 2020). The influence of other features of the study quality, such as learning topic/ content equivalence, tool/ software equivalence, and procedure of effect size extraction, have not been investigated as potential moderators in past meta-analyses. However, in this study, these features served as a significant moderator variable for at least one learning outcome dimension. In sum, this calls for future research to consider the features of study quality to explore whether the moderator effects exist and might contribute to the observed differences.

5.4.3 Limitations and future research

Many studies were not included in this meta-analysis because the necessary information was not reported. Out of 235 potentially relevant journal articles found in the databases and journal websites, only 61 studies could finally be used for the analyses. Studies were excluded not only because they lacked statistical data but also because of other missing information that is important for meta-analyses. As stated by Sung, Li, Yang, and Chang (2019), mobile-learning research has suffered from methodological shortcomings that might hinder the ability of mobile-learning research to obtain reliable evidence for sustaining innovative practices and creating valid theories. To this end, Sung, Li, Yang, and Chang (2019) suggest mobile-learning researchers should utilize valid designs for their research tools, procedures, and statistical methods and focus on presenting their research results more clearly by applying the checklist for the Rigor of Education-Experiment Designs (CREED). Owing to the limited number of empirical mobile-learning studies, the quality of experimental research was not used as a criterion for the inclusion or exclusion of research samples, except that these studies were peer-reviewed; instead features of study quality were analyzed as potential moderators. Furthermore, we had few studies examining differential effects on affective and behavioral learning outcomes. We recommend that outcomes beyond cognitive learning outcomes are given more attention in research designs to fully explore the complex array of student outcomes in a learning situation. Other factors, such as training of teachers and students on technology/ content, software used, and school type, could provide more practical and theoretical insights into the effects of using mobile technologies on school students' learning. These variables were not included in the moderator analyses of the present study due to low variability in categories or missing information in the studies. Lastly, because all included studies were written in English, we suggest that future meta-analyses could consider adding more articles written in different languages to yield more robust findings than using an English single language.

5.4.4 Implications for policymakers and practitioners

The findings above may provide insight into the optimal arrangement of mobile learning regarding the presage (e.g., SES), process (e.g., student-to-hardware ratio, hardware used), study quality (e.g., learning content/ topic equivalence, software/ tool equivalence), and product (e.g., cognitive, affective and behavioral learning) variables, which are the central concerns of mobile learning policymakers, practitioners, and parents.

First, the study is timely given the current debates by policymakers and politicians, about the use of mobile devices in schooling. There is a focus in the media and much professional commentary on the adverse effects of school-aged students' use of mobile devices, including health problems like eyesight (China), potentially ethical issues (Indonesia), cyber-safety (Japan), classroom management concerns (Malaysia), and technology addiction (South Korea) (Churchill, Pegrum, & Churchill, 2018). The current meta-analysis provides a clear indication for policymakers on the effectiveness of mobile technology usage and evidence-based guidance on the use of mobile devices in schooling that provides a counterpoint to some of the current concerns. For example, some people believed that the use of mobile devices is not good for students' eyes, but in fact, the individual device helps students with poor eyesight see the learning content more clearly compared with look up at the backboards or whiteboards, especially those sitting in the back rows in a large classroom. For children, a mobile device is fast becoming a must-have not a nice-to-have, and it extends learning time and space (Norris & Soloway, 2015) and may sometimes serve as an unavoidable alternative for online learning (Dhawan, 2020). We recognize that hardware alone does not fulfill its potential in education and change teaching and learning fundamentally. However, different from traditional classroom learning and supported by mobile technologies' innovative features and their educational affordances, student-centered and active learning will become the new norm in tomorrow's education systems. More importantly, while the academic success of students historically determines the quality of school learning, the quality of the "learning process" has increased in importance and extends the understanding of learning outcomes (OECD, 2019). Therefore, policymakers who hesitate to scale up the use of mobile devices in education are encouraged to take actions either for improving educational quality or for bridging the digital divide. And before approving all actions under a given policy, there is an urgent need to articulate strategic intentions supplemented by established decision-making mechanisms and support.

Second, educational practitioners and parents may need to be convinced of the value of mobile learning to better prepare and support student learning. Long-term educational technology integration with appropriate supporting logistics may increase teachers' readiness to use digital technology (Christensen & Knezek, 2017) and the level of commitment to integrating their teaching with the students' learning (Khlaif, 2018). For example, if there is a lack of targeted teacher training in the preparation stage, and insufficient technical and pedagogical support during the phases of implementation, teachers might not be able to provide innovative teaching methods, and they might even reduce the time available for students to use mobile devices. Moreover, these conditions should include removing the negative effects, such as distraction, increased cognitive load, and mobile phone addiction. One way to solve these problems is to strengthen learners' self-regulation skills, as they are especially important for informal learning like homework performance (Nikou & Economides, 2018). Besides, the role of parents is important, as researchers pointed out that students' view of parental support is not only related to their learning motivation but also to their actual behaviors in self-regulating their learning (Sha, Looi, Chen, Seow, & Wong, 2012).

5.4.5 Conclusions

As interest in the tendencies of mobile learning and the affordances of mobile technologies, it is not only crucial of reimagining teaching and learning with mobile technology in primary and secondary education, but also valuable of reassessing the effectiveness of mobile technology usage on different learning outcomes as well as how to use mobile technologies for learning effectively, enjoyably, and engagingly. This study using the best evidence from experimental or quasi-experimental studies aimed to answer whether school students learn better with mobile technology and which factors explain the differences in results. Results of our meta-analyses of 72 cognitive comparisons from 59 studies, 24 affective comparisons from 22 studies, and 14 behavioral comparisons from 13 studies, indicated that mobile technology usage was positively and significantly associated with cognitive, affective, and behavioral learning outcomes. From both educational and methodological perspectives, the impacts of mobile technology usage were moderated by multiple factors, especially the student factors, learning process, and study quality factors. In the near future, researchers need to optimize the quality of experimental studies, and educational stakeholders need to take responsibility and get ready to adopt and support mobile technology usage in educational practices.

Teacher beliefs, classroom process quality, and student engagement in the smart classroom learning environment: A multilevel analysis

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This chapter was submitted in an adapted form as:

Wang, J., Tigelaar, D. E., & Admiraal, W. Teacher beliefs, classroom process quality, and student engagement in the smart classroom learning environment: A multilevel analysis.

Abstract

A smart classroom learning environment enables learners to learn better and faster. Although the number of studies focusing on the impact of learning environments on student engagement is increasing, still limited empirical knowledge is available about how secondary school students' engagement can be enhanced in a smart classroom learning environment. Also, more studies are needed that include both pedagogical and technological perspectives. In this study, by using teacher and student questionnaires, the relationship among teacher beliefs, classroom process quality, and student engagement in smart classrooms in secondary schools was investigated. Three components of classroom process quality were distinguished: cognitive activation, connectedness, and the use of technology. Results from a multilevel regression analysis revealed that at the classroom level, students' shared perceptions of connectedness and the use of technology, teachers' degree, and teaching year were linked to student engagement. At the student level, students' individual perceptions of all three domains of classroom process quality and students' gender were related to their engagement. Multilevel mediation analysis results showed that students' shared perceptions of connectedness and the use of technology mediated the relationships between teachers' degree level and student engagement. Remarkably, the relationships between teacher beliefs and students' shared perceptions of classroom process quality were nonsignificant. However, classroom process quality could be explained by teacher background characteristics, such as teacher degree, teacher gender, and teaching grade. Theoretical and practical implications are discussed, and suggestions for future research are given.

Keywords

Improving classroom teaching; Pedagogical issues; Mobile learning; Media in education; Secondary education

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6.1 Introduction

Engaging students is seen as crucial for student learning in various environmental settings, educational stages, and school subjects (e.g., Bergdahl, Nouri, Fors, & Knutsson, 2020; Lazarides & Buchholz, 2019; Raes et al., 2020). Student engagement, i.e., students' involvement in their own learning activities, can be regarded as a product of individual and class influences. Student engagement is known to be fostered in classroom learning environments with supportive teachers and peers, and challenging goals and authentic tasks (Fredricks, Blumenfeld, & Paris, 2004; Shernoff et al., 2016). Recently, emerging enhanced technologies, such as cloud computing, learning analytics, and wearable technology, have transformed traditional classroom learning environments to smart classroom learning environments (SCLEs) that are more effective, efficient, and engaging (Spector, 2014) when it comes to supporting instructors and to stimulating better and faster student learning (Koper, 2014). In many countries, governmental programs have been implemented for the development of SCLEs, such as in Turkey (FATİH project), Poland (Digital School), Australia (The Smart Classrooms), South Korea (SMART education), and Thailand (One Tablet per Child project). The accessibility of digital devices and educational resources has been the starting point of these ICT initiatives aimed at encouraging technology-based teaching and learning. Overall, the effects of these projects provide preliminary support that technology-based environments do have an influence on student engagement (Schindler, Burkholder, Morad, & Marsh, 2017). However, additional research is needed with regards to how technological factors interact with instructional factors that together may influence student engagement (Chang et al., 2015; MacLeod, Yang, Zhu, & Li, 2018) and the setting of the current SCLEs as the SCLEs goes beyond the simple use of technology (Kinshuk, Chen, Cheng, & Chew, 2016). While technology has changed how students can be supported in the learning environment, the principles of effective instruction have not changed (Price, 2015). Therefore, determining how to best develop an engaging smart classroom learning environment is an essential issue for research on educational technology, pedagogical instruction, and student learning today.

Maintaining students engaged especially in technology-based learning environments, however, seems challenging due to in-class distractions that occur routinely and disengagement leads to poor academic performance and spending more time for non-school related activities (Bergdahl et al., 2020). Moreover, mobile technologies increase the complexity of the student learning experiences, and there are situations in which students face more challenges. For example, issues of low engagement often arise within secondary schools (Krauss, Kornbluh, & Zeldin, 2017) since the students face self-regulatory challenges (Brooks & Weaver, 2019), which threats the preparation for university education (Van Rooij, Jansen, & Van de Grift, 2017). Furthermore, Asian systems are usually hierarchical in nature, which means that teachers tend to be strict, and teaching practices tend to be teacher-centered (Chand, Deshmukh, & Shukla, 2020). Due to a lack of student autonomy and a tendency to discourage independence of thought, students in Asian countries have been found to suffer from a low-level of engagement (Tan, 2017). Increasing interactivity and engagement among students is vital, given that smart classrooms are prevalent in secondary schools and new conditions for engagement emerge (Bergdahl et al., 2020). Hence, for secondary students' learning, especially for those in an Asian hierarchical system, the quality of smart classroom learning environments is highly significant for student engagement.

With regards to positively affecting student engagement, investigating classroom process quality, and in particular, the interactional patterns between teachers and students (Fauth, Atlay, Dumont, & Decristan, 2021), is considered important because these patterns have been found to influence students' learning outcomes (e.g., Lazarides & Buchholz, 2019; Olivier, Galand, Morin, & Hospel, 2021; Shernoff et al., 2016). The core mechanism behind classroom process quality that is widely acknowledged is instructional quality, which is involving three global dimensions (i.e., cognitive activation, supportive climate, and classroom management; Klieme, Pauli, & Reusser, 2009). Undoubtedly, a teacher's contribution to creating a supportive climate in smart classrooms is essential, but whether teachers really are engaged with creating such a climate and how they attempt to do so is known to be dependent on their beliefs (Chand et al., 2020). Recent evidence supports the idea that teacher beliefs (e.g., about their self-efficacy) are related to students' perceptions of the three dimensions of instructional quality (Burić & Kim, 2020), which in turn influence student engagement and learning. Although both pedagogical and technological factors are crucial contributing to student engagement, research findings on the relationship between the use of technology and student learning in the specific context of SCLEs have been inconsistent (see e.g., Becker, Klein, Gößling, & Kuhn, 2020; Thomas, Parsons, & Whitcombe, 2019). Furthermore, despite evidence showing that teacher beliefs are expected to be more indirectly related to student engagement in the classroom in general (Burić & Kim, 2020), it can be assumed that classroom process quality can function as a connection between teacher beliefs to student engagement in SCLEs remains to be studied.

By now, empirical studies investigating whether teacher beliefs on SCLEs, instructional quality, and the use of technology in SCLEs contribute to student engagement in the SCLEs is rare. Moreover, research has not identified which aspects of classroom process quality matter the most, especially not in situations where Asian secondary students experience more potential challenges when learning in the SCLEs than their peers. Therefore, the current study is aimed at empirically examining the underlying relationships between teacher beliefs toward SCLEs, classroom process quality (i.e., instructional quality and the use of technology), and engagement of students nested in smart classrooms by incorporating secondary school teachers' and students' viewpoints. The findings can add to the existing knowledge of underlying mechanisms of learning that can be facilitated by teachers' instructional quality combined with the use of technology, and provide valuable evidence for the design and implementation of smart classrooms.

6.2 Background

6.2.1 Classroom process quality in the smart classroom learning environment

Research has identified key aspects of good teaching practices that emphasize on the classroom process quality. One of the most cited international theoretical models is the model of basic (deep structure) dimensions of instructional quality (Klieme et al., 2009). Three global dimensions (i.e., cognitive activation, supportive climate, and classroom management) have been identified in secondary education studies (e.g., Atlay, Tieben, Hillmert, & Fauth, 2019). These three deep structure level dimensions were hypothesized to influence students' learning outcomes. According to Klieme et al. (2019), cognitive activation refers to promoting students' conceptual understanding through appropriate instructional strategies like providing students challenging tasks or opportunities to discuss ideas with classmates within the learning environment. A supportive classroom climate requires positive social interactions in classrooms characterized by caring teacher behavior and constructive feedback. Classroom management is not only coping with disruptive behavior, but also requires teachers to stay focused and provide clear and consistent rules and procedures in terms of content and social norms. Previous research has mainly focused on broad dimensions of teaching quality in secondary education; however, student learning is known to be improved more by integrating particular educational strategies (e.g., the use of technology in the classroom) with global factors of instructional quality (Decristan et al., 2015). Therefore, Lazarides and Buchholz (2019) suggest identifying specific educational strategies related to creating supportive, well-structured, and activating learning environments.

Smart classrooms, as one of the student-centered learning environments permitting the co-learning procedure through enhanced technology, have recently attracted attention in academia (Jou & Wang, 2019). A typical smart classroom is equipped with technologies such as, wireless Internet, interactive whiteboard and projectors for the whole class, and mobile devices for the teacher and individual student use, cameras to record and store lectures, sensors and acoustics to control the physical environment, and educational management and assessment tools (Saini & Goel, 2019). MacLeod et al. (2018) have summarized and validated the most relevant features of SCLEs: Student Negotiation, Inquiry Learning, Reflective Thinking, Ease of Use, Perceived Usefulness, Multiple Sources, Connectedness, and Functional Design. In smart classrooms, students use technologies for active learning in the first place, rather than merely reacting to learning activities as a given. The extent to which and how technologies are integrated in learning activities need further investigation, although it is already known that students learn more when digital technologies are used in combination with other teaching methods rather than as substitutes (Hillmayr, Ziernwald, Reinhold, Hofer, & Reiss, 2020). Since the use of technology is important for understanding the classroom process quality, in the present study, we adopt the use of technology together with the three global dimensions that represent the classroom process quality.

6.2.2 Connections between teacher beliefs of and classroom process quality in the smart classroom learning environment

Teacher beliefs are the sum of their judgments and evaluations about school-, teaching-, learning- and students-related matters, as well as about matters beyond their profession (Pajares, 1992). Although researchers have argued that teacher beliefs are likely to compatible with their teaching behavior (Bandura, 1986; Eisenhart, Shrum, Harding, & Cuthbert, 1988), the available research has shown that relations between different teacher beliefs (e.g., teaching-specific or general beliefs) and their instructional practices are mixed. For example, secondary school teachers' self-reported beliefs in their teaching capabilities are linked with student-reported classroom management, cognitive activation, and supportive climate (Burić & Kim, 2020). In contrast, Fauth et al. (2019) found nonsignificant relations between teachers' constructivist beliefs and their teaching quality in science education. In another study, constructivist beliefs of secondary school teachers were negatively associated with classroom management (Kunter et al., 2013).

Besides the fact that the success of innovations in teaching with technology are heavily depended on the teachers who perceive and interpret classroom events, researchers have underlined that empirical evidence on the relationship between teachers' technology adoption and their constructivist beliefs about teaching with technologies is ambiguous (Chand et al., 2020). For instance, in the Spanish context, secondary school teachers with constructivist and learner-centered beliefs were more likely to use technology (Gil-Flores, Rodríguez-Santero, & Torres-Gordillo, 2017). In another study, Han, Byun, and Shin

(2018) found that although South Korean teachers having similar constructivist beliefs with teachers in the United States, they were unable to transform their beliefs into technology-enhanced teaching practices. Mills, Jass Ketelhut, and Gong (2019) reported that the belief of a science teacher was changed after a three-year inquiry-based technology program; however, his classroom practice remained didactic and teacher-centered. Therefore, a better understanding of the relations between teacher beliefs and classroom process quality is necessary to ensure the SCLEs is not hindered.

6.2.3 Classroom process quality and student engagement in smart classroom learning environment

Engagement typically includes behavioral, emotional, and cognitive dimensions (Archambault & Dupéré, 2017). Student engagement represents a central issue for teachers and students because it encompasses many different aspects of the teaching and learning process. Researchers generally emphasize the directional flow that the quality of environmental challenges and support has on students' subsequent engagement during learning activities (Shernoff et al., 2016; Xu, Chen, & Chen, 2020). For instance, despite the influence of individual student perceptions of SCLEs on learning, Decristan et al. (2015) found that students' cognitive engagement outcome (i.e., conceptual understanding) were also affected by the aggregated student ratings of cognitive activation, supportive climate, and classroom management. Concerning emotional engagement, research has shown that cognitive activation, teacher support, and classroom management can have an impact on various types of student emotions (e.g., interest, enjoyment, bored, and anxiety), but these effects vary at the student or classroom level (see e.g., Fauth, Decristan, Rieser, Klieme, & Büttner, 2014; Lazarides & Buchholz, 2019). Besides, teacher emotionally-supportive has been linked with students' behavioral engagement. (Ruzek et al., 2016).

However, student engagement in SCLEs manifests differently than engagement in traditional classrooms, and in previous research on teaching quality it has been ignored how technologies shape engagement. Still, Schindler et al.'s (2017) review does provide preliminary support that technology-based environments have an influence on student engagement. Recent research on secondary school students' classroom learning processes and learning outcomes has shown that using mobile devices can support a reduction of cognitive load and increase conceptual understanding and thus can improve performance more than teacher behavior (Becker et al., 2020). Hammer, Göllner, Scheiter, Fauth, and Stürmer (2021) therefore argue that using tablets is more appealing to students than instruction without technology, making learning activities more interesting and meaningful with integrated tablets. Yang, Yu, Gong, and Chen (2017) conducted experimental research to compare primary students' perceptions about both the traditional and smart classroom learning environment and found that compared with traditional multimedia classroom students perceptions of both instructional quality and the use of technology scored significantly higher, and also, students were more engaged with individual learning and collaborative learning in the SCLEs. However, a recent study (Thomas et al., 2019) investigating university students' perceived learning in SCLEs indicated that social support significantly affected learning, but the use of technology did not. Thus, which aspect of classroom process quality matters most has remained unclear, especially in the context of SCLEs in secondary education.

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6.2.4 Classroom process quality as a mediator

Despite the commonly accepted direct relationships between teacher beliefs and student engagement in technology-rich classrooms (Gebre, Saroyan, & Bracewell, 2014), the relationship found is not stable based on studies analyzing the responses of both teachers and students and recognizing the multilevel nature of such data (see e.g., Burić & Kim, 2020). Especially, the effect of teacher beliefs faded out when interpersonal teacher behavior was included (Van Uden, Ritzen, & Pieters, 2014). According to the model of teaching quality (Fauth et al., 2020), three dimensions of instructional quality can function as a bridge between teacher characteristics (e.g., teacher beliefs) and student outcomes (e.g., student engagement). In terms of this suggested cross-level meditation, scientific evidence is minimal. To our knowledge, Fauth et al. (2019) alone have reported that the three basic dimensions of instructional quality mediate the relations between teacher beliefs (i.e., teaching enthusiasm and pedagogical content knowledge) and student interest. Furthermore, the lack of research on the mediation role of technology makes it difficult to determine whether students see differences in benefits derived from instructional quality and the use of technology. Thus, further elucidation of the mediation role of classroom process quality (i.e., cognitive activation, supportive climate, classroom management, and the use of technology) between teacher beliefs and student engagement in SCLEs is warranted.

6.2.5 The present study

Given that teachers' self-reports of their teaching practices are subject to various biases, including social desirability (Retelsdorf, Butler, Streblow, & Schiefele, 2010), Fraser (1998) suggests that students' perceptions of their classroom learning environment matter for learning. Although research has shown that even the ratings reported by primary school students can be regarded a reliable, valid, and stable indicator of classroom process quality (Fauth et al., 2014; Fauth et al., 2020), additional examination of the perspective of teachers may yield a more comprehensive view of the predictors and the outcomes of classroom process quality (Burić & Kim, 2020; Decristan et al., 2015). Given this importance, studying how teachers think of SCLEs and how students perceive their learning processes in SCLEs can further clarify what may impact their engagement, which in turn can help researchers and practitioners to maximize the effectiveness of SCLEs by identifying critical aspects that students in specific settings most prefer (e.g., Chang et al., 2015).

Theoretically speaking, classroom process quality refers to classroom-level variables. This means that aggregating student ratings can indicate the general classroom process quality at the classroom level. Nevertheless, both differences within and between classrooms can bring valuable insights into how learners view their learning environments (Göllner, Wagner, Eccles, & Trautwein, 2018). Moreover, the preferences of the analysis level depend on the research questions investigated (Marsh et al., 2012). Previous results provide strong empirical support that student ratings of instructional quality can be seen as construct-specific responses consisting of shared perceptions at the classroom level and individual perceptions at the student level (Fauth et al., 2014; Wagner, Göllner, Helmke, Trautwein, & Luedtke, 2013). Until now, in the context of the SCLEs, research that simultaneously investigates the effects of classroom process quality at both the student and classroom level is scant.

Upon reviewing relevant literature, this study aims to fulfill the gaps in earlier studies by examining the relationships among teacher beliefs, classroom process quality, and student engagement in secondary school smart classrooms. Also, given the potential role of teacher and student background characteristics on student engagement (Olivier et al., 2021; Xu et al., 2020; Winkler, Söllner, & Leimeister, 2021), we included several relevant characteristics as covariates. We attempt to address the following research questions specifically (see Figure 6.1):

RQ1. At the classroom level, which variables (i.e., teacher beliefs, teacher background variables) explain differences between students' shared perceptions of classroom process quality in SCLEs?

RQ2. At the classroom level (i.e., teacher beliefs, teacher background variables) and student level (i.e., students' shared and individual perceptions

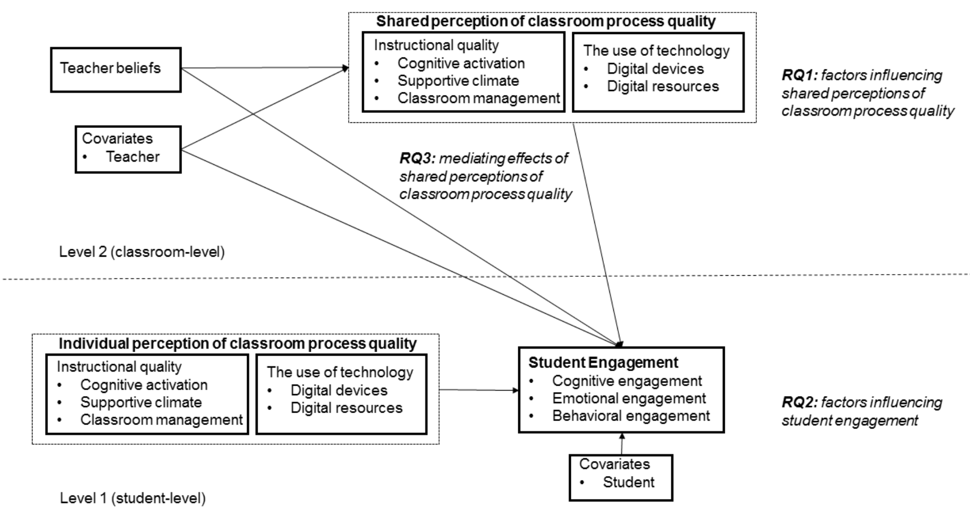

Figure 6.1. The proposed research model.

of classroom process quality, student demographic variables), which variables explain differences between student engagement in SCLEs?

RQ3. Is there an indirect effect of teacher beliefs, and teacher background variables on student engagement in SCLEs through students' shared perceptions of classroom process quality?

6.3 Methods

6.3.1 Research context

Given the potential impact of smart classrooms on the traditional teaching structure, China has made efforts to facilitate smart classrooms. The Chinese central government calls teachers to move beyond traditional teaching and embrace innovative pedagogical approaches with technologies (MOE, 2018). In order to respond to the national call and promote the smart classrooms, many local governments have issued their action plans. However, except some economically developed areas where schools have been provided with student personal tablet PCs and interactive desks (Li, Kong, & Chen, 2015), other local governments typically only provide the infrastructure and equipment for classrooms, and it is not possible to equip each student with a mobile device. Under this circumstance, when students hope to study in smart classrooms, their parents need to buy them mobile devices.

In the current study, three areas (i.e., Chongqing, Suining, and Guangyuan) in China were selected where efforts from the local governments, companies, schools, and parents have resulted in the implementation of smart classrooms. Smart classrooms in secondary schools were selected where each student owns a mobile device (here: tablets with multiple functions; mobile phones are not allowed in most Chinese secondary schools), and the internet speed is sufficient for effective teaching and learning. All teachers and students participating in the study have had at least some experience with smart classrooms. Although we intend to include all secondary education grades (i.e., grades 7 to 12), the teachers and students participating in this study were all from the lower level of secondary education (i.e., grades 7 to 9) due to the high pressure during the final three years for Gaokao (national exams).

6.3.2 Participants and procedures

The participants were teachers and their students in smart classrooms. We developed two digital questionnaires; the student questionnaire was developed to measure classroom process quality and student engagement, and the teacher questionnaire was developed to measure teacher beliefs. We also collected their background information through the respective questionnaire.

We collected data by sending a hyperlink via WeChat to teachers from first author's network and participation was voluntary. To be able to link the teacher questionnaire to the student questionnaire, we administered a teacher questionnaire and a student questionnaire in each class. Each set of links was sent directly to teachers and then indirectly through teachers to their students. As we were interested in teachers' general beliefs toward SCLE and students' perceptions of the actual learning processes in SCLEs, students were requested to complete the questionnaire after the class; teachers completed their questionnaire in their free time. The final sample included 1825 students and their 38 teachers. In each class, the number of participating students varied between 16 and 85 ($M = 48.026$, $SD = 16.511$) and only three classes had less than 30 participants. This sample size satisfies the 30/30 rule which means a sample of at least 30 groups with at least 30 individuals in each group, and this could be sufficient for the estimation of the regression coefficient (Kreft, 1996). The data collection period lasted from October 12th to December 17th, 2020. Table 6.1 shows the demographic information of the students and teachers.

6.3.3 Measures

Since most instruments are in English, the original items were first translated into Chinese by a Chinese researcher, and then were translated back to English by another bilingual researcher. All items for each measure have been included in the Appendix I.

6.3.3.1 Teacher beliefs

Teacher beliefs of smart classroom learning environment were evaluated with the adaption of the Chinese version of Preference Instrument of Smart

Table 6.1. Demographic information of the students and teachers.

Variables	Category	Frequency	Percent
Student information			
Student age	12	516	28.3
	13	820	44.9
	14	421	23.1
	15	65	3.6
	16	3	0.2
Student gender	Female	935	51.2
	Male	890	48.8
Teacher information			
Teacher age	<26	0	0
	26-30	0	0
	31-35	7	18.4
	36-40	13	34.2
	41-45	4	10.5
	46-50	13	34.2
	51-55	1	2.6
	>55	0	0
Teacher gender	Female	23	60.5
	Male	15	39.5
Teacher degree	Secondary Vocational School Education	0	0
	Three-year college Education	2	5.3
	Bachelor	35	92.1
	Master	1	2.6
Teaching years in SCLEs	<1	11	28.9
	1-2	14	36.8
	3-4	11	28.9
	4-5	2	5.3
	>5	0	0
Teaching grade in SCLEs	7	15	39.5
	8	16	42.1
	9	7	18.4

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Classroom Learning Environments (PI-SCLE) (MacLeod et al., 2018). The scale includes eight measures, i.e., Student Negotiation (SN, 5-items), Inquiry Learning (IL, 5-items), Reflective Thinking (RT, 5-items), Ease of Use (EU, 5-items), Perceived Usefulness (PU, 5-items), Multiple Sources (MS, 5-items), Connectedness (CN, 5-items), Functional Design (FD, 5-items). Because the original version of the PI-SCLE was evaluated from the students' perspective, the subject of some items was changed from "I" to "students". After this process, SN3 was deleted from the original questionnaire because SN3 was the same as SN2. Teachers responded to the 39 items scaled from 1 (strongly disagree) to 5 (strongly agree).

6.3.3.2 Classroom process quality: Instructional quality

Instructional quality was assessed using the measures of cognitive activation (CA) and connectedness (CN) from PI-SCLE (MacLeod et al., 2018), and classroom management (CM) from the Teaching Quality Scales (Fauth et al., 2014). CA consists of three dimensions: Student Negotation (SN), Inquiry Learning (IL), and Reflective Thinking (RT). All items were rated on a 5-point scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

6.3.3.3 Classroom process quality: The use of technology

In addition, we investigated the use of technology in SCLEs for assessing classroom process quality. This scale consists of two dimensions: the use of digital devices (DD) and the use of digital resources (DR). The instrument assesses the frequency that the use of technology during one lesson taught in the smart classroom. The two items of the use of digital devices were self-developed, while the seven items of the use of digital resources were adapted from Teachers' Use of Digital Educational Resources (Wang, Tigelaar, & Admiraal, 2019). These items were scored on a 5-point scale, ranging from 1 (never) to 5 (very much).

6.3.3.4 Student engagement

Student engagement was assessed by applying an adaptation of the scale of Student Engagement (Jang, Kim, & Reeve, 2012; Reeve & Tseng, 2011). This scale evaluates student behavioral engagement (BE), cognitive engagement (CE), and emotional engagement (EE). The 10 items were included with a 5-point scale, scoring from 1 (strongly disagree) to 5 (strongly agree).

6.3.3.5 Covariates

Except for the teacher beliefs toward SCLEs, the teacher questionnaire included the background information of the teachers, i.e., age, gender, degree, years of teaching in smart classrooms, and the current teaching grade in the smart classroom. Students also provided their demographic information (i.e., age and gender) in the student questionnaire. The gender of teachers and students was dummy coded (0 = female, 1 = male).

6.3.4 Data analyses

We performed five steps for data analyses. First, to examine the underlying structure of instructional quality, the use of technology, and student engagement, exploratory factor analyses (EFA) were performed using SPSS 25. After Principal Component Analysis with Oblimin rotation on 24 items of SN, IL and RT, CN, and CM, three variables were extracted: CA, CN, and CM. Similarly, 9 items of the use of digital devices and digital resources were entered into an EFA, yielding one variable: TECH; 10 items of CE, EE, and BE were entered into an EFA, yielding one factor: ENGAGE.

Second, a series of single-level Confirmatory factor analysis (CFA) were conducted for CA, CN, CM, TECH, and ENGAGE. However, the results of discriminant validity did not support the four-factor structure of classroom process quality and there is a high correlation between CA and CM. Therefore, we decided to delete CM from the model (Cohen, Cohen, West, & Aiken, 2003). The results showed acceptable convergent validity and internal reliability of all measurement models.

Third, because factors of classroom process quality observed by students were also conceptualized at the classroom level, student-level scores are aggregated to create a classroom-level score for CA, CN, and TECH. A multilevel confirmatory factor analysis (MCFA) was performed to validate each measure.

Table 6.2 presents the fit indices, which are considered acceptable (Hu & Bentler, 1999). We also examine aggregation for variables at the classroom level by using the intra-class correlation coefficients (ICCs). We computed ICC(1) to compare the variance between classes with the variance within classes using the individual responses and ICC(2) to assess the reliability of the classroom-level means as aggregated from the student level measures (Lüdtke, Marsh, Robitzsch, & Trautwein, 2011). For CA, CN, TECH, the ICC(1) was 0.078, 0.094, 0.113, and the ICC(2) was 0.802, 0.791, 0.859, respectively, suggesting sufficient between-class variation and good reliability of class-mean ratings (LeBreton & Senter, 2008).

Table 6.2. Fit indices and inter-class correlation coefficients (ICCs).

	Acceptable values	Model values			
		CA	CN	TECH	ENGAGE
Fit index					
χ^2		12.871	0.111	10.624	15.001
df		4	0	10	10
RMSEA	≤ 0.08	0.035	0.000	0.006	0.017
CFI	≤ 0.9	0.995	1.000	1.000	0.998
TLI	≤ 0.9	0.985	1.000	0.999	0.997
$SRMR_W$	≤ 0.08	0.008	0.000	0.008	0.008
$SRMR_B$	≤ 0.08	0.015	0.002	0.039	0.033
ICCs					
ICC(1)	≥ 0.05	0.078	0.094	0.113	0.070
ICC(2)	≥ 0.7	0.802	0.791	0.859	0.783

Fourth, to answer RQ1 and RQ2, we employed multilevel regression analysis to build a multilevel-level model. Given the sample's stratified nature, students were nested within class. All multilevel analyses were conducted using M*plus* 8 software (Muthén & Muthén, 1998-2017) using the robust maximum likelihood estimation. All of the student-level variables were centered around the group mean and the aggregated ratings of classroom process quality were centered at the grand mean. There were three different models for the data analysis. In the first stage, we conducted an unconditional, two-level regression analysis: students at Level 1, classroom at Level 2. The preliminary results show that between-class variance (ICC) for student engagement is 0.065, which is greater than the suggested value of 0.059 (Cohen, 1988), and it means that multilevel modeling is appropriate for examining the data. Next, a conditional model with covariates at both levels was conducted. Student-level covariates contained students' age and gender, and classroom-level covariates included teachers' gender, age, degree, teaching years, and grade in smart classrooms. Third, the full model with variables and covariates at both levels was conducted. Except for the covariates at both levels, student-level variables contained students' individual perceptions of CA_S, CN_S, TECH_S, and classroom-level variables contained teacher ratings of teacher beliefs and the average of students' perceptions of CA_C, CN_C, TECH_C. We compared different models using the Akaike Information Criterion (AIC), and Bayes Information Criterion (BIC), for which lower values indicate better model fit (Raftery, 1993). We also used the Wald χ^2 test used to look for significant *p*-values indicating a model fit the data better.

Finally, to answer RQ3, we performed the multilevel mediation analysis. As shown in Figure 6.1, the two-level regression model was performed for a 2-2-1 mediation design. Here we regarded teacher beliefs, teacher background variables as the independent variable, students' shared perceptions of classroom process quality (i.e., CA_C, CN_C, TECH_C) as mediators, student engagement as the dependent variable. We used the *model indirect* command implemented in M*plus* to test the indirect effects controlling for student covariates.

6.4 Results

6.4.1 Predicting students' shared perceptions of classroom process quality

The descriptive statistics and correlations of variables at the student and classroom levels are reported in Tables 6.3 and 6.4. The values of Cronbach's *α* are given on the diagonal in bold. The student results in Table 6.3 show that the lowest level for students' individual perceptions of classroom process quality with regard to TECH_S (M = 3.80, SD =0.816). Students reported experiencing more CN_S (M = 4.674, SD = 0.589) than CA_S (M = 4.430, SD = 0.711). The class results in Table 6.4 show that teachers most often tend to moderately agree with the statements about SCLEs (M = 3.994, SD = 0.578). CN_C had the highest agree rating from the class (M = 4.644, SD = 0.184) and TECH_C had the lowest agree rating from the class (M = 3.790, SD = 0.290). The three classroom process quality domains were not significantly associated with teacher beliefs.

A summary of the results from the multilevel mediation models is given in Table 6.5. Regarding RQ1, teacher beliefs was not significantly related to all domains of students' shared perceptions of classroom process quality (CA_C: B = -0.018, β = -0.048, p = 0.782; CN_C: B = -0.002, β = -0.007, p = 0.969; and TECH_C: B = -0.032, β = -0.063, p = 0.697). In terms of covariates, male teachers showed significantly lower CA_C (B = -0.156, β = -0.344, p = 0.017), and teachers with higher degrees was associated with significantly higher CA_C (B = 0.321, β = 0.405, $p < 0.001$), CN_C (B = 0.160, β = 0.244, p = 0.001) and TECH_C (B = 0.393, β = 0.379, $p < 0.001$). Teachers teaching in higher grades performed higher TECH_C (B = 0.123, β = 0.311, p = 0.017) than teachers teaching lower grades.

6.4.2 Predicting student engagement in SCLEs

Regarding RQ2, we tested whether teacher beliefs, students' shared and individual perceptions of classroom process quality and covariates at both levels are related to student engagement. The results in Table 6.5 showed that Model 0 predicting students' engagement yielded an ICC of 0.065, indicating that the student-level variance accounted for 93.5% of the total variance in the outcome variable, whereas 6.5% of the total variance was at the classroom level. Compared to Model 0, the residual variance of Model 1 (ICC = 0.065) was reduced. The proportion of variance explained by covariates was 0.33% ((0.307-0.306)/0.307 = 0.0033) at the student level and 38.10% ((0.021-0.013)/0.021 = 0.3810) at the classroom level. At the student level, boys reported a significantly higher engagement than girls (B = 0.057, β = 0.051, p = 0.033). At the classroom level, male teachers were negatively associated with student engagement (B = -0.124, β = -0.417, p = 0.015) and teachers with higher degrees were positively associated with student engagement (B = 0.264, β = 0.508, $p < 0.001$).

Table 6.3. Means, standard deviations, and correlations of variables at student level.

Variable	M	SD	1	2	3	4	5
1. CA_S	4.430	0.711	**0.903**				
2. CN_S	4.674	0.589	0.683***	**0.892**			
3. TECH_S	3.830	0.816	0.519***	0.359***	**0.840**		
4. ENGAGE	4.580	0.567	0.686***	0.670***	0.415**	**0.877**	
5. Student age	2.024	0.819	-0.051	-0.072	0.119**	-0.023	
6. Student gender	0.488	0.500	0.021	0.000	0.073**	0.055*	0.038*

Note. (a) CA_S = students' individual perceptions of cognitive activation, CN_S = students' individual perceptions of connectedness, TECH_S = students' individual perceptions of the use of technology; (b) $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$; (c) student gender was coded as 1 = female, 2 = male.

Table 6.4. Means, standard deviations, and correlations of variables at classroom level.

Variable	M	SD	1	2	3	4	5	6	7	8
1. Teacher beliefs	3.994	0.578	**0.973**							
2. CA_C	4.390	0.221	-0.161							
3. CN_C	4.644	0.184	-0.166	0.857***						
4. TECH_C	3.790	0.290	-0.071	0.653**	0.363*					
5. Teacher age	4.684	1.195	0.102	0.075	-0.055	-0.053				
6. Teacher gender	1.605	0.489	-0.171	0.251	0.197	0.277*	-0.259			
7. Teacher degree	2.974	0.279	-0.182	0.368*	0.281**	0.229	-0.182	-0.076		
8. Teaching year	2.105	0.882	0.344*	-0.098	-0.255	0.305**	-0.168	0.096	0.524***	
9. Teaching grade	1.789	0.731	0.067	-0.188**	-0.263*	0.313**	-0.167	0.136	-0.284	-0.095

Note. (a) CA_C = students' shared perceptions of cognitive activation, CN_C = students' shared perceptions of connectedness, TECH_C = students' shared perceptions of the use of technology; (b) $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$; (c) teacher gender was coded as 1 = female, 2 = male.

Table 6.5. Multilevel analysis: Relations among teacher beliefs, classroom process quality, and student engagement.

	Mediators: Students' shared perceptions of classroom process quality			Outcome: ENGAGE		
	CA_C	CN_C	TECH_C	Model 0	Model 1	Model 2
Intercept	4.451***(0.039)	4.681***(0.033)	3.856***(0.051)	4.556***(0.273)	4.578***(0.035)	4.546***(0.013)
Level 1 (student-level) variables						
Student age					0.025(0.031)	0.031(0.022)
Student gender					0.057* (0.027)	0.043*(0.018)
CA_S						0.313***(0.028)
CN_S						0.362***(0.037)
TECH_S						0.047**(0.014)
Level 2 (classroom-level) variables						
Teacher beliefs	-0.018 (0.066)	-0.002(0.054)	-0.032(0.081)			0 (0.014)
CA_C						-0.003(0.101)
CN_C						0.693***(0.086)
TECH_C						0.141*(0.069)
Teacher age	0.043(0.027)	0.000(0.022)	0.044(0.034)		0.015(0.019)	0.012(0.008)
Teacher gender	-0.156*(0.065)	-0.094(0.058)	-0.166(0.089)		-0.124* (0.051)	-0.043(0.023)
Teacher degree	0.321***(0.091)	0.160**(0.050)	0.393***(0.080)		0.264***(0.037)	0.102***(0.024)
Teaching year	0.001(0.048)	-0.038(0.048)	0.067(0.051)		0.015(0.035)	0.033*(0.013)
Teaching grade	-0.024(0.046)	-0.032(0.042)	0.123*(0.052)		-0.024(0.035)	-0.018(0.021)
Random effects						
Level 1 residual				0.307***(0.103)	0.306***(0.023)	0.145***(0.011)
Level 2 residual	0.036***(0.007)	0.027***(0.007)	0.057***(0.013)	0.021**(0.006)	0.013**(0.004)	0(0.001)
R^2 level 1					0.003	0.522
R^2 level 2	0.275	0.200	0.319		0.397	0.997
Model fit (-2LL)				3076.967	3056.918	1652.968
Wald χ^2					135.383 ($p < 0.001$)	1102.143 ($p < 0.001$)
AIC				3082.967	3076.918	1686.969
BIC				3099.496	3131.651	1780.627
Reference					Model 0	Model 1

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For the full model (Table 6.5, Model 2, ICC = 0.080), CA_S (B = 0.313, β = 0.384, p < 0.001), CN_S (B = 0.362, β = 0.370, p < 0.001) and TECH_S (B = 0. 047, β = 0. 065, p = 0.001) were all significantly and positively related to student engagement, after all covariates at both levels were controlled for. In terms of classroom level, students' shared perceptions of CN_C (B = 0.693, β = 0.782, p < 0.001) and TECH_C (B = 0.141, β = 0.250, p = 0.252) was significantly and positively related to student engagement, but teacher beliefs and CA_C were not. Compared to Model 1, adding teacher beliefs and students' shared perceptions of CA_C, CN_C, TECH_C, and students' individual perceptions of CA_S, CN_S, and TECH_S as predictors of student engagement reduced the between-class variance by 61.9%% ((0.013–0)/0.021 = 0.619).

We also assessed the improvement of each model over the preceding one (from the intercept-only model to the models with the predictor variables). As shown in Table 6.5, our results provide evidence that the full model fit the data better.

6.4.3 Mediated relations

Table 6.6 shows the indirect effects. The results indicated that only the indirect effect of teachers' degree level on students' engagement through CN_C (B = 0.111, p = 0.003), and the indirect effect of degree level on students engagement through TECH_C (B= 0.055, p = 0.043) were statistically significant. The results did not support the mediation relationships between teacher beliefs and ENGAGE via students' shared perceptions of CA_C (B= 0.000, p = 0.982), CN_C (B = -0.001, p = 0.969), and TECH_C (B = -0.004, p = 0.712).

Table 6.6. Indirect effect results.

Mediation path	*B*	*SE*	95% CI for indirect effect	
(IV → MV→ DV)			Lower limit	Upper limit
Teacher beliefs → CA_C → ENGAGE	0.000	0.002	-0.003	0.003
Teacher age → CA_C → ENGAGE	0.000	0.004	-0.008	0.008
Teacher gender → CA_C → ENGAGE	0.000	0.015	-0.028	0.029
Teacher degree → CA_C → ENGAGE	-0.000	0.030	-0.060	0.059
Teaching year → CA_C → ENGAGE	0.000	0.000	0.000	0.000
Teaching grade → CA_C → ENGAGE	0.000	0.002	-0.004	0.005
Teacher beliefs → CN_C → ENGAGE	-0.001	0.037	-0.074	0.071
Teacher age → CN_C → ENGAGE	0.000	0.015	-0.029	0.030
Teacher gender → CN_C → ENGAGE	-0.065	0.041	-0.145	0.015
Teacher degree → CN_C → ENGAGE	0.111**	0.037	0.038	0.184
Teaching year → CN_C → ENGAGE	-0.027	0.034	-0.092	0.039
Teaching grade → CN_C → ENGAGE	-0.022	0.029	-0.080	0.035
Teacher beliefs → TECH_C → ENGAGE	-0.004	0.012	-0.028	0.019
Teacher age → TECH _C → ENGAGE	0.006	0.006	-0.006	0.018
Teacher gender → TECH _C → ENGAGE	-0.023	0.015	-0.052	0.006
Teacher degree → TECH _C → ENGAGE	0.055*	0.027	0.002	0.109
Teaching year → TECH _C → ENGAGE	0.009	0.009	-0.007	0.026
Teaching grade → TECH _C → ENGAGE	0.017	0.011	-0.004	0.038

Note. B indicates the strength of the indirect effect.

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6.5 Discussion

In the present study, we examined the relationships among teacher beliefs, classroom process quality, and student engagement across the student and class levels in the smart classrooms in secondary education. This research offers a significant understanding of classroom process quality within SCLEs by arguing that both the global factors of instructional quality (i.e., cognitive activation and connectedness) and specific teaching practices (i.e., the use of technology) have the potential to create activating, supportive, and efficient learning environments, resulting in a high level of students' perceived engagement.

Unexpectedly, teacher beliefs had no effects on classroom process quality, but teacher degree exhibited significant positive effects on all three dimensions (i.e., cognitive activation, connectedness, and the use of technology). Moreover, the classes taught by male teachers scored lower on cognitive activation, and teachers teaching in higher grades contributed to the use of technology more often in smart classrooms. Additionally, both teacher (i.e., teacher degree and teaching year) and student (i.e., gender) characteristics were related to student engagement. Another unexpected result was that boys reported a significantly higher engagement than girls did in this Chinese secondary school context. This result differs from Archambault and Dupéré's (2017) finding that schoolboys were more likely to show more disruptive behavior and to be less engaged in the literacy domain as perceived by teachers. One possible explanation for this finding may be that boys perceived more social support from teachers and peers (Lietaert, Roorda, Laevers, Verschueren, & De Fraine, 2015), thus having more opportunities to be (especially behaviorally and emotionally) engaged in technology-supported learning activities.

To better clarify the relationships proposed by this study, below we discuss the main findings and their theoretical and practical implications in details. First, with regard to RQ1, we found that teacher beliefs were neither related to cognitive activation, connectedness, nor the use of technology in the specific context of SCLEs in secondary education. The result is in agreement with the recent findings showing that simply having certain beliefs about teaching and learning could not guarantee high instructional quality (Fauth et al., 2019), and perceived usefulness about the use of technology does not predict any technology integration practice in classrooms (Cheng, Lu, Xie, & Vongkulluksn, 2020; Mills et al., 2019). It is suggested that teachers' pedagogical beliefs have to be aligned with their competences to integrate ICT into education more effectively (Aslan & Zhu, 2017). Therefore, our findings extend previous research on the relationships between teacher beliefs and classroom process quality (see e.g., Backfisch, Lachner, Stürmer, & Scheiter, 2021). Furthermore, teacher degree was found to be positively related to three aspects of classroom process quality. Owning a higher academic degree may imply that teachers have more opportunities to specialize in a subject area and thus gain more knowledge regarding teaching. The finding extends previous research that improving teacher quality can increase teaching quality (Fauth et al., 2019).

Secondly, concerning RQ2, classroom process quality and covariates were found to be related to student engagement. We conclude that students' interactions with teachers, peers, and technologies can improve their learning experiences and engagement: both shared and individual perceptions of connectedness and the use of technology were related to student engagement with connectedness at both levels as the strongest predictor of student engagement. This finding is in line with the results of Manwaring, Larsen, Graham, Henrie, and Halverson (2017), who found that in blended learning environments in higher education classes student-perceived learning activities had a stronger influence on engagement than individual student characteristics. The climate effects of connectedness and the use of technology at the classroom level suggest that establishing supportive relationships and equipping technologies for the whole class are important for teachers to consider in the design of smart classrooms. However, secondary students' perceptions of cognitive activation at the classroom level were not related to their individual engagement. This result is consistent with Fauth et al. (2019), who showed that elementary school students' interest was not predicted by cognitive activation observed by external raters. Atlay et al. (2019) further stated that the non-association between cognitive activation at the classroom level and learning achievement could be explained by the low ICC(1) value of cognitive activation, which may lead to relatively low reliability of this measure, and this explanation holds true for the present study.

Finally, regarding RQ3, the mediation results reveal that teachers with higher degrees contributed to higher student engagement because they facilitated a higher level of connectedness and the use of technology. Fauth et al. (2020) have argued that teaching quality is theoretically assumed to connect teacher and student characteristics and student outcomes. A previous study proved the mediating role of teaching quality between teacher beliefs and student performance (Fauth et al., 2019). Yet, the current study did not find such effects due to low correlations between teacher beliefs and all factors of classroom process quality. The results have significant theoretical implications that the potential of teacher degree that representing teachers' specialist knowledge need to be considered when examining the mediating role of teaching quality.

6.6 Limitations and future directions

Several limitations need to be addressed. The first limitation relates to the possible biased sample of our study. Even though the sample of the current study meets the basic requirement for multilevel analysis, it could be the case that our findings only emerged as the voluntary classes with special characteristics were obtained. Therefore, it would be valuable to replicate our study with a more diverse sample size (especially larger class size), and within other specific social and cultural contexts. Second, surveys may be the most effective but not the only means for understanding student engagement (Henrie, Halverson, & Graham, 2015). In particular, in the present study classroom management was only examined based on students' perceptions. Classroom management could also be obtained through either interviews with teachers or observations in the smart classrooms. In doing so, further research could gain more insights into teachers' reasoning on how they behave in the classroom and how technologies are used, thereby obtaining a more comprehensive picture of the diverse conditions for improving classroom process quality and gaining more valid results for teaching quality at the classroom level. Lastly, although a few demographic variables of the sample have been investigated in this study, the consideration of other student and teacher characteristics would provide further insights about what should be considered at a pilot phase of developing smart classrooms to maximize the efficiency of unique smart classroom hardware and software. For example, it would be interesting to examine whether SCLEs differentially benefit certain types of students (e.g., from rural schools and urban schools), and whether and to what extent this new condition for learning closes the educational gap between student groups in terms of their engagement.

6.7 Conclusions

We have explored cross-level mediation relationships among teacher beliefs, classroom process quality, and student engagement. First, teacher beliefs were not related to cognitive activation, connectedness, and the use of technology, but other teacher characteristics had significant effects on at least one aspect of classroom process quality. Second, in addition to the critical role of student and teacher characteristics, students' perceptions of connectedness and the use of technology at both the individual and classroom levels positively influenced student engagement while only individual perceptions of cognitive activation explained differences in student engagement. Third, connectedness and the use of technology at the classroom level mediated the relationship between teacher degree and student engagement.

Findings have implications for advancing our knowledge of the design and implementation of smart classrooms. Despite the popularity of the smart classroom in secondary education, understanding how it can be used to promote student engagement is still evolving. Although much research exists on teaching quality in education in general, few studies have combined the specific teaching practice with global factors of classroom process quality in the context of SCLEs. This study provides empirical evidence regarding what pedagogical and technological factors are likely to affect student engagement and offers insights regarding which dimensions of classroom process quality deserve closer attention for enhancing student engagement. Drawn from the finding, we argue that researchers should consider student perspectives to examine classroom practices. In addition, it is essential to improve teachers' specialist knowledge before enacting the technology-integrated lessons in smart classrooms.

This research offers several practical implications to establish conditions that foster an engaging smart classroom learning environment. We argue that the critical role of teacher degrees, which may reflect teachers' quality, to improve all aspects of the classroom process quality has been underestimated for a long time. For policymakers, paying more attention to teacher competence seems to be an effective way to promote student learning (Fauth et al., 2019). As we found several teacher characteristics were important for classroom process quality, these specific characteristics offers valuable starting points for selecting the right group of teachers to participate in the smart classrooms in the early phase of implementing smart classrooms. Especially, given the critical role of teacher degree, teacher education and professional development seem to be good levers to bring change to scale. Additionally, the learning environments including high levels of cognitive activation, connectedness and the use of technology support student engagement best. To improve student engagement, teachers should use technology to provide integrated learning experiences, and create incentives, such as real-time feedback systems, reward systems, or game-based systems, for students to engage them in active learning.

General discussion

7

7.1 Introduction

This dissertation is intended to contribute to theoretical and practical knowledge of technology integration in education by several different stakeholders, in different technological practices, and different contexts. The focus is on the pedagogical use of technology for teaching and learning in primary and secondary education. Five studies were performed on: (1) an overview of the link between local information and communications technology (ICT) policy plans and the ICT practices of rural schools (Chapter 2); (2) rural teachers' use of digital educational resources aimed at promoting digital equity and education for all (Chapter 3); (3) rural teachers' sharing of digital educational resources aimed at promoting teacher professional learning opportunities and development (Chapter 4); (4) (a meta-analysis on) the effectiveness of various mobile technology usage on cognitive, affective, and behavioral learning outcomes in primary and secondary education (Chapter 5); (5) the relationships among teacher beliefs, classroom process quality, and student engagement in smart classroom learning environments in secondary education (Chapter 6). It is important to understand technology integration in education from multiple perspectives, using multilevel models, and in different contexts, because this practice has long been regarded as complex and multifaceted (Mumtaz, 2000; Scherer, Siddiq, & Tondeur, 2019) and successful technology integration is known to be influenced by various factors which can change over time (Backfisch, Lachner, Stürmer, & Scheiter, 2021). Also, the evaluation of the effectiveness of technology integration is vital to offer insights regarding which factors deserve closer attention for achieving long-term sustainability and scalability in technical innovation and integration (Niederhauser et al., 2018). All empirical studies in this dissertation have been carried out in a primary or secondary school context, involving two different contexts (i.e., rural and urban schools) in Western China. In this final chapter first each study's main findings are summarized, followed by a discussion of the findings, strengths and reflections of the studies, suggestions for further research, and practical implications for policymakers, teacher education and continuing training, school leaders and teachers.

7.2 Summary of the main findings

In **Chapter 2,** a mixed-method research approach was applied involving 25 rural schools in three regions in Western China. The study aimed to contribute to insights into whether and how local ICT policy plans are linked with the ICT practices of rural schools. In particular, the study is aimed at examining the content of local ICT policy plans that have been developed and to investigate how school leaders and teachers perceive their experience with ICT practices by using the Four in Balance (FIB) model (Kennisnet, 2013) as a framework. Data was collected from multiple sources (policy documents, interviews with school leaders, focus groups with teachers, classroom observations, an ICT inventory, and a teacher survey). Overall, this study revealed three types of challenges for ICT integration in rural schools: (1) guidance and learning opportunities as a political challenge, (2) ICT infrastructure and digital content as a technical challenge, and (3) teacher training and technical support as a human challenge. With regards to the findings, in specific, all elements in the FIB model were identified in the local ICT policy plans, but the vision of local ICT policy plans was not shared by all school leaders and teachers. Moreover, although all participating schools had access to basic infrastructures and digital content, access to sufficient computers and updated equipment appears to be a new technical challenge when it comes to addressing the urban-rural gap, involving that the lack of contextual digital content needs to be addressed in further studies. In addition, the results in Chapter 2 show that the majority of teachers had positive attitudes toward ICT use and that teachers gained basic ICT skills from continuous training programs but teachers used ICT in teacher-centered ways. Another important challenge found in this study was that the majority of schools revealed to be poor supportive school environment for ICT integration and therefore recruitment or the appointment of professional and technical staff for rural schools is needed. It is important to stress that the schools that were most successful in integrating innovative ICT were those pilot schools that had the most materials (e.g., proposals for applying pilot schools and annual reporting materials) and shared a vision regarding the innovative use of ICT, and that used 1:1 mobile technology (e.g., clickers, tablets) in the classroom. Based on the findings, it is recommended to enable teachers who do not work in pilot schools, to be successful in ICT integration in rural schools, a collaboration based on teachers' needs and their geographical settings may be a practical approach to explore.

In **Chapter 3**, we aim to understand what digital educational resources (DERs) are actually being used by teachers and to elucidate the degree to which certain teacher- and school-level factors explain rural school teachers' use of DERs. A questionnaire was developed to gather information about teachers' use of DERs, and school- and teacher-level factors that might influence this. The Integrative Model of Behavior Prediction (IMBP; Fishbein & Ajzen, 2011) was applied as a framework on teacher-level factors that explain teachers' DERs usage in rural schools, including attitude, self-efficacy, subjective norm, behavioral intention, knowledge and skills, and facilitating conditions. The school-level factors considered in this study were school location and school type. Multilevel analyses were employed to build a two-level model: teachers at Level 1, schools at Level 2. A total of 462 teachers from 25 primary and secondary schools in rural areas completed the questionnaire. The research questions were: (1) What types of digital educational resources do rural teachers use for their teaching? (2) Which school-level variables explain differences between rural teachers in their use of digital educational resources in teaching? and (3) Which teacher-level variables explain differences between rural teachers in their use of digital educational resources in teaching? The descriptive statistics indicate that although a diversity of DERs were being used, the general view of the use of DERs in Chinese rural schools was quite traditional. Traditional DERs, such as electronic lesson plans/ instruction design, and multimedia courseware, were being used frequently, but the more recent and innovative resources, such as micro-teaching videos, subject-specific software, and tools seemed under-utilized. Although the results support the use of multilevel analyses to verify the influence of school-level characteristics on teachers' DERs usage in the Chinese context, the findings also indicate that rural school teachers' use of DERs should be considered as a teacher-level phenomenon, since only 12.5% of the variance in rural school teachers' use of DERs was attributed between schools. In particular, at the school level, the remoteness of a rural school appeared not to be not significantly related to teachers' use of DERs, and the impact of primary and secondary schools on teachers' use of DERs was not significant. With regard to IMBP-core variables, we only found teachers' perceptions of attitude, knowledge and skills, and facilitating conditions to be significantly related to the use of DERs. Among these, attitude was the variable that most strongly explained the use of DERs. In addition, teachers' age and teaching year with DERs were related to the use of DERs. However, results did not support the crucial role of self-efficacy, subjective norm, and intention to use for explaining differences in DERs use. This means that for explaining DERs use in Chinese rural schools, teacher characteristics are more significant factors than school characteristics. These findings indicate that the use of DERs might increase when teacher characteristics are taken into account. Therefore, future research should predominantly focus on other teacher variables affecting their use of DERs, such as motivation for technology and constructivist beliefs about teaching and learning.

Having explored the factors influencing teachers' use of DERs, we were also curious about which factors were affecting their sharing behavior regarding DERs. **Chapter 4** is focused on investigating: How is motivation related to sharing behavior regarding digital educational resources within and outside school? In this study, we studied individuals' underlying motivations and two types of sharing contexts: sharing with colleagues at their school (within school sharing) and sharing with others through the Internet (outside school sharing). To answer the main research question, the following sub-questions were formulated: RQ1 (a-e). Is motivation related to each of the dispositional variables (a) self-efficacy, (b) attitudes, and (c) subjective norm, (d) sharing intention within school, and (e) sharing behavior within school?; RQ2 (a-e). Is motivation related to each of the dispositional variables (a) self-efficacy, (b) attitudes, and (c) subjective norm, (d) sharing intention, and (e) sharing behavior outside school? Moreover, since more research on the link between intention and behavior is needed, the relationships between sharing intention and sharing behavior were examined, together with environmental variables. For this the following research questions were formulated: RQ3 (a-c). Is (a) sharing intention, (b) sharing climate, and (c) work pressure related to sharing behavior within school?; RQ4 (a-c). Is (a) sharing intention, (b) sharing climate, and (c) work pressure related to sharing behavior outside school?; RQ5. Is there an indirect effect of the motivation on the sharing intention within school through the dispositional variables?; RQ6. Is there an indirect effect of the motivation on the sharing intention outside school through the dispositional variables?

Self-reported questionnaires from 709 rural teachers were collected and analyzed employing the Structural Equation Modeling. Like the study in Chapter 3, the questionnaire for teacher factors was based on the IMBP but the list of determinants was extended with motivation, since the literature indicates that teachers' sharing behavior cannot be fully understood without taking individuals' underlying motivation into consideration (Leonard, Beauvais, & Scholl, 1999). Different factors were found to be related to rural teachers' sharing behavior in the two contexts. Firstly, among the motivational factors, in this study it was found that both internal motivation and external motivation significantly influenced attitudes, as well as sharing behavior within or outside school. However, internal motivation positively influenced whereas external motivation negatively influenced both attitude and sharing behavior. Secondly, intention and sharing climate only had a positive relationship with sharing behavior outside school. Moreover, and unexpected, work pressure did not significantly influence sharing behavior in both contexts. Finally, attitudes mediated the relationships of internal motivation and external motivation with sharing intention within school, and self-efficacy mediated the relationship between internal motivation and sharing intention outside school. This research highlights important reasons why teachers in rural school contexts share (because of internal motivation) or do not share DERs (because of external motivation) as well as identifies two mediators (i.e., self-efficacy and attitudes) to improve DERs sharing. The findings indicate that the higher the internal motivation from rural teachers is and the higher their level of self-efficacy, the more they contribute their DERs. However, it is important to emphasize that the role of variables in the research model might vary from context to context.

Comparing these insights to distinguished contexts in future research may contribute to the sharing of DERs in rural schools and to making DERs more contextualized and to enhancing new ways of teaching and learning.

Having identified the key factors that influence teachers' pedagogical practices with technology, we moved forward to find out what mobile technology integration might look like and how to influence student learning in primary and secondary education. To quantify the overall effects of mobile technology usage on cognitive and noncognitive learning outcomes and close the research gap related to primary and secondary student learning, in **Chapter 5,** we employed a meta-analysis to compare mobile learning effects with traditional learning in primary and secondary education. By using the best evidence from experimental or quasi-experimental studies, this study was aimed at investigating whether school students learn better with mobile technology and which factors explain the differences in results. The results from the meta-analysis show that compared with traditional technology and non-technology groups, mobile technology has produced medium positive and statistically significant effects on primary and secondary students' learning in terms of cognitive, affective, and behavioral learning outcomes. The meta-analysis in chapter 5 is aimed at providing the converging 'best evidence' for the overall beneficial effects of using mobile technology in education. The main effects of mobile technology mentioned above appeared not to be the same for all student groups and learning contexts. Therefore, in this study, moderator analyses were performed with student factors, teaching context, learning process, and study quality as moderators. The results from a series of moderator analyses supported the importance of variables from three categories, i.e., student factors, learning process, and study quality, that explained differences in learning outcomes between mobile learning and traditional learning. The results on cognitive learning outcomes identified two moderators (i.e., learning topic/ content equivalence, and procedure of effect size extraction), on affective learning outcomes identified one moderator (i.e., learning topic/ content equivalence), and on behavioral learning outcomes identified one moderator (i.e., tool/ software equivalence). Furthermore, the effect sizes varied significantly for cognitive learning outcomes according to

SES, hardware used, ratio. The mobile technology interventions were more beneficial for students using handheld devices with multiple functions, and using mobile devices on their own, except for students with low socioeconomic status (SES) backgrounds. Because few studies examined differential effects on affective and behavioral learning outcomes, we suggest that in order to fully evaluate the diverse dimensions of student outcomes, study designs should pay closer attention to non-cognitive outcomes.

Based on the results from Chapter 5, we purposefully selected the research context and participants in the study reported in **Chapter 6**. That is smart classrooms in secondary schools in urban areas where each student owns a tablet with multiple functions were selected. Also, we recognize that hardware alone does not fulfill its potential in education and change teaching and learning fundamentally; classroom process quality, which includes global factors of instructional quality (i.e., cognitive activation, supportive climate, and classroom management) and specific teaching practices (i.e., the use of technology), has increased in importance and extends the understanding of learning outcomes. Therefore, the study reported in Chapter 6 aims to fulfill the gaps in earlier studies by examining the relationships among teacher beliefs, classroom process quality, and student engagement in secondary school smart classrooms. Unexpectedly, teacher beliefs appeared to have no effects on classroom process quality, but teacher degree exhibited significant positive effects on all three dimensions (i.e., cognitive activation, connectedness, and the use of technology). Moreover, the classes taught by male teachers scored lower on cognitive activation, and teachers teaching in higher grades appeared to contribute to the use of technology more often in smart classrooms. Additionally, classroom process quality and covariates were found to be related to student engagement. The results indicate that both shared and individual perceptions of connectedness and the use of technology are related to student engagement with connectedness at both levels as the strongest predictor of student engagement. However, secondary students' perceptions of cognitive activation at the classroom level were not related to their individual engagement. Furthermore, teacher degree and teaching year were related to student engagement. Another unexpected result was that boys reported a significantly higher engagement than girls did in this Chinese secondary school context. Finally, the mediation results reveal that teachers with higher degrees contributed to higher student engagement because they facilitated a higher level of connectedness and the use of technology. Drawing on the findings, we argue that researchers should consider student perspectives to examine classroom practices. The learning environment including high levels of cognitive activation, connectedness, and the use of technology supports student engagement best. In addition, it is essential to improve teachers' specialist knowledge before enacting the technology-integrated lessons in smart classrooms.

7.3 Enhancing teacher practices and student outcomes

With the rapid development of technology in recent decades, it has been widely recognized that teachers should integrate technology into their educational practices adequately and sufficiently. Since recognizing the potential benefits of this practice and obstacles before and during the implementation, large-scale initiatives were invested and implemented to facilitate technology access and use. These interventions, however, appear to be mostly ineffective; teachers still tend to be reluctant to use technology in their teaching (Schulte, 2015; Van Acker, Van Buuren, Kreijns, & Vermeulen, 2013). Even in some situations where teachers adopt technology, these technologies were simply used as substitutes to replace the existing teaching and learning methods (Lan, Tsai, Yang, & Hung, 2012). As a result, the substitution-level of use was not positivity correlated with higher learning outcomes and students do not profit enough for learning in technology-based learning environments (Zhai, Zhang, Li, & Zhang, 2019). However, the successful integration of technology not only requires teachers to use technology, but also emphasizes the quality of interactional patterns between teachers and students through developing effective, efficient, and engaging technology-based learning environments (Fauth, Atlay, Dumont, & Decristan, 2021).

Many models either on technology use or teaching and learning have been developed and validated in the literature that contribute to the knowledge on enhancing teacher practices and student outcomes. Since technology integration in nature is complex and multifaceted, teacher practices and student outcomes cannot be fully understood without considering various levels and different stakeholder perspectives. Therefore, we develop a model that allows us to provide a big picture of the teachers' and students' practices with currently available technologies as shown in Figure 7.1. In specific, in top-down order, the variables are presented in a hierarchical structure with policy-, school-, teacher-, and student-levels; from left to right, the whole process of technology integration in education is unfolded, and the inside of the black box of teaching practices is discovered. The model serves as a conceptual model based on which we identified the relevant variables that emerged from existing models and contextual aspects and gave an overview of this dissertation related to the five studies reported in the Chapters 2 to 6. For example, two models (i.e., FIB and IMBP) emerging from practices or scientific research, are helpful to understand teacher practices with technology by including both individual and environmental variables. The most cited models focusing on teaching and learning are the model of basic (deep structure) dimensions of instructional quality (Klieme, Pauli, & Reusser, 2009) and Biggs' 3P learning process model (Biggs, 2003). The two models were used in a mobile learning context. The studies in this dissertation are an addition to the existing literature because they integrate most critical variables on several levels that explain teachers' and students' practices with technology. Technologies for enhancing teacher practices and student outcomes have been implemented worldwide to improve teaching and learning quality. The Chinese context is an example of a newly emerging economy, and the findings of the empirical studies in this dissertation could be translated into broader (international) contexts.

7.3.1 Factors influencing teachers' pedagogical practices with technology

In previous models concerning technology integration in education various factors have been identified that influence teachers' practices with technology, especially emphasizing individual and environmental factors, and a tendency has been found that teacher-level factors outweigh school-level factors for the

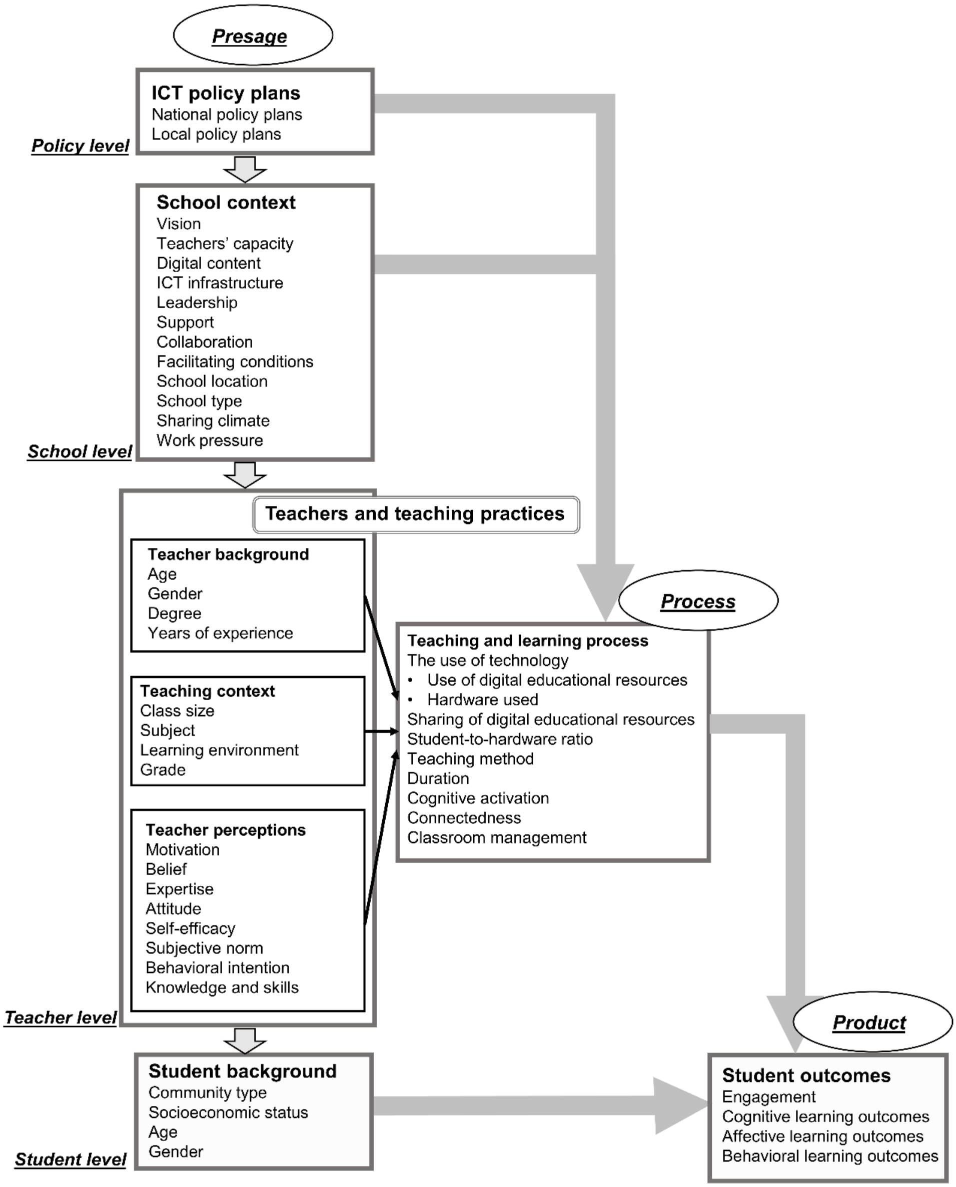

Figure 7.1. An overview of conceptual model for technology integration in education.

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integration of technology (Liu, Ritzhaupt, Dawson, & Barron, 2017). In many studies it has been attempted to establish a connection between individual and environmental variables, one the one hand, and teacher practices with technology, on the other hand. In some qualitative studies it has been tried to identify both facilitating and restricting factors for technology use at school level (Lumagbas, Smith, Care, & Scoular, 2019) and a number of quantitative studies are aimed at showing a link between personal variables and the use of technology (Kreijns, Van Acker, Vermeulen, & Van Buuren, 2013). In other studies mixed methods were used with a focus on context-specific processes of technology integration (Tondeur, Krug, Bill, Smulders, & Zhu, 2015). In general, the findings of these studies do not provide sufficient evidence to comprehensively understand teachers' perceived use of technology in view of various individual-, school-, and policy-level factors that can underlie these perceptions. The findings in this dissertation suggest that the FIB, IMBP and the Self-Determination Theory (SDT; Deci & Ryan, 1985) together can provide a valuable combination of models for explaining teachers' behaviors in this respect (see Figure 7.1). Combining the models emerging from scientific research and practice can enrich the link between research and educational practices, which can in turn improve the relevance and impact of technology integration research. In addition, taking into account teachers' underlying motivation can help to understand why the degree of technology use is sometimes different for teachers who work under the same conditions. For this reason, in Chapters 2, 3, 4 and 6, we examined the interaction between the teacher-, school- and policy- level factors that together can explain teachers' behavior relating to using technologies. Examining factors from all three levels can reveal the rationales underlying teachers' decisions concerning their technology use in daily instructional practices and this might help to clarify which rationales play a critical role in enhancing teacher practices across population and practices.

We argue that more needs to be done to develop expertise in using technology in educational practices. The results from the study presented in Chapter 2 indicate that rural teachers need sufficient expertise to integrate general ICT in the classroom as teachers play a crucial role in the implementation process. In particular, this study emphasizes the importance of rural teachers' competences in relation to innovative technology integration. These results add to the findings of previous studies indicating that teachers' competence beliefs are a better indicator of technology use in classrooms compared to their value beliefs (Cheng, Lu, Xie, & Vongkulluksn, 2020). Therefore, the two quantitative studies reported in Chapters 3 and 4 took a closer look at both teachers' confidence in competences (self-efficacy) and actual competences (knowledge and skills) that might influence teachers' adoption of the specific technology (i.e., DERs). The findings of the studies suggest that how frequently rural teachers use or share their DERs is strongly related to perceptions of their competence to use or share DERs. These studies provide insights into understanding teachers' competences in terms of how they relate to their specific technology behavior. These studies add to the literature emphasizing that a lack of confidence and competence can lead teachers to take a back seat in technology-driven teaching environments, and that it is necessary to help teachers to develop the professional competences they need to manage technology for their purposes (Tondeur, Aesaert, Pynoo, Van Braak, Fraeyman, & Erstad, 2017).

In addition to teacher competence regarding the relevance of research to teacher practices with technology, the findings presented in Chapters 2, 3, and 4 indicate that attention also needs to be paid to other affective variables, such as beliefs about teaching and learning, attitudes, and motivation toward using technology in teaching practices. The research described in Chapter 6 places emphasis on teacher beliefs and teacher background characteristics in smart classroom learning environments. Unexpectedly, the findings presented in Chapter 6 indicate that teacher beliefs had no effects on classroom process quality including the use of technology due to their low correlations. However, teachers with higher degrees exhibited significantly positive effects on classroom quality and further influenced student engagement. A possible explanation for this is that teachers with a higher academic degree may have more chances to specialize in a subject field and acquire more teaching and technology experience. The results validate previous research that improving teacher quality in terms of teaching and technology can foster teaching quality (Bower, Dalgarno, Kennedy, Lee, & Kenney, 2015; Fauth et al., 2019).

Furthermore, the studies presented in Chapters 3 and 4 have shown that relations between rural teachers' attitude toward using technology and their actual behavior are mixed. For example, as reported in Chapter 3, rural teachers' attitudes toward using DERs are positively linked with their behavior in using DERs in their pedagogical practices. In contrast, the results in Chapter 4 show that attitude was a negative predictor of sharing behavior outside school and this effect did not exist in the context of sharing within school. Chinese rural teachers in cultures where uncertainty is avoided and collaboration is not encouraged do not easily accept new things (Fei, 1992). This may imply that having a positive attitude is not necessarily enough to determine the performance of active behavior, and there has to be the presence of other factors such as trust toward the receiving party or a policy that affects knowledge sharing among employees (Akosile & Olatokun, 2020; Norulkamar & Hatamleh, 2014).

Teacher motivation was chosen as the focus of the study presented in Chapter 4 to understand the effects of various motivation types influencing teachers' sharing behavior regarding DERs. Technology integration researchers consider teachers' motivation as an origin of their behavior that can enhance the use of DERs in educational practices (Kreijns, Vermeulen, Van Acker, & Van Buuren, 2014). Previous research highlights the positive relationship between motivational constructs and professional learning, specifically when learning is collaborative (Durksen, Klassen, & Daniels, 2017). The findings from the study presented in Chapter 4 indicate that both internal motivation and external motivation significantly influenced attitudes, as well as sharing behavior within or outside school context. However, internal motivation positively influenced, whereas external motivation negatively influenced both attitude and sharing behavior. This study adds to the growing body of evidence that the effects of motivation differ depending on the study context (Wang & Hou, 2015), and that individual teachers' sharing activity is best understood when the context is taken into account (Schuwer & Janssen, 2018). The important role of internal motivation found in Chapter 4 is in line with many studies on teacher professional development and innovative behavior (see e.g., Durksen et al., 2017; Jansen in de Wal, Van den Beemt, Martens, & den Brok, 2020; Klaeijsen, Vermeulen, & Martens, 2018). In contrast to previous research, our research finding is compatible with the recent findings by Akosile and Olatokun (2020), who stated that external motivation (i.e., reward system) is only a weak incentive for long-term knowledge sharing among academics. It should be noted that teacher behavior is embedded in context and Chinese rural teachers work in a culture of avoidance of uncertainty and power distance (Fei, 1992), thus external motivation such as economic reward may not be an adequate motivator of knowledge sharing but may be perceived as empathy, resulting in another direction of expected behavior.

For a long time, intention is believed to be a good determinant of behavior; many previous studies on teacher behavior used the variable of intention instead of actual behavior to measure teachers' technology integration (see e.g., Jolaee, Nor, Khani, & Yusoff, 2014; Teo, 2011). However, the findings from Chapters 3 and 4 show that data from rural teachers' judgement does not support the hypothesized effect of intention on the use or sharing of DERs in teaching practices based on IMBP. The finding contributes to the growing knowledge that the assumption regarding the intention-behavior relationship was challenged (Scherer, Siddiq, & Tondeur, 2020). Van Acker, Vermeulen, Kreijns, Lutgerink, and Van Buuren (2014) explained that many teachers with reasonably high intentions never conduct the behavior. Based on the findings, we argue that the intention-behavior link may not be significant in all situations and we give our specific suggestion for future research in section 7.4.3.

Although teachers' practices heavily depend on their motivation, self-efficacy, knowledge and skills, their pedagogical practices are also influenced by school- or system-level factors (Kreijns, Vermeulen, Kirschner, Buuren, & Acker, 2013). Throughout this dissertation, we discussed how different context characteristics could influence teachers' practices with general ICT and specific technology (i.e., DERs). In the study presented in Chapter 2, we found many factors from different levels that influence teachers' implementation practices. By comparing the teaching and learning practices in pilot schools with other rural schools, we found that it is essential to take the local and school context into account when there is a wish to implement innovative technology use.

This finding adds importance to considering contextual variables in order to successfully implement policy plans or technology initiatives (Al-Huneini, Walker, & Badger,2020; Akcaoglu, Gumus, Bellibas, & Boyer, 2015). The empirical study reported in Chapter 3 took place in the same context of 25 rural schools in Western China and explored which school- and teacher-level factors might explain teachers' use of DERs. Although both school location and school type were not significantly related to teachers' behavior, 12.5% of the variance in rural school teachers' use of DERs was attributed to differences between these schools. Obviously, when considering the hierarchical structure of nested variables, school-level factors do contribute to the differences of teacher practices, although the contribution is relatively small (Vanderlinde, Aesaert, & Van Braak, 2014).

Moreover, even though studies have identified the key factors influencing technology integration in different situations, we cannot assume that every teacher uses technology in different contexts in a similar way. To establish conditions that stimulate knowledge sharing in various contexts, the study presented in Chapter 4 distinguishes rural teachers' within school sharing from their outside school sharing. The results indicate that attitude and sharing climate were only found to be related to sharing behavior outside school but not within school. The findings complement other sharing behavior studies (see e.g., Hou, Chang, & Sung, 2010; Van Acker et al., 2014) in which teachers seem to shy away from sharing outside school. Comparing the different results from two sharing contexts may contribute to the sharing of DERs in rural schools and fill these gaps in promoting sharing in various contexts.

Based on the findings of the studies reported in this dissertation (Chapters 2, 3, 4, and 6), we argue that for teachers, competencies, degree, attitude, motivation are important components of highly integrated use of technology in educational practices and their instructional practices but may vary in different contexts. In particular, we recognize that this development of competencies and specialist knowledge need necessitates a great and complex change in teacher practices, which will not be easy to achieve. In section 7.5 we elaborate on several suggestions for relevant stakeholders as well as for future research into teachers' developing quality.

7.3.2 Factors influencing student outcomes in mobile learning environments

Research on the effectiveness of technology in schools tends to show positive learning outcomes for both primary and secondary students (Chauhan, 2017; Hillmayr, Ziernwald, Reinhold, Hofer, & Reiss, 2020). In the last decade, many schools have integrated mobile technology into daily teaching practice. However, it is unclear when and how those mobile devices can be used to maximize their potential best. To gain a more comprehensive picture of the diverse conditions for improving student outcomes in mobile learning environments, this dissertation has combined three research approaches (a mixed-method explorative study, a systematic review study with meta-analysis, and a multilevel exploratory study) to evaluate the effects of mobile technology usage on student outcomes. In this respect, we first gathered preliminary information by school visits in 25 schools that helped develop the hypothesis that increasing the use of mobile technology contributes to better learning outcomes (Chapter 2). Next, we employed meta-analysis methods to assess the certainty about the overall effects of mobile technology usage on different types of outcome variables and to identify the potential influences of relevant moderators (Chapter 5). Finally, we used an exploratory study with multilevel analysis to examine the relationships among teacher factors, classroom process quality, and student engagement in the specific context of smart classroom learning environments in secondary education (Chapter 6). Therefore, the findings can provide valuable evidence for the design and implementation of integrating mobile technology in teaching and learning.

In Chapters 2, 5, and 6, we focus on the effects of mobile technology usage on student learning. With regard to student engagement, the findings in Chapter 2 suggest that students using their own clickers show a higher level of engagement. Learning in smart classroom learning environments appeared to allow students to interact with teachers and be more engaged in learning. However, only the schools involved in the 'Smart School Pilot Project' had developed such smart classrooms, and in other schools student digital devices were mainly available in computer rooms, which have the potential to increase the educational inequity in terms of the availability of and access to mobile devices. Likewise, the study presented in Chapter 6 conducted in secondary schools in urban areas indicated that both students' shared and individual perceptions of the use of technology (including using 1: 1 tablets and DERs) were related to student engagement. Thus, according to the results from two empirical studies, the use of technology is important for developing student engagement in both rural and urban contexts. Through the findings from Chapters 2 and 6, we have more insight in technology-based learning environments in which different groups of students may benefit from the use of mobile technology.

Unsurprisingly, the findings from the systematic review study in Chapter 5 showed that the use of mobile technologies has a medium positive and significant effect on multidimensional learning outcomes (i.e., cognitive, affective, and behavioral learning outcomes) compared with traditional technology (e.g., desktop computers and whiteboards) and non-technology (e.g., pen and paper) groups. However, the effects vary significantly for different conditions. Since we were interested in the differences among different student groups, we included SES background as a moderator. The results showed that studies including students from middle or high SES backgrounds resulted in a higher differential effect size than studies in which low SES background students were involved. The finding is crucial in understanding the current digital divide, and in line with other research we argue that insights in how different groups of students learn in technology-based learning environments are urgently needed (Bergdahl, Nouri, Fors, & Knutsson, 2020). Moreover, taking into account there are abundant mobile technologies in the markets, it is important to consider the features of mobile technology. We found that studies in which handheld devices (e.g., tablets) with diverse functions were used produced significantly larger effect sizes on cognitive learning outcomes than studies with single-function devices (e.g., clicker). This result adds to literature in which the value of multifunctional mobile devices is emphasized (Becker, Klein, Gößling, & Kuhn, 2020). Besides, our findings also provide new evidence to support the results of Winkler, Söllner, and Leimeister (2021), who state that smart personal assistant technology can change students learning processes by enabling students' to learn at their own pace and receive individual support.

In addition, understanding when and how mobile devices should be used is valuable to gain insight in best practices. Although in Chapter 5 we found that education level was not significant for cognitive learning outcomes, secondary students showed relatively higher cognitive learning outcomes than primary students. Also, in Chapter 6, we investigated the effects of lower secondary school grade level on classroom process quality including the use of technology, and the results indicate that students at higher grade levels use technology more. It seems that students at a higher grade benefit more than those at a lower grade level. The differences might be that students at higher grade levels have developed a higher level of self-regulation skills (Tseng, Yi, & Yeh, 2019), which is critical for effective learning in technology-based learning environments. Therefore, it becomes necessary for schools to develop students' self-regulation skills and technological competence since students are required to carry out their learning at their own pace and stay focus on learning, and if schools fail to do so students might be disengaged for learning (Bergdahl et al., 2020).

There is no doubt that mobile technology is an essential component of how students engage and learn with technology, as this enables them to learn better and faster (Koper, 2014). More importantly, we believe that the value of mobile technology lays in how it is integrated with pedagogy and curriculum. The findings in Chapter 6 suggest that teachers have an important role to play in facilitating student learning. The learning environments including high levels of cognitive activation, connectedness and the use of technology appear to support student engagement best. Students' shared perceptions of connectedness and the use of technology at the teacher/ classroom level can function as a bridge between teacher degree and student engagement. These findings complement the claim of Zhai, Zhang, and Li (2018), who state that learning activities that involve students more interactively and engagingly need to be planned and implemented by teachers. Besides, connectedness is among the three classroom process quality variables that most strongly explain student engagement at both the teacher/ classroom and student level. Accordingly, also in classrooms, it is essential to build positive social interactions, and teachers need to show more caring behavior and have to provide timely constructive feedback.

7.4 Strengths, reflections and future research

7.4.1 Strengths

To successfully integrate technology in education, research in this dissertation was approached through a holistic view, that is, from several different stakeholders, with different technological practices, and in different contexts. An integrated model of many aspects of a process or a central phenomenon can help construct this holistic picture (see e.g., Creswell & Brown, 1992). The visual map summarizes the variables at different levels and at different stages that have been examined in this dissertation and is presented in Figure 7.1. The model is a simplified representation of research and practice in technology integration in education that can be used as a foundation for future research as a holistic approach, allowing for more precise predictions of student learning. In summary, the main strengths of this dissertation are: (1) identifying key factors at different levels that contribute to differences in teacher practices with regards to technology use through building upon existing models and elaborating on relevant contextual aspects, and (2) drawing solid conclusions with regards to the effect of mobile technology usage on student learning from both broader and in-depth perspectives.

The first three studies included in this dissertation extend insights derived from previous studies into local ICT policy plans, school practices, and teacher perceptions in the particular context of rural schools. The combination of variables from the FIB, IMBP, and SDT models (Chapters 2, 3 and 4) provide insights into the influence of local ICT policy plans as well as school context and teacher characteristics on rural teachers' judgment of their own behaviors and the general impression of the use of technology in teaching practices (see e.g., Akcaoglu et al., 2015). Furthermore, the quantitative research method used in the studies presented in Chapters 3 and 4 provides an opportunity to explore factors influencing rural teachers' behavior regarding DERs under the national call to integrate DERs into teachers' pedagogical practices. Most importantly, the multilevel design with the teacher at level 1 and school at level 2 is a powerful tool to examine which level factors contribute more to teacher behavior in using technology; differentiating among the various situations where teachers share their DERs contributes to an in-depth understanding that variable roles might vary from context to context (see e.g., Van Acker et al., 2014).

In contrast to the research focus on teacher practices with technology in the first few chapters, the studies presented in Chapters 5 and 6 gave attention to student outcomes in mobile learning environments in order to provide examples of whether, when, and how students should use mobile technology for learning. To answer these questions, a systematic review with meta-analysis (i.e., synthesize the overall effects of various experimental or quasi-experimental studies on learning with mobile technology) on 61 studies of 56 peer-reviewed papers was employed to obtain inclusive answers. Since every method has its own biases and strengths, integrating both teacher and student perspectives would be a valuable complement to other performance measures, and it is necessary to examine the underlying relationships at an appropriate level of analysis (Burić & Kim, 2020). Therefore, using a multilevel design (i.e., considering both the teacher/ classroom and student levels' influences on student engagement in the specific context of smart classroom learning environments) can contribute to a better understanding of the complex phenomena.

7.4.2 Reflections

This dissertation is intended to gain new knowledge about teachers' practices with technology and identify effective technology integration practices to measure student engagement and learning outcomes in technology-based learning environments. The empirical studies in this dissertation were conducted in the Chinese school context. On the one hand, the results cannot simply be generalized to other countries with different cultures. On the other hand, considering that there are huge geographical and social differences in China, that the number of schools participating in these studies was small and that these were mainly located in Western China, concerns may raise about the generalizability to other settings. Nevertheless, for the first three studies with a focus on rural context, all rural school types are represented in Chapters 2 and 3. Furthermore, the sample in the study presented in Chapter 4 is close to the main characteristics of the distribution of the rural teacher population in China (Wu & Qin, 2019) and the size of the sample was justified (López, Valenzuela, Nussbaum, & Tsai, 2015). Similarly, for the study reported in Chapter 6 which was conducted in the urban context, we specified the inclusion criteria for the sample and justified the sample size for multilevel analysis (Kreft, 1996). In this respect, these studies can serve as examples enhancing teacher practices and student outcomes in various contexts and when applying different technological practices. Considering the potential differences that may exist according to different educational research and practice contexts, we expect that researchers, policymakers, educators, school leaders, teachers, and other educational stakeholders, as they consider our model (Figure 7.1), may need to make adaptations that fit their own contexts in identifying effective ways to succeed in technology integration in education.

The nature of data collection may also restrict the conclusions drawn from the studies in this dissertation. In the studies presented in Chapters 3, 4, and 6, self-reported survey data was used to collect teachers' or students' thoughts and behavior about practices. Both teachers' and students' perceptions matter in understanding their teaching and learning (Burić & Kim, 2020; Fraser, 1998) and surveys are cost-effective and broadly applicable tools to evaluate the use of technology in education (see e.g., Lai & Bower, 2019). However, with regard to the use of technology, our studies were restricted to the frequency of technology use and did not include the quality of technology integration. In this regard, we think it is important to address the value of gathering data using multiple methods for technology integration (Henrie, Halverson, & Graham, 2015). Although in the study presented in Chapter 2, we used a mixed-method approach, in most studies (i.e., in Chapters 3, 4, and 6) in this dissertation, we used a survey method for measuring technology integration. In contrast, other new studies used longitude data (Backfisch et al., 2021), student assessment data (Admiraal, Vermeulen, & Bulterman-Bos, 2020), and teachers log file data (Huang & Lajoie, 2021). We believe that multiple data collection methods can shed new light on the phenomenon of concern (Liu et al., 2017) since various data methods can inform the complexities of technology integration in primary and secondary schools and offer more details behind practitioners' behavior in achieving effective technology integration that connected to specific contexts (Heitink, Voogt, Verplanken, Van Braak, & Fisser, 2016).

7.4.3 Future research

The first three studies presented in Chapters 2, 3, and 4 specifically were focused on investigating teachers' practices with technology in rural school context. Because we did not use representative samples of teachers, it would be better in future research to use representative samples because this is the best way to generalize the findings to the whole population (López et al., 2015). In addition, both the intention and actual behavior measures were based on self-perceived measures in two quantitative studies presented in Chapters 3 and 4, and this may cause the problem of self-reported bias. As such, future research should explore the stability of the construct of actual behavior for teachers by classroom observations and/or interviews with students. The two studies reported in Chapter 3 and 4 were focused on teachers' frequency of technology use which is one aspect of technology integration and adding the quality of technology integration as dependent variable would boost our understanding of effective teacher practices (Vongkulluksn, Xie, & Bowman, 2018). In future studies, it would be worthwhile to examine teacher factors, such as teachers' competencies, motivation, and attitude, and their relationship with both the quantity and quality of technology integration. And as noted in section 7.4.2, adding other data collection methods can help to develop broader and deeper knowledge on technology integration in education. Meanwhile, it would be necessary to include school context variables when examining teacher practices. Although it is no doubt that school context is related to teacher practices in the study presented in Chapter 3, it is unclear which school-level variables play a role. Given the potential impact of local policy plans, leadership, support, the availability of contextual digital content, the availability of mobile technology from the findings shown in Chapter 2, we recommend including these variables in future technology integration research.

Our aim in taking the student perspective in studies presented in Chapters 5 and 6 of this dissertation was to provide a deeper view of the complex practice and technology integration product. We did this by examining whether, what, when, and how technology should be used by students in the context of mobile learning environments. It seems that students at higher grades learn better with multiple-function devices on their own compared with traditional learning, and their teachers have an important role in facilitating their learning process. In future studies multilevel analysis can be employed to explore the hierarchical structure of data under which students are nested within classes/teachers, teachers are nested within schools, and schools are nested within local education authorities. All variables at all levels have the potential to affect the learning process and outcomes of students. Unfortunately, our results did not reveal a clear understanding about why certain student groups benefit more than others in terms learning outcomes, i.e., cognitive, affective, and behavioral learning outcomes. The finding that students from middle and high SES backgrounds produce significantly higher cognitive learning outcomes is critical in understanding the current educational inequity and provides an interesting direction for more research into differences among subgroups such as ethnicity, migration status, and community types. In doing so, we will be able to make the best use of technology integration to improve student learning and ultimately connect all schools to quality education.

7.5 Practical implications

7.5.1 Implications for policymakers

Efforts to improve teaching and learning quality through technology integration yield widely disparate outcomes in different countries and areas, despite similar investments and initiatives. Not only educational practitioners hesitate to put the goals into practice but also policymakers are not confident about the effects of these new technologies on empowering education and thus are struggling with the innovative technology integration on a larger scale. The content of policy plans about the use of technology in education is sometimes contradictory and misaligned (Eickelmann, 2018), which can further increase teachers' confusion and programs' failure. We would recommend to begin with integrating research knowledge directly with practical guidance about the pedagogical use of technology. This means that policymakers work together with researchers to determine why, and identify the conditions and consequences of the policy tasks.

Rapid advances in educational theories and technologies provide new possibilities, and new design and delivery challenges of policy plans for innovative technology integration. Rather than being a rational and linear process that includes the initiation, growth, discussion, communication, execution, and assessment of policies (Buse, Mays, & Walt, 2005), policymaking is iterative and influenced by interests. As a result, we propose an iterative process of planning and implementation of technology integration in education. More importantly, the intended policy plans never fit all, and variations exist in technology integration in education. In this respect, policymakers should actively compare efforts across countries, regions, and schools, allowing them to learn from one another and exchange best practices, as well as adapting plans to meet their needs. Finally, given the international call of education for all, policymakers should pay special attention to disadvantaged groups to ensure that these students do not remain disadvantaged when learning with technology.

7.5.2 Implications for teacher education and continuing training

We think that it is crucial to offer many learning opportunities for teachers to integrate technology effectively. Besides the diverse and ample potential that technology offers, the extent to which and how technologies are integrated in teaching and learning largely depends on teachers who perceive and implement the practices. In studies described in Chapters 2, 3, 4, and 6, the vital role of the teachers in integrating technology in their pedagogical practices and facilitating student learning were found to be important. This suggests that teachers can maximize the impact of technology integration, for example, when they have specialist knowledge regarding teaching, positive attitudes toward using technology, and confidence and skills in dealing with and solving technical issues.

Teacher education programs are often aimed at one single subject, whereas courses specifically aimed at integrating technology in specific subjects could be more helpful for developing teachers' specialist knowledge to further apply in practices. Hence, teacher education should first facilitate pre-service teachers in developing professional skills, pedagogical methods, and subject understanding, and how these connect and align to one another (Mishra, & Koehler, 2006). To better prepare teachers for integrating technology in their teaching practices, developing positive attitudes toward technology use is another way. Although the supposed educational benefits of technology are well known worldwide, it seems that certain groups of teachers need to see the 'obvious' benefits of technology in the classroom, especially in more challenging environments (see e.g., Perrotta, 2013). Thus, programs should build teachers' positive attitudes toward using technology, for example, through peer observations and teaching competition. This recommendation is based on the persuasion communication model (McGuire,1985).

When facing technology integration barriers, teachers are at the first to cope with these difficult issues. It is also important that during teacher education, teachers to develop some basic technology skills. In the longer term in their continuing training, teachers need to become familiar with advanced technologies in order to develop more competences and gain a better idea of how technology can be integrated in their pedagogies. In agreement with recent literature on individualized technology mentoring (Top, Baser, Akkus, Akayoglu, & Gurer, 2021), we suggest offering every teacher opportunities to apply their knowledge, skills, and ideas in their own teaching practice and to receive feedback from expert teachers during training programs, especially the teaching internship program.

7.5.3 Implications for school leaders

School conditions are also essential for successful technology integration. Our findings indicate that teacher practices are not only influenced by teachers, but also affected by school context factors, such as school-level policy plans, leadership, support, and collaboration. School leaders have the power to facilitate teachers with supportive conditions and mechanisms to integrate technology efficiently. However, before immediately responding to the national or local call to integrate technology in schools, it would be worthwhile for school leaders to join training programs on the leadership of technology integration practices. This would benefit school leaders from at least two aspects: (1) to overcome biases arising from years of experience in using the traditional leadership approach (Navaridas-Nalda, Clavel-San Emeterio, Fernández-Ortiz, & Arias-Oliva, 2020), and (2) to recognize all the options and opportunities that lead to the integration processes and outcomes. Since school leaders often are experts in local and school conditions, there is a strong need for them to develop a school policy plan based on school culture and including all the supporting and hindering conditions to integrate technology in schools, but this also requires effort for involving teachers and developing a shared vision (Vanderlinde, Van Braak, & Dexter, 2012). Another recommendation for school leaders is to create within- and cross-school communities or networks to provide support in terms of pedagogical and technical aspects, and offer collaboration opportunities to share ideas, experience, and best practices. This process-oriented connection serves as a source of school improvement, and the joint efforts can make technology integration sustainable and persistent.

7.5.4 Implications for teachers

To successfully integrate technology into classroom practices, teachers have to be aware of the origins of their behavior, such as their motivation, beliefs, and attitude toward using technology in teaching. Research has shown that except for working environment, training and professional development, teacher motivation is influenced by perceived technology competence, confirmation of pre-acceptance expectations, and technology usefulness beliefs (see e.g., Rasheed, Humayon, Awan, & Ahmed, 2016; Sørebø, Halvari, Gulli, & Kristiansen, 2009). Although environmental conditions are known to be needed to support teacher practices, teachers should also be prepared to have sufficient expertise to effectively design and implement lessons that engage students in technology-based learning environments. More importantly, it is often teachers' creation, adaptation, and refinement of their practices themselves that make change happen. As our findings in Chapters 2 and 4 suggest, teachers' active involvement in technology integration is vital in creating contextualized and culturally embedded DERs, and sharing teaching-related knowledge supports their professional learning and development. In addition, it might be helpful to introduce teachers to our model (see Figure 7.1) when effective teaching and engaging learning are pursued. In particular, teachers need to know the importance of students' perceived connectedness for students' learning experience, including but not limited to providing timely feedback in the classroom. This recommendation is grounded in Chapter 6, in which we conclude that connectedness deserves closer attention among the three global dimensions of instructional quality.

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Appendices

Appendix A. Content of local ICT policy plans and illustrations of content per subcategory

Category and subcategory of local ICT policy plans content	Illustrations of content for the subcategories
1. Vision	
1.1 Development background	e.g., The ICT infrastructure construction is lower than the national average level. The broadband speed in more than 50% of the compulsory education schools in the towns or villages is less than 10 Mbps, and the sharing level of resources is low. The principals' ICT leadership and teachers' ICT skills need to be improved, and the effect of ICT use is not high. (Policy A)
1.2 Development goals	e.g., By 2020, establishing an ICT service system for anyone to learn anywhere and anytime, which is consistent with the goal of educational modernisation. (Policy B)
2. Expertise	
2.1 Teachers' ICT skills improvement	e.g., Carrying out the training on teachers' ICT use, capacity to improve teachers' capacities of instructional design, content presentation, and teaching evaluation. (Policy B)
2.2 Leaders' ICT leadership and skills' improvement	e.g., Conducting training on ICT leadership and ICT skills to enhance leaders' capacities for ICT planning, management, and execution. (Policy C)
Students' ICT literacy improvement	e.g., Strengthening student ICT use capacity and self-learning capacity, and improving students' modern ICT literacy. By 2020, 90% of students could use ICT for autonomous learning. (Policy B)
3. Digital content	
3.1 Quality digital educational resources construction	e.g., Introducing high-quality resources of schools, enterprises and institutions, and developing the educational resources for basic education. (Policy A)
3.2 Digital educational resources public service platform construction	e.g., Promoting the interconnection of local-level platforms and national platforms to develop an educational resources public service system. (Policy A)

A

3.3 Educational management public service platform construction	e.g., According to the requirements of the Ministry of Education, accelerating the completion of the local-level construction of the educational management public service platform. (Policy B)
3.4 E-learning space construction	e.g., Accelerating the construction and use of "e-learning space for everyone" through purchasing services by the governments and schools. (Policy A)
3.5 Educational service portal and integrated business support cloud platform construction	Descriptions of the construction of an educational service portal and integrated business support cloud platform. (Policy B)
3.6 E-Governance improvement	e.g., By 2020, building a decision-making service system based on educational big data. (Policy B)
4. ICT Infrastructure	
4.1 Descriptions of the Internet	e.g., By 2020, the average export bandwidth for classes in urban schools that access to the education metropolitan area network will not be less than 30Mbps, the average export broadband for classes in rural schools will not be less than 10Mbps, and the average export broadband for classes in teaching points will be more than 8Mbps. (Policy B)
4.2 Descriptions of computers allocation	e.g., Implementing the construction of computer network classrooms in primary and secondary schools based on the project "comprehensive improvement of basic conditions for weak schools in compulsory education". (Policy A)
4.3 Descriptions of multimedia teaching equipment	By 2020, all schools will be equipped with multimedia equipment in compulsory education. (Policy A)
5. Leadership	
5.1 Involvement	e.g., Promoting the Chief Information Officer (CIO) system at all levels of schools to guide a school's ICT development. (Policy B)
5.2 Assessment	e.g., Incorporating the work of ICT in education into the annual assessment of districts and schools. (Policy B)
6. Support	
6.1 Pedagogical support	e.g., Constructing 1,000 pilot schools and 50 pilot districts of good practices in ICT use. (Policy A)
6.2 Technical support	e.g., Accelerating the construction of a professional team. (Policy A)
6.3 Financial support	e.g., Increasing the financial support for ICT in education in rural and remote areas. (Policy C)

7. Collaboration	
7.1 Global collaboration	e.g., By 2020, establishing three Chinese-foreign cooperative research institutions for ICT in education, and developing 200 ICT leaders and educational experts with international vision. (Policy C)
7.2 Regional and industry collaboration	e.g., Integrating the resources of different departments and forming a joint force to provide quality, convenient and efficient services for schools, teachers, and students. (Policy A)
8. Pedagogical use of ICT	
8.1 Innovative use of emerging technologies	e.g., Conducting a variety of learning experience activities for students by using virtual reality, 3D printing, intelligent robots, and other technologies. (Policy C)
8.2 Pedagogical approach changes	Promoting the transformation of teaching mode (e.g., situational teaching method, project-based learning, and flipped classrooms). (Policy B)

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Appendix B. Rural schools' ICT practices: Summary of categories and sample quotations per subcategory

Category and subcategory of ICT practice	Description	Sample quotations
1. Shared vision and school policy		
1.1 Purposes for ICT use	To improve teaching quality and efficacy.	I hope that teachers can use ICT as much as possible to effectively serve classroom teaching. (Leader, School A-03)
	To promote student learning.	Because the effect of the animation is very intuitive, primary school students prefer it. (Teacher, School B-05)
	To create "digital schools" or "smart schools" according to the local ICT policy plans.	According to the unified arrangement of the Center for Educational Technology, our school will carry out the creation of "digital schools". (Leader, School C-02)

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1.2 Schools' ICT policy plans	No ICT policy plans were available in ten schools.	The policy plans are not yet available. Mainly in accordance with the requirements of the Center for Educational Technology, we organise training twice a year and then upload the training video to indicate that we implement the practice. (Leader, School C-07)
	Schools' ICT policy plans were presented in other plans (e.g., teaching and research work plan, curriculum reform plan, reporting materials in nine schools.	Specialised ICT policy plans are not yet available, but they are presented in the annual teaching plan. (Leader, School C-01)
	Specialised ICT policy plans were available in six schools.	We have a five-year plan for the development of ICT, from 2010 to 2015. Because of the lack of guidance, we did not update it. (Leader, School C-06)
2. Expertise		
2.1 Teachers' knowledge and skills in ICT	Teachers were provided with training at different levels in how to use ICT (e.g., electronic whiteboard, multimedia courseware, and digital resources platforms).	All teachers have received training from the "National Primary and Secondary School Teachers ICT Application Capacity Improvement" project. (Leader, School B-04)
	Teachers had difficulty in using advanced technologies.	Video is video, PowerPoint is PowerPoint, and how to integrate videos into PPT is not only a technical problem. If this problem is solved, the teacher's ability to apply ICT will be highly improved. (Leader, School B-07)

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2.2 Teacher attitudes toward using ICT	Most teachers had positive attitudes toward ICT because of the benefits of using ICT.	Embedding audio and video clips in the courseware could be very helpful for the students to concentrate, so I like them very much. (Teacher, School A-02)
	Some teachers worried about the side effects of ICT on students.	I teach mathematics. I feel that excessive use of ICT will affect the development of abstract thinking and hands-on ability of middle school students. (Teacher, School A-06)
3. Digital content		
3.1 Sources	Search engines, colleagues or friends, school teaching resources, and digital resources platforms, commercial database, etc.	The education bureau has signed agreements with many publishers. We just need to log in to the public service platform, and many resources are available for us to download. (Leader, School A-03)
3.2 Types	Multimedia courseware, multimedia material, electronic lesson plans, teaching cases and videos of famous teachers, and question bank, etc.	The resources we use include lesson plans, courseware, test papers, learning plan, and classroom recording videos. (Leader, School C-08)
3.3 Relevance to teaching	Digital content that was consistent with the textbook version was the most relevant.	The CD-ROM for the teacher's reference book we bought is most relevant to teaching because it is most closely integrated with the textbook. (Leader, School B-01)

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4. ICT infrastructure		
4.1 Computers	The computers and/or multimedia equipment were purchased by the national project, local education bureaus and/or the school.	There are 51 teacher and student computers, most of which are distributed by the national project. The school mainly purchases laptops for teachers. (Leader, School A-05)
	There were public computers in teacher offices, but not all teachers had their own personal computers. Student computers were available in computer classrooms.	There is a desktop and a laptop in each office, shared by 3 to 4 teachers. (Leader, School B-04) The student computers are in the computer classroom, about 60, and a few are too old and broken. (Leader, School B-05)
4.2 Multimedia equipment	Multimedia equipment was available but the quality of some was not good.	The clarity of the electronic whiteboard is not high, so the students in the back row cannot see it very clearly. (Teacher, School C-08)
4.3 Internet	The internet involved unified planning by the local authorities and was purchased by the school.	We are connected to the metropolitan area network of the Education Bureau, but sometimes the internet speed is not good. (Leader, School C-05)
	Wi-Fi was available in some schools.	Teachers' mobile phones can be connected to Wi-Fi anywhere in the school. (Teacher, School C-03)

5. Leadership		
5.1 Involvement	The overall participation was high.	The principal leads the academic affairs office, and the academic affairs office leads the grade leaders and the teaching and research team leaders. It is a top-down guarantee mechanism. (Leader, School B-09)
	Most schools set up a leadership team or information centre.	The general director is responsible for hardware management and the director of the academic affairs office is responsible for the use. (Leader, School B-03)
5.2 Prescription	Teachers must use multimedia equipment in some cases.	Teachers are required to use electronic whiteboards in teaching competitions. There is no prescription on which digital content to use. (Leader, School C-01)
	Teachers had options to use various resources for their lessons but recommendations were given by some principals.	The principal sometimes recommends websites such as Onion Math, Middle School Chinese Network. (Leader, School A-06)
	Some schools request teachers to record their usage.	Teachers who teach in the function classroom need to record their usage on the platform. (Leader, School B-08)
5.3 Assessment	The leadership team is responsible for the assessment of teaching with ICT.	The principals and directors have to listen to 20 lessons per semester, examining the teacher's teaching level and the use level of ICT. (Leader, School A-05)
	The leadership team (e.g., academic affairs office) is also responsible for the assessment of digital lesson plans.	The assessment is in the form of submitting digital lesson plans by teachers. (Leader, School A-01)

5.4 Teacher professional development strategies	Making the training content specific.	The ways of using ICT may differ in different disciplines, so teachers need to get the training related to their subjects. (Leader, School A-06)
	Strengthening supervision in training and post-training assessment.	If the teaching assessment is unqualified, the performance bonus will be deducted, a lot, tens of thousands of yuan a year. (Leader, School B-05)
	Setting good examples for other teachers to prove that ICT can improve teaching quality.	I think the first strategy is still typical propaganda. The role of the role model is endless. If teachers are forced to use it, this may be counterproductive. (Leader, School C-01)
6. Support		
6.1 Pedagogical support	Teachers were encouraged to switch from traditional teaching methods to ICT-based teaching methods.	In the school conference, I encourage all the old teachers to use ICT because it is good for their health and improving work efficiency. (Leader, School B-03)
	Principals and directors of teaching took the lead in the use of ICT in the main subjects.	Leaders take the lead in making courseware and providing teachers with ideas on the use of ICT in school teaching and research activities. (Teacher, School A-02)
	School leaders provided pedagogical supports outside schools.	When new technologies are introduced in the school, we will provide the opportunity to study outside school with teachers. (Leader, School B-08)

6.2 Technical support	Teachers had access to internal support from ICT teachers but the support was quite limited.	Only one teacher in our school who is responsible for equipment maintenance. (Leader, School B-06)
	Teachers had access to external support from the superior maintenance department and computer company.	When we encounter big technical problems, the company we hired will fix them. (Leader, School B-02)
6.3 Financial support	Schools purchased digital content (e.g., commercial resources, management platform).	Since 2012, our school has purchased commercial resources and shared them in school. (Teacher, School C-08)
	Schools purchased digital equipment.	In 2008, the school raised 300,000 RMB and purchased 12 sets of electronic whiteboards. (Leader, School A-01)
7. Collaboration		
7.1 Collaboration within-schools	Teachers who teach the same subject shared resources (e.g., courseware, practice questions) with colleagues.	The digital content made by each teacher is required to be uploaded to the school's resource library for sharing. (Leader, School B-01)
	Teachers who teach in the same subject work together to prepare for lessons.	The teachers prepare for lessons together using No.7 Middle School's recording class resources or self-made resources. (Leader, School C-06)
	Teachers in the same schools shared ideas in teaching and research activities.	Colleagues exchange ideas about the development of school courses, for example, Maker. (Teacher, School C-03)

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7.2 Collaboration across- schools	Teachers prepared lessons together across-schools in the same district.	There are not many psychology teachers, so the psychology teachers in our district have to prepare lessons together. (Teacher, School B-07)
	Teachers in union schools shared resources and ideas.	We and other schools conduct teaching and research activities through videoconferencing. (Leader, School B-01)
	Teachers in some primary schools teach lessons synchronously.	We work with other two schools in villages to conduct music lessons synchronously in order to help those schools who are short of music teachers. (Leader, School A-03)
8. Pedagogical use of ICT		
8.1 Types of multimedia classroom	There are six multimedia classroom configurations.	One interactive LCD panel + one booth (eight schools); One interactive LCD panel + one booth + two projectors (two schools); One projector + one electronic whiteboard + one booth (eight schools); One projector + one electronic whiteboard + one booth+ one television (three schools); One projector + one curtain + one booth (two schools); One television+ student computers (one school).
8.2 Most used digital content	Most teachers used electronic lesson plans to prepare lessons and use multimedia courseware and materials to implement lessons in their classroom practices.	

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8.3 Most used ICT infrastructure	Most teachers used interactive electronic whiteboard and projection booth in class.
8.4 Pedagogical approach	Most of these lessons tended to be teacher-driven focusing on knowledge transfer.

Appendix C. Overview of the measurements and their constituting items

Variable	Item
Attitude	Please indicate how much a particular item applies to you as a teacher: 1. Because of the use of digital educational resources, I am more satisfied with my work. 2. I like to use digital educational resources in my teaching. 3. Students are more motivated for my teaching when I use digital educational resources. 4. Because of the use of digital educational resources, my teaching becomes more efficient. 5. Teaching with digital educational resources in an effective way inspires me. 6. The use of digital educational resources improves my teaching. 7. I can teach with digital educational resources without the help of others. 8. I am able to apply digital educational resources in class. 9. I learn to use digital educational resources in teaching quite fast. 10. I am able to use digital educational resources in class in an effective way. 1 (*absolutely inapplicable*) to 7 (*absolutely applicable*)
Self-efficacy	Please indicate how much a particular item applies to you as a teacher: 1. I doubt my ability to use digital educational resources in teaching. 2. If students have questions about digital educational resources, I am unable to help them. 1 (*absolutely inapplicable*) to 7 (*absolutely applicable*)

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Subjective norm	Please indicate how much a particular item applies to you as a teacher: 1. In our school, digital educational resources have an important place in teaching. 2. Our school vision clearly describes teaching with digital educational resources. 3. In our school, teaching with digital educational resources is appreciated. 4. My colleagues think teaching with digital educational resources is important. 5. In my work context, teaching with digital educational resources is perceived as important. 6. Our school leaders pay a lot of attention to the use of digital educational resources in teaching. 1 (*absolutely inapplicable*) to 7 (*absolutely applicable*)
Knowledge and skills	Please indicate how you feel about a particular item: 1. I can choose digital educational resources that enhance the teaching approaches for a lesson. 2. I can choose digital educational resources that enhance students' learning for a lesson. 3. I think deeply about how digital educational resources influence the teaching approaches I use in my classroom. 4. I can reflect on how to use digital education resources in class. 5. I can use digital educational resources in various teaching activities. 1 (*strongly disagree*) to 7 (*strongly agree*)
Facilitating conditions	Please indicate how you feel about a particular item: 1. A specific person is available to provide assistance. 2. Guidance is available to me in selecting digital educational resources to use. 3. I know where to seek assistance. 4. Specialized instruction concerning digital educational resources is available to me. 5. I am given timely assistance. 1 (*strongly disagree*) to 7 (*strongly agree*)
Intention	Please indicate how much a particular item applies to you as a teacher: 1. I plan to use digital educational resources in class. 2. I intend to use digital educational resources in class. 3. I should use digital educational resources in class. 4. I will use digital educational resources in class. 1 (*absolutely inapplicable*) to 7 (*absolutely applicable*)

Actual behavior	Please indicate how often you use the following types of digital educational resources in your teaching: 1. Multimedia Courseware, 2. Multimedia material (text, pictures, animation, video, audio, etc.), 3. Electronic lesson plans / instructional design, 4. Teaching cases and videos of famous teachers, 5. Question bank/ test papers, 6. Microlecture/ microvideo, 7. Subject software and tools (Geometry, virtual lab, etc.), 8. Online Course, 9. Thematic page/website, 10. E-books/periodicals 1 (*never*) to 7 (*always*)

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Appendix D

Table D.1. Additional demographic statistics of participants ($N = 709$).

Measures	Items	Frequency	Percent
Position	Teacher	654	92.2
	Director	37	5.2
	Principal	18	2.5
Years of sharing experience	<1	155	21.9
	1-3	232	32.7
	4-5	103	14.5
	6-10	147	20.7
	>10	72	10.2
School type	Teaching site in village	56	7.9
	Primary school in village	139	19.6
	Primary school in town	204	28.8
	Secondary school in town	148	20.9
	Nine-year School in town	162	22.8

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Table D.2. Convergent validity and internal reliability.

Constructs	Parameters of significant test		Composite Reliability (CR)	Average of Variance Extracted (AVE)	Cronbach's α
	Factor Loading	Measurement Error			
INT			0.824	0.541	0.822
INT1	0.781***	0.021			
INT2	0.678***	0.025			
INT3	0.705***	0.024			
INT4	0.772***	0.021			
EXT			0.792	0.559	0.791
EXT1	0.703***	0.026			
EXT2	0.791***	0.025			
EXT3	0.747***	0.025			
SE			0.863	0.677	0.861
SE1	0.806***	0.018			
SE2	0.893***	0.016			
SE3	0.765***	0.020			
ATT			0.863	0.678	0.861
AT1	0.773***	0.019			
AT2	0.843***	0.017			
AT3	0.852***	0.017			
SC			0.878	0.645	0.876
SC1	0.778***	0.018			
SC2	0.884***	0.013			
SC3	0.808***	0.017			
SC4	0.734***	0.020			
WP			0.788	0.561	0.769
WP1	0.649***	0.029			
WP2	0.919***	0.028			
WP3	0.645***	0.029			
SIIS			0.854	0.661	0.852
SIIS1	0.833***	0.018			
SIIS2	0.775***	0.020			
SIIS3	0.829***	0.018			
SIOS			0.886	0.722	0.885

SIOS1	0.878***	0.014			
SIOS2	0.827***	0.016			
SIOS3	0.843***	0.015			
SBIS			0.803	0.577	0.801
SBIS1	0.790***	0.024			
SBIS2	0.717***	0.025			
SBIS3	0.769***	0.024			
SBOS			0.911	0.674	0.909
SBOS1	0.775***	0.017			
SBOS2	0.740***	0.019			
SBOS3	0.884***	0.011			
SBOS4	0.819***	0.014			
SBOS5	0.877***	0.011			

***$p < 0.001$.

Table D.3. Path coefficients for within and outside school.

Paths	Path coefficients for within school	Results for within school	Path coefficients for outside school	Results for outside school
INT → SE	0.587***	Yes	0.583***	Yes
INT → ATT	0.790***	Yes	0.787***	Yes
INT → SI	0.078	No	0.216**	Yes
INT → SB	0.274**	Yes	0.318***	Yes
EXT → SE	0.029	No	0.030	No
EXT → ATT	-0.172***	Yes	-0.172***	Yes
EXT → SI	-0.022	No	-0.038	No
EXT → SB	-0.104*	Yes	-0.092*	Yes
SE → SI	0.433***	Yes	0.543***	Yes
SE → SB	0.325***	Yes	0.215***	Yes
ATT → SI	0.382***	Yes	0.047	No
ATT → SB	-0.148	No	-0.208**	Yes
SI → SB	0.073	No	0.118*	Yes
SC → SB	0.122	No	0.139*	Yes
WP → SB	0.028	No	0.017	No

Note: ***$p < 0.001$, **$p < 0.01$, * $p < 0.05$.

Table D.4. Bias-corrected bootstrapped confident intervals of the indirect effects.

Mediation path	*B*	SE	95% CI for indirect effect	
(IV → MV→ DV)			Lower limit	Upper limit
Within school				
INT → SI	0.691	0.148	0.470	1.065
Specific 1: INT → SE → SI	0.315	0.065	0.216	0.475
Specific 2: INT → ATT → SI	0.375	0.128	0.163	0.673
EXT → SI	-0.049	0.043	-0.148	0.022
Specific 1: EXT → SE → SI	0.011	0.024	-0.037	0.057
Specific 2: EXT → ATT → SI	-0.060	0.027	-0.131	-0.018
Outside school				
INT → SI	0.553	0.157	0.287	0.853
Specific 1: INT → SE → SI	0.496	0.093	0.350	0.721
Specific 2: INT → ATT → SI	0.057	0.166	-0.362	0.260
EXT → SE →SI	0.010	0.044	-0.089	0.087
Specific 1: EXT → SE → SI	0.019	0.037	-0.057	0.088
Specific 2: EXT → ATT → SI	-0.009	0.027	-0.051	0.047

Note. B indicates the strength of the indirect effect.

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Appendix E. The remaining items for each variable

INT
1. Because this represents a meaningful choice to me.
2. Because this is an important goal to me.
3. Because I enjoy doing it.
4. Because it's fun.

EXT
1. Because that's something others (principals, colleagues, etc.) want me to do.
2. Because others (principals, colleagues, etc.) oblige me to do so.
3. Because that's what others (principals, colleagues, etc.) expect me to do.

SE
1. It's easy for me to share digital educational resources.
2. I have enough skills to share digital educational resources.
3. I can help others if they have digital educational resources sharing-related questions.

ATT
1. If I share my digital educational resources, I feel enjoyable.
2. If I share my digital educational resources, I feel valuable.
3. If I share my digital educational resources, I feel beneficial.

SC
1. In our school, there are sufficient supports for sharing digital educational resources.
2. In our school, teachers share conceptions and ideas about their educational vision.
3. In our school, teachers share knowledge about developments in education.
4. In our school, teachers share knowledge and experiences about changes they implemented in their lesson practices.

WP
1. Do you have to work very fast?
2. Do you have too much work to do?
3. Do you need to work extra hard to get your work done?

SIIS
1. How big is the chance for you to share digital educational resources in school
2. Do you plan to share digital educational resources in school?
3. Do you intend to share digital educational resources in school?

SIOS
1. How big is the chance for you to share digital educational resources outside school
2. Do you plan to share digital educational resources outside school?
3. Do you intend to share digital educational resources outside school?

SBIS
1. Digital text
2. Micro lecture/ micro video
3. Subject software and tools

SBOS
1. Electronic lesson plans
2. Exercises
3. Digital text
4. Micro lecture/ micro video
5. Subject software and tools

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Appendix F. References of studies included in the present meta-analysis

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Appendix G. Overview of studies included in the meta-analysis

Study	Region	Community type	SES	Education level	Learning environment	School subjects	Mobile technologies used in intervention group	Student-to-hardware ratio in intervention group	Teaching method in intervention group	Duration of the intervention	Research design	Instructor equivalence	Learning topic/ content equivalence	Software/ tool equivalence	Degree of technology use in control group	Procedure of effect size extraction
Al-Balushi, Al-Musawi, Ambusaidi, and Al-Hajri (2017)	Oman	Not reported	Not low	Secondary school	Formal setting	Science	Handheld devices with multiple functions	Own	Mixed	> 4 weeks	Quasi-experimental	Different	Same	Same	Pen-and-paper	Calculated from exact descriptive
Alcoholado,-Diaz,Tagle, Nussbaum, and Infante (2016)	Chile	Not reported	Low	Primary school	Formal setting	Mathematics	Handheld devices with multiple functions	[a] Shared: comparison 1; own: comparison 2	Computer-assisted testing/ assessment	> 4 weeks	Quasi-experimental	Same	Same	Same	Pen-and-paper	Calculated from exact descriptive
Alfadil (2020)	Saudi Arabia	Not reported	Not low	Secondary school	Formal setting	Language arts	Handheld devices with multiple functions	Shared	Game-based learning	1 day-4 weeks	Quasi-experimental	Same	Same	Not reported	Pen-and-paper	Calculated from exact descriptive
Cavus and Ibrahim (2017)	Cyprus	Not reported	Not low	Secondary school	Unrestricted	Language arts	Handheld devices with multiple functions	Own	Self-directed learning	1 day-4 weeks	Experimental	Not reported	Same	Same	Pen-and-paper	Calculated from exact descriptive
Çetinkaya and Sütçü (2018)	Turkey	Not reported	Not low	Secondary school	Unrestricted	Language arts	Handheld devices with multiple functions	Own	Self-directed learning	> 4 weeks	Quasi-experimental	Same	Same	Different	Not reported	Calculated from exact descriptive
Chang et al. (2020)	Taiwan	Not reported	Not low	Secondary school	Formal setting	Science	Handheld devices with multiple functions	Shared	Mixed	< 1 day	Quasi-experimental	Same	Same	Different	Traditional technology	Calculated from exact descriptive
Chang and Hwang (2018)	Taiwan	Not reported	Not low	Primary school	Formal setting	Science	Handheld devices with multiple functions	Not reported	Inquiry-oriented learning	1 day-4 weeks	Quasi-experimental	Same	Same	Not reported	Pen-and-paper	Calculated from exact descriptive
Chien, Tsai, Chen, Chang, and Chen (2015)	Taiwan	Urban	Not low	Secondary school	Formal setting	Science	Handheld devices with one specific function	Shared	Inquiry-oriented learning	< 1 day	Experimental	Different	Same	Same	Traditional technology	Calculated from inferential statistics
Chu (2014)	Taiwan	Not reported	Not low	Primary school	Unrestricted	Social studies	Handheld devices with one specific function	Not reported	Computer-assisted testing/ assessment	< 1 day	Experimental	Same	Same	Same	Pen-and-paper	Calculated from exact descriptive

Danaei, Jamali, Mansourian, and Rastegar-pour (2020)	Iran	Not reported	Not low	Primary school	Informal setting	Language arts	Handheld devices with multiple functions	Own	Self-directed learning	Not reported	Quasi-experimental	Not reported	Same	Same	Pen-and-paper	Calculated from inferential statistics
del Olmo-Muñoz, Cózar-Gutiérrez, and González-Calero (2020)	Spain	Not reported	Not low	Primary school	Formal setting	Professional subjects	Handheld devices with multiple functions	Own	Inquiry-oriented learning	< 1 day	Quasi-experimental	Different	Different	Different	Not reported	Calculated from exact descriptive
Edwards, Rule, and Boody (2017)	USA	Not urban	Not low	Secondary school	Formal setting	Mathematics	Handheld devices with multiple functions	Own	Lectures	Not reported	Quasi-experimental	Same	Same	Same	Pen-and-paper	Calculated from inferential statistics
Erbas and Demirer (2019)	Turkey	Not reported	Not low	Secondary school	Formal setting	Science	Handheld devices with multiple functions	Not reported	Inquiry-oriented learning	> 4 weeks	Quasi-experimental	Same	Same	Different	Pen-and-paper	Calculated from exact descriptive
Fidan & Tuncel (2019)	Turkey	Not reported	Not low	Secondary school	Formal setting	Science	Handheld devices with multiple functions	Own	Inquiry-oriented learning	> 4 weeks	Quasi-experimental	Same	Same	[a] Same: comparison 1; Different: comparison 2	Traditional technology	Calculated from exact descriptive
Furió, Juan, Seguí, and Vivó (2015)	Spain	Not reported	Not low	Primary school	Formal setting	Social studies	Handheld devices with multiple functions	Own	Game-based learning	Not reported	Experimental	Not reported	Same	Not reported	Not reported	Calculated from exact descriptive
Giasiranis and Sofos (2017	Greece	Not reported	Not low	Secondary school	Formal setting	Professional subjects	Handheld devices with multiple functions	Not reported	Inquiry-oriented learning	< 1 day	Quasi-experimental	Not reported	Same	Same	Traditional technology	Calculated from exact descriptive
Huang, Su, Yang, and Liou (2017)	Taiwan	Not reported	Not low	Primary school	Formal setting	Mathematics	Handheld devices with one specific function	Own	[a] Inquiry-oriented learning: comparison 1; Lectures: comparison 2	1 day-4 weeks	Quasi-experimental	Different	Same	Same	Pen-and-paper	Calculated from exact descriptive
Huang, Yang, Chiang, and Su (2016)	Taiwan	Not reported	Not low	Primary school	Informal setting	Language arts	Handheld devices with multiple functions	Not reported	Self-directed learning	< 1 day	Quasi-experimental	Same	Different	Different	Pen-and-paper	Calculated from exact descriptive
Huang, Chen, and Hsu (2019)	Taiwan	Not reported	Not low	Primary school	Informal setting	Social studies	Handheld devices with multiple functions	Own	Inquiry-oriented learning	< 1 day	Quasi-experimental	Different	Same	Same	Pen-and-paper	Calculated from inferential statistics

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Huang and Lin (2017)	Taiwan	Not reported	Not low	Primary school	Informal setting	Science	Handheld devices with multiple functions	Not reported	Inquiry-oriented learning	< 1 day	Experimental	Same	Same	Different	Pen-and-paper	Calculated from exact descriptive
Huang, Shadiev, Sun, Hwang, and Liu (2017)	Taiwan	Not reported	Not low	Secondary school	Formal setting	Language arts	Handheld devices with multiple functions	Own	Inquiry-oriented learning	> 4 weeks	Quasi-experimental	Same	Same	Same	Pen-and-paper	Calculated from exact descriptive
Hung, Xu, and Lin (2020)	Mainland China	Urban	Not low	Primary school	Formal setting	Science	Not reported	Own	Inquiry-oriented learning	< 1 day	Quasi-experimental	Different	Same	Same	Traditional technology	Calculated from exact descriptive
Hung and Young (2015)	Taiwan	Not reported	Not low	Primary school	Formal setting	Language arts	Handheld devices with multiple functions	Own	Inquiry-oriented learning	< 1 day	Quasi-experimental	Not reported	Same	Same	Pen-and-paper	Calculated from exact descriptive
Hwang, Zhao, Shadiev, Lin, Shih, and Chen (2020)	Taiwan	Not reported	Not low	Primary school	Informal setting	Social studies	Handheld devices with multiple functions	Not reported	Inquiry-oriented learning	> 4 weeks	Quasi-experimental	Same	Same	Same	Pen-and-paper	Calculated from exact descriptive
Jere-Folotiya et al. (2014)	Zambian	Not reported	Not low	Primary school	Formal setting	Language arts	Handheld devices with multiple functions	Not reported	Game-based learning	1 day-4 weeks	Quasi-experimental	Different	Different	Different	Not reported	Calculated from exact descriptive
Jong, Chan, Hue, and Tam (2018) Sample 1	Hongkong	Not reported	Not low	Secondary school	Informal setting	Social studies	Handheld devices with multiple functions	Not reported	Mixed	< 1 day	Quasi-experimental	Different	Same	Same	Pen-and-paper	Calculated from exact descriptive
Jong, Chan, Hue, and Tam (2018) Sample 2	Hongkong	Not reported	Not low	Secondary school	Informal setting	Social studies	Handheld devices with multiple functions	Not reported	Mixed	< 1 day	Quasi-experimental	Different	Same	Same	Pen-and-paper	Calculated from exact descriptive
Jong, Chan, Hue, and Tam (2018) Sample 3	Hongkong	Not reported	Not low	Secondary school	Informal setting	Social studies	Handheld devices with multiple functions	Not reported	Mixed	< 1 day	Quasi-experimental	Different	Same	Same	Pen-and-paper	Calculated from exact descriptive
Joo-Nagata, Abad, Giner, & García-Peñalvo (2017)	Chile	Urban	Not low	Primary school	Informal setting	Social studies	Handheld devices with multiple functions	Not reported	Computer-assisted testing/ assessment	< 1 day	Quasi-experimental	Not reported	Same	Same	Traditional technology	[c] Calculated from exact descriptive/ Calculated from inferential statistics
Khan, Hwang, Azeem Abbas, and Rehman (2019) Sample 1	Pakistan	Not urban	Not low	Primary school	Formal setting	Language arts	Handheld devices with multiple functions	Own	Game-based learning	1 day-4 weeks	Quasi-experimental	Different	Same	Same	Pen-and-paper	Calculated from exact descriptive

Khan, Hwang, Azeem Abbas, and Rehman (2019) Sample 2	Pakistan	Not urban	Not low	Primary school	Formal setting	Language arts	Handheld devices with multiple functions	Own	Game-based learning	1 day-4 weeks	Quasi-experimental	Different	Same	Same	Pen-and-paper	Calculated from exact descriptive
Ku, Huang, and Hus (2015)	Taiwan	Not reported	Not low	Primary school	Informal setting	Social studies	Handheld devices with one specific function	Not reported	Game-based learning	Not reported	Quasi-experimental	Same	Same	Not reported	Traditional technology	Calculated from exact descriptive
Lai, Chen, and Lee (2019)	Taiwan	Not reported	Not low	Primary school	Formal setting	Science	Handheld devices with multiple functions	Own	Mixed	1 day-4 weeks	Quasi-experimental	Same	Same	Same	Traditional technology	Calculated from exact descriptive
Lee, Hao, Lee, Sim, and Huang (2019)	Taiwan	Not urban	Low	Secondary school	Formal setting	Science	Handheld devices with one specific function	Own	Computer-assisted testing/ assessment	> 4 weeks	Quasi-experimental	Same	Different	Different	Traditional technology	Calculated from exact descriptive
Lin (2014)	Taiwan	Not reported	Not low	Secondary school	Formal setting	Language arts	Handheld devices with multiple functions	Own	Inquiry-oriented learning	> 4 weeks	Quasi-experimental	Same	Same	Same	Traditional technology	Calculated from exact descriptive
Lin (2017)	Taiwan	Not reported	Not low	Secondary school	Formal setting	Language arts	Handheld devices with multiple functions	Own	Inquiry-oriented learning	1 day-4 weeks	Quasi-experimental	Different	Same	Same	Pen-and-paper	Calculated from exact descriptive
Nikou and Economides (2018)	Europe	Not reported	Not low	Secondary school	Informal setting	Science	Mixed	Own	Computer-assisted testing/ assessment	> 4 weeks	Experimental	Same	Same	Same	Pen-and-paper	Calculated from exact descriptive
Outhwaite, Gulliford, and Pitchford (2017) Study 1	UK	Not reported	Low	Primary school	Formal setting	Mathematics	Handheld devices with multiple functions	Own	Not reported	> 4 weeks	Quasi-experimental	Different	Not reported	Not reported	Not reported	Calculated from inferential statistics
Outhwaite, Gulliford, and Pitchford (2017) Study 4	Uk	Not reported	Not low	Primary school	Formal setting	Mathematics	Handheld devices with multiple functions	Own	Not reported	> 4 weeks	Quasi-experimental	Same	Not reported	Not reported	Traditional technology	Calculated from exact descriptive
Passig, Tzuriel, and Eshel-Kedmi (2016)	Israel	Urban	Not low	Primary school	Formal setting	Mathematics	Handheld devices with multiple functions	Own	Computer-assisted testing/ assessment	< 1 day	Experimental	Same	Same	Not reported	Pen-and-paper	Calculated from exact descriptive
Purba, Hwang, Pao, and Ma (2019)	Taiwan	Not reported	Not low	Secondary school	Unrestricted	Science	Handheld devices with multiple functions	Not reported	Inquiry-oriented learning	1 day-4 weeks	Quasi-experimental	Same	Same	Same	Pen-and-paper	Calculated from exact descriptive

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Quintas, Bustamante, Pradas, and Castellar (2020)	Spain	Urban	Not low	Primary school	Formal setting	Science	Handheld devices with multiple functions	Own	Game-based learning	1 day-4 weeks	Quasi-experimental	Same	Same	Different	Pen-and-paper	Calculated from exact descriptive
Ruiz-Ariza, Casuso, Suarez-Manzano, and Martínez-López (2018)	Spain	Not reported	Not low	Secondary school	Informal setting	Not reported	Handheld devices with multiple functions	Own	Game-based learning	> 4 weeks	Experimental	Not reported	Different	Different	Not reported	[b] Calculated from exact descriptive/ Calculated from inferential statistics
Sahin and Yilmaz (2020)	Turkey	Not reported	Not low	Secondary school	Formal setting	Science	Not reported	Not reported	Lectures	1 day-4 weeks	Quasi-experimental	Different	Same	Different	Pen-and-paper	Calculated from exact descriptive
Shadiev, Hwang, Huang, and Liu. (2015)	Taiwan	Not reported	Not low	Secondary school	Formal setting	Language arts	Handheld devices with multiple functions	Not reported	Self-directed learning	> 4 weeks	Quasi-experimental	Not reported	Same	Same	Pen-and-paper	Calculated from exact descriptive
Shadiev, Hwang, and Liu (2018)	Taiwan	Not reported	Not low	Secondary school	Formal setting	Language arts	Handheld devices with multiple functions	Not reported	Self-directed learning	1 day-4 weeks	Quasi-experimental	Same	Same	Same	Pen-and-paper	Calculated from exact descriptive
Stanojević and Ranđelović (2018)	Serbia	Not reported	Not low	Secondary school	Formal setting	Professional subjects	Handheld devices with multiple functions	Own	Computer-assisted testing/ assessment	1 day-4 weeks	Quasi-experimental	Same	Same	Same	Pen-and-paper	Calculated from exact descriptive
Su and Cheng (2015)	Taiwan	Not reported	Not low	Primary school	Informal setting	Science	Handheld devices with multiple functions	Own	[a] Mixed: comparison 1; Inquiry-oriented learning: comparison 2	1 day-4 weeks	Quasi-experimental	Same	Not reported	Not reported	Pen-and-paper	Calculated from exact descriptive
Sung, Hwang, Lin, and Hong (2017)	Taiwan	Urban	Not low	Primary school	Formal setting	Language arts	Handheld devices with multiple functions	Not reported	Game-based learning	< 1 day	Quasi-experimental	Not reported	Same	Not reported	Traditional technology	Calculated from exact descriptive
Vanbecelaere, Van den Berghe, Cornillie, Sasanguie, Reynvoet, and Depaepe (2020)	Belgium	Not reported	Not low	Primary school	Formal setting	[b] Language arts/ Mathematics	Handheld devices with multiple functions	Own	Game-based learning	> 4 weeks	Quasi-experimental	Not reported	Same	Same	Pen-and-paper	Calculated from exact descriptive

Volk, Cotič, Zajc, and Starcic (2017)	Slovenian	Not reported	Not low	Primary school	Formal setting	Mathematics	Handheld devices with multiple functions	Own	Mixed	> 4 weeks	Quasi-experimental	Different	Same	Same	Pen-and-paper	Calculated from exact descriptive
Walczak and Taylor (2018)	USA	Not urban	Low	Primary school	Formal setting	Social studies	Handheld devices with multiple functions	Shared	Mixed	1 day-4 weeks	Experimental	Different	Same	Different	Pen-and-paper	Calculated from inferential statistics
Wang (2016)	Taiwan	Not reported	Not low	Secondary school	Informal setting	Language arts	Handheld devices with multiple functions	Own	Self-directed learning	1 day-4 weeks	Quasi-experimental	Same	Same	Same	Pen-and-paper	Calculated from exact descriptive
Wang (2017a)	Taiwan	Urban	Not low	Secondary school	Unrestricted	Language arts	Handheld devices with multiple functions	Own	Self-directed learning	1 day-4 weeks	Quasi-experimental	Not reported	Same	Same	Pen-and-paper	Calculated from exact descriptive
Wang (2017b)	Taiwan	Not reported	Not low	Secondary school	Formal setting	Language arts	Handheld devices with multiple functions	Own	Computer-assisted testing/ assessment	1 day-4 weeks	Quasi-experimental	Same	Not reported	Not reported	Pen-and-paper	Calculated from inferential statistics
Wollscheid, Sjaastad, Tømte, and Løver (2016)	Oslo	Not urban	Not low	Primary school	Formal setting	Language arts	Handheld devices with multiple functions	Own	Not reported	> 4 weeks	Quasi-experimental	Different	Not reported	Not reported	Pen-and-paper	Calculated from exact descriptive
Yallihep and Kutlu (2020)	Turkey	Not reported	Not low	Primary school	Formal setting	Professional subjects	Handheld devices with multiple functions	Not reported	Game-based learning	1 day-4 weeks	Quasi-experimental	Same	Same	Different	Not reported	Calculated from exact descriptive
Zhang, Sung, Hou, and Chang (2014) sample 1	Taiwan	Not reported	Not low	Primary school	Formal setting	Science	Handheld devices with multiple functions	Not reported	Inquiry-oriented learning	< 1 day	Quasi-experimental	Different	Same	Same	Pen-and-paper	Calculated from exact descriptive
Zhang, Sung, Hou, and Chang (2014) Sample 2	Taiwan	Not reported	Not low	Primary school	Informal setting	Science	Handheld devices with multiple functions	Not reported	Inquiry-oriented learning	< 1 day	Quasi-experimental	Different	Same	Same	Pen-and-paper	[c] Calculated from exact descriptive/ Calculated from inferential statistics
Zheng, Warschauer, Hwang, and Collins (2014)	USA	Urban	Low	Primary school	Unrestricted	Science	Handheld devices with multiple functions	Own	Inquiry-oriented learning	> 4 weeks	Quasi-experimental	Different	Not reported	Not reported	Not reported	Calculated from inferential statistics

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Zhu and Urhahne (2018)	Germany	Not reported	Not low	Secondary school	Formal setting	Mathematics	Handheld devices with multiple functions	Own	Computer-assisted testing/assessment	> 4 weeks	Quasi-experimental	Different	Same	Not reported	Not reported	Calculated from exact descriptive

[a] variables were different in the comparison groups for the same outcome variable.
[b] both variables were presented in one comparison group for the same outcome variable.
[c] both variables were presented in one comparison group for the different outcome variables

Appendix H. Moderator analyses for affective and behavioral outcome variables

Table H.1. Moderator analyses and weighted mean effect sizes for affective outcome variables.

Moderator category	Moderator variables	N	*g*	SE	95% CI	Q_B	*p*
Teaching context	**Education level**						
	Primary school	14	0.449	0.165	[0.126, 0.773]	0.523	0.470
	Secondary school	10	0.613	0.154	[0.311, 0.915]		
	Learning environment						
	Formal settings	18	0.548	0.156	[0.243, 0.854]	0.075	0.784
	Informal settings	5	0.483	0.177	[0.136, 0.831]		
	School subjects						
	Language arts	5	0.459	0.166	[0.133, 0.785]	1.809	0.179
	Science	10	0.846	0.234	[0.386, 1.305]		
Learning process	**Teaching method**						
	Inquiry-oriented learning	10	0.729	0.238	[0.262, 1.196]	3.949	0.052
	Game-based learning	6	0.216	0.114	[-0.007, 0.439]		
	Duration of the intervention						
	< 1 day	7	0.370	0.169	[0.038, 0.702]	0.636	0.728
	1 day-4 weeks	8	0.612	0.302	[0.020, 1.204]		
	> 4 weeks	8	0.518	0.181	[0.163, 0.872]		

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Study quality	**Research design**						
	Quasi-experimental	20	0.484	0.139	[0.212, 0.757]	0.410	0.522
	Experimental	4	0.645	0.208	[0.236, 1.053]		
	Instructor equivalence						
	Same	12	0.767	0.194	[0.386, 1.148]	1.377	0.241
	Different	4	0.300	0.347	[-0.380, 0.980]		
	Learning topic/ content equivalence						
	Same	20	0.590	0.141	[0.314, 0.866]	5.713	0.017
	Different	4	0.169	0.106	[-0.039, 0.377]		
	Software/ tool equivalence						
	Same	11	0.342	0.128	[0.091, 0.594]	0.562	0.454
	Different	10	0.502	0.170	[0.170, 0.834]		
	Degree of technology use in the control group						
	Pen-and-paper	12	0.498	0.198	[0.110, 0.886]	0.254	0.614
	Traditional technology	8	0.631	0.175	[0.289, 0.973]		

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Table H.2. Moderator analyses and weighted mean effect sizes for behavioral outcome variables.

Moderator category	Moderator variables	N	g	SE	95% CI	Q_B	p
Teaching context	**Education level**						
	Primary school	10	0.610	0.165	[0.286, 0.934]	0.298	0.585
	Secondary school	4	0.334	0.479	[-0.605, 1.272]		
	School subjects						
	Language arts	4	0.555	0.299	[-0.031, 1.141]	0.174	0.677
	Science	7	0.707	0.211	[0.294, 1.120]		
Learning process	**Duration of the intervention**						
	< 1 day	6	0.581	0.275	[0.042, 1.119]	0.021	0.885
	1 day-4 weeks	6	0.628	0.179	[0.278, 0.978]		
Study quality	**Instructor equivalence**						
	Same	7	0.574	0.199	[0.184, 0.964]	0.001	0.979
	Different	5	0.563	0.367	[-0.156, 1.282]		
	Software/ tool equivalence						
	Same	8	0.787	0.176	[0.442, 1.132]	5.423	0.020
	Different	5	0.070	0.253	[-0.426, 0.565]		

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Appendix I. Overview of the measurements and their constituting items

Items marked with an asterisk indicate items included in the multilevel analysis.

Teacher beliefs
*SN1: In the smart classroom, students can get the chance to talk to each other.
*SN2: In the smart classroom, students can ask each other to explain their ideas.
SN3: In the smart classroom, students can ask each other to explain their ideas.
*SN4: In the smart classroom, students can discuss with each other how to conduct investigations.
*SN5: In the smart classroom, students can discuss their ideas with each other.
*IL1: In the smart classroom, students can find out answers to questions by investigation.
*IL2: In the smart classroom, students can carry out investigations to test their own ideas.
*IL3: In the smart classroom, students can conduct follow-up investigations to answer their new questions.
*IL4: In the smart classroom, students can design their own ways of investigating problems.
*IL5: In the smart classroom, students can approach the problem from more than one perspective.
*RT1: In the smart classroom, students can think deeply about how they learn.
*RT2: In the smart classroom, students can think deeply about their own ideas.
*RT3: In the smart classroom, students can think deeply about new ideas.
*RT4: In the smart classroom, students can think deeply about how to become better learners.
*RT5: In the smart classroom, students can think deeply about their own understanding.
*FD1: In the smart classroom, students can have enough workspaces to use digital devices and learning resources.
*FD2: In the smart classroom, students can have an atmosphere which is comfortable to be in.
*FD3: In the smart classroom, students can have flexible furniture arrangements for multiple learning purposes.
*FD4: In the smart classroom, students can have visual displays that support teacher and student interactions.
*FD5: In the smart classroom, students can have enough space for multiple small group discussions.
*CN1: In the smart classroom, I feel like the students and I care about each other.
*CN2: In the smart classroom, I feel connected to the students in the class.
*CN3: In the smart classroom, I feel a spirit of community.
*CN4: In the smart classroom, I feel that this class is like a family.

*CN5: In the smart classroom, I feel a sense of trust toward others.
*EU1: The smart classroom can provide strong and reliable wireless connectivity.
*EU2: The smart classroom can have user-friendly learning devices and software.
*EU3: The smart classroom can use learning devices and software that take only a short time to learn how to use.
*EU4: The smart classroom can have learning devices and software which are fun to use.
*EU5: The smart classroom can use technology which is easy to navigate.
*PU1: The smart classroom can benefit my teaching experience.
*PU2: The smart classroom can present information in meaningful ways.
*PU3: The smart classroom can improve students' abilities to communicate with others.
*PU4: The smart classroom enables opportunities for engagement and interaction
*PU5: The smart classroom enables technology that is useful in a wide range of ways.
*MS1: The smart classroom enables discussion on a learning topic through teacher and student perspectives.
*MS2: The smart classroom enables presentation of a learning topic by personal research, group discussion, and lecture.
*MS3: The smart classroom enables exploration of various information sources during learning.
*MS4: The smart classroom can share content from me and my students through digital devices.
*MS5: The smart classroom can provide a combination of face-to-face and digital instruction.
Classroom process quality: Instructional quality
SN1: In the smart classroom, students got the chance to talk to each other.
SN2: In the smart classroom, students asked each other to explain their ideas.
*SN3: In the smart classroom, students discussed with each other how to conduct investigations.
SN4: In the smart classroom, students discussed their ideas with each other.
IL1: In the smart classroom, students found out answers to questions by investigation.
*IL2: In the smart classroom, students carried out investigation to test their own ideas.
*IL3: In the smart classroom, students conducted follow-up investigation to answer their new questions.
IL4: In the smart classroom, students designed their own ways of investigating problems.
IL5: In the smart classroom, students approached the problem from more than one perspective.
RT1: In the smart classroom, students thought deeply about how they learn.
RT2: In the smart classroom, students thought deeply about their own ideas.

*RT3: In the smart classroom, students thought deeply about new ideas.
RT4: In the smart classroom, students thought deeply about how to become better learners.
RT5: In the smart classroom, students thought deeply about their own understanding.
*CN1: In the smart classroom, I felt like the students and teacher care about each other.
CN2: In the smart classroom, I felt connected to the teacher and students in the class.
*CN3: In the smart classroom, I felt a spirit of community.
*CN4: In the smart classroom, I felt that this class is like a family.
CN5: In the smart classroom, I felt a sense of trust toward others.
CM1: In the smart classroom, none of the students disturbed the lesson.
CM2: In the smart classroom, students were quiet when the teacher spoke.
CM3: In the smart classroom, everybody listened and students were quiet.
CM4: In the smart classroom, nobody interrupted with talking.
CM5: In the smart classroom, everybody followed the teacher.
Classroom process quality: The use of technology
DD1: Digital devices for the teacher and whole class (e.g., projection screen, interactive whiteboard, and touch screen television).
*DD2: Mobile devices for the teacher and individual student (e.g., laptop, tablet, and smart phone).
DR1: Multimedia courseware
*DR2: Multimedia material (text, pictures, animation, video, audio, etc.)
*DR3: Question bank/test papers
*DR4: Subject software and tools (Geometry, virtual lab, etc.)
DR5: Thematic page/website
DR6: E-textbook/ periodicals
*DR7: Course management software
Student engagement
*BE1: In the smart classroom, I listened carefully in class.
*BE2: In the smart classroom, I paid attention in class.
*BE3: In the smart classroom, the first time my teacher talked about a new topic, I listened very carefully.
*BE4: In the smart classroom, I asked questions.
CE1: In the smart classroom, when doing the assignment, I tried to relate what I was learning to what I already know.
CE2: In the smart classroom, while studying, I tried to connect what I was learning with my own experiences.
CE3: In the smart classroom, I tried to make all the different ideas fit together and made sense.
*EE1: I felt curious about what we were learning.
EE2: I felt interested about what we were learning.
EE3: I enjoyed the class.

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Summary

Chapter 1: General introduction

The integration of technology in schools has been recognized as critical in achieving digital equity in education as well as school improvement, high-quality teaching and learning. However, we still see inadequate or ineffective use of technology in teaching and learning. In addition to providing Internet-connected computers in the classroom and using technologies for replicating traditional teaching and learning, effective technology integration in education system necessitates a long-term and sustained improvement in primary and secondary schools as a result of the adoption of technology to support students in their knowledge construction. Despite the fact that many studies have stressed the importance of technology integration for educational equity and education for all, there are several gaps in how technology integration can be approached in policy plans, implemented in pedagogical practices, and adopted by teachers and students.

Technology integration in education has long been regarded as complex and multifaceted. It can be understood by a range of social, organizational, personal, contextual, and technological factors that can change over time. In line with this, several conceptual models about the factors affecting teachers' technology use have been developed to guide research and practice, with a tendency to incorporate variables from different educational system levels into a multilevel structure. In this dissertation, building upon current models and elaborating on specific contextual aspects, various factors at different levels that are likely to influence teacher practices in primary and secondary education were investigated.

Regarding the technical innovation and integration, knowledge on how educational practitioners respond to a new program or innovation (e.g., integrating mobile technology in education) is somewhat fragmented and inconsistent. Thus, evaluation of current technology integration in education is vital for policymakers, school leaders, and teacher educators to decide on infrastructure investments, teacher professional development, and supporting logistics. In this dissertation, to provide a broader perspective and more in-depth understanding of students' learning with mobile technology, we examined the overall effects of mobile technology usage in primary and secondary education and the underlying relations among teacher factors, classroom process quality, and student engagement in the context of smart classroom learning environments in secondary education.

Enhancing teacher practices and student outcomes has been implemented worldwide to improve teaching and learning quality. The Chinese context is an example of newly emerging economies, and the findings of the empirical studies in this dissertation could be converted into broader contexts. For a long time, there have been significant educational gaps between eastern and western areas and between urban and rural schools. The Chinese government has therefore provided special funds and projects for schools located in Western and rural areas since the beginning of the 21st century, with the hope that technology can support disadvantaged groups and equalize educational opportunities. Knowledge about education and technology primarily flows from developed eastern regions to the less developed western regions and from the urban areas to the rural areas in China. Since connectivity was prioritized over potential pedagogical impacts, many previous initiatives did not achieve the planned educational goals. To address this, several national ICT policy plans have been developed. Meanwhile, local governments have formulated and implemented their policy plans under the call of the central government in the national plan. The central idea behind these ICT policy plans was to move beyond traditional teaching and the shift to teaching and learning using new technologies and integrating a more learner-centered pedagogy.

In this dissertation, we aim to gain more comprehensive knowledge of the pedagogical use of technology for teaching and learning in primary and secondary education through a holistic view from a range of educational stakeholders, technological practices, and contexts. We mainly focus on the link between ICT policy plans and ICT practices in rural schools, rural teachers' pedagogical practices with digital educational resources, and students' learning with mobile technology. Five studies have been performed to achieve this goal, enabling one to gain broader, more profound knowledge on technology integration in education.

Chapter 2: Integrating ICT in Chinese rural schools

This exploratory research aimed to know more about whether and how local ICT policy plans are connected with the ICT practices in the context of rural schools in China. Since research has often overlooked the complex and dynamic nature of technology integration in education, our interest in the rural context focuses on how these technology integration practices are affected by broader political, cultural, and social contexts of teaching in terms of connecting rural schools to quality education. This study used the Four in Balance (FIB) model as a framework to examine the content of ICT policy plans that have been developed by local educational departments as well as how school leaders and teachers perceive their experience with ICT practices of rural schools. The FIB model assumes that technology integration in the classroom is determined by four essential elements (i.e., vision, expertise, digital content, and ICT infrastructure) as well as leadership, support, and collaboration. This study was driven by two research questions: (1) How are elements of ICT integration in schools represented in local ICT policy plans? (2) What are rural school practices with ICT from the perspectives of both school leaders and teachers? A mixed-method research approach was used, involving 25 rural schools in three regions in Western China. Data was obtained from various sources (policy documents, interviews with school leaders, focus groups with teachers, classroom observations, an ICT inventory, and a teacher survey). Three local ICT policy plans were examined using the directed content analysis. Other qualitative sources (i.e., interviews with school leaders, focus groups with teachers, classroom observations, and an ICT inventory) were examined using within- and cross-case analyses. The teacher survey was analyzed using descriptive statistics.

In this first study, we found that all elements in the FIB model were identified in the local ICT policy plans, and these factors influenced teachers' pedagogical use of ICT for teaching and learning. It is worth noting that the schools that were most effective in integrating innovative ICT were those pilot schools, characterized with having the most materials (e.g., proposals for applying pilot schools and annual reporting materials) and shared vision regarding the innovative use of ICT, the use of 1:1 mobile technology (i.e., clickers and tablets) in smart classrooms. When comparing the teaching and learning practices in pilot schools to other rural schools, we found that it is important to consider the policy and school context when introducing new technology. Moreover, this study emphasizes rural teachers' high-level competencies in relation to the integration of innovative technology. For teachers who were not in pilot schools, to allow them to be active in ICT integration in rural schools, a collaboration based on teachers' needs and their geographical settings could be a practical approach to explore. In conclusion, the findings revealed three types of challenges for ICT integration in rural schools: (1) guidance and learning opportunities as a political challenge, (2) sound ICT infrastructure and appropriate digital content as a technical challenge, and (3) teacher training and technical support as a human challenge. These challenges have implications for policymakers and practitioners when improving rural education through ICT integration.

Chapter 3: Rural teachers' use of digital educational resources

In Chapter 3, we employed a quantitative study to explore the types of digital educational resources (DERs) teachers used for teaching, as well as which school- and teacher-level factors affected their behavior regarding using DERs. The target population in this study were rural teachers in three areas in Western China, which have been encouraged to use DERs under the national and local call. The Integrative Model of Behavior Prediction (IMBP) was applied as a framework and investigated the relations between teacher-level factors (i.e., attitude, self-efficacy, subjective norm, behavioral intention, knowledge and skills, and facilitating conditions) and teachers' frequency of DERs usage in rural schools. Furthermore, we included school location and school type as school-level variables, given the potential impact of school-level factors on teachers' DERs usage in the Chinese rural context. As a result, all rural school types were represented in this study. Teachers' views of school and teacher-level variables that may affect their use of DERs and their actual behavior of using DERs were obtained using a self-reported questionnaire. Multilevel analyses were performed on 462 rural teachers in 25 primary and secondary schools, taking into account the nested structure.

Despite the fact that various types of DERs were used, the findings showed that traditional DERs (e.g., electronic lesson plans/ instruction design, and multimedia courseware) were used much more often than those more complex DERs (e.g., micro-teaching videos, subject software and tools). Moreover, the multilevel analysis results favored the hierarchical structure of the data, with teachers within schools. However, the results further suggested that teacher-level variables accounted for most of the variance in explaining the differences of teacher's use of DERs. Since the investigated factors (i.e., school type and school location) were not significant predictors of teacher behavior, it is still unknown which school-level factors could explain teachers' behavior regarding using DERs. With regard to teacher-level factors and unexpectedly, the hypothesized relations in IMBP, that self-efficacy, subjective norm, and intention to use could influence technology behavior, were not supported by our data. However, the findings indicated that among the significant positive factors in IMBP (i.e., attitude, knowledge and skills, and facilitating conditions), facilitating conditions was the weakest one. To increase teachers' use of DERs, it is worthy of the efforts put in increasing the level of teachers' attitude, and knowledge and skills. These findings suggest that teacher factors have an important role in understanding their behavior in using DERs in pedagogical practices, directing future studies to focus on teacher-relevant factors, such as motivation for using technology and general beliefs about teaching and learning.

Chapter 4: Rural teachers' sharing of digital educational resources

After addressing which factors explaining teachers' behavior of using DERs, in Chapter 4, the focus moved to teachers' behavior of sharing behavior in order to promote teacher professional learning opportunities and development. To achieve this purpose, the understanding of sharing behavior necessitates an emphasis placed on teacher motivation, as well as a distinction of the sharing contexts between sharing behavior regarding DERs within and outside school. The primary research question is 'how is motivation related to sharing behavior regarding digital educational resources within and outside school?'. To explore the underlying relationships, the core variables in IMBP (i.e., attitude, self-efficacy, subjective norm, intention) were included, and the list of determinants was extended to include motivation as the origin of behavior. In addition, the proposed research model contains two environmental variables (i.e., sharing climate and work pressure) that may influence teachers' sharing behavior. Rural teachers in southwest China were invited to participate in this study through convenient sampling with an online survey. In total, 709 valid responses were collected and analyzed using the Structural Equation Modeling in Mplus 8.3. According to our preliminary results, internal motivation and external motivation reflected the teachers' overall motivation, whereas subjective norm was excluded from the research model.

While the results reported in Chapter 3 showed that attitude was the strongest predictor of teachers' using behavior regarding DERs, the findings in Chapter 4 indicate that attitude was only found to be negatively linked to sharing behavior outside school, suggesting that role of variables in the research model might differ depending on the context. Likewise, intention and sharing climate was only related to sharing behavior outside school but not within school. Moreover, and unexpected, work pressure did not affect sharing behavior in both contexts. With regard to motivation, internal motivation was positively but external motivation was negatively related to sharing behavior in two contexts. The findings suggest that external motivation (e.g., expectation from others to share DERs) can discourage sharing behavior, but internal motivation (e.g., personal interest and value in sharing DERs) can encourage sharing behavior. Another important factor was self-efficacy, which was a positive and significant predictor for both sharing intention and actual behavior in both contexts. In respect to mediated relations, the most important finding was the mediating role of self-efficacy between internal motivation and sharing intention in both contexts.

The findings indicate that the higher the internal motivation from rural teachers is and the higher their level of self-efficacy, the more they contribute their DERs. The finding suggests that the priority should be shifted from external expectations to internal motivation and from developing a positive attitude to developing stronger self-efficacy to promote teachers' sharing behavior.

Chapter 5: The effects of mobile technology usage on learning outcomes

Having identified technology integration in terms of what technologies are being used by teachers, how teachers used these technologies in their pedagogical practices, and what individual and organizational factors have an impact on their practices, we consider technology integration in terms of students' use of mobile technology to provide examples of a series of elements that may contribute to higher learning outcomes. The purpose of this study was to investigate whether mobile technology intervention would improve various learning outcomes of primary and secondary students. To quantify the overall effectiveness of integrating mobile technology for learning and explore which factors explain the differences in results, we employed a meta-analysis to compare mobile learning effects with traditional learning on cognitive, affective, and behavioral learning outcomes. Unlike previous meta-analysis studies, this study was not limited to focus on cognitive learning outcomes but also included non-cognitive learning outcomes, and we considered a series of moderators from both educational and methodological aspects. We systematically reviewed the mobile learning studies using experimental or quasi-experimental designs published between 2014 and 2020. Based on our inclusion and exclusion criteria, 61 studies of 56 peer-reviewed papers were included for the meta-analyses. We used the random-effects model to calculate the average effect sizes. Moreover, moderator analyses, sensitivity analyses, and publication bias were conducted.

In contrast to using traditional technology (e.g., desktop computers and whiteboards) or not using any technology (e.g., pen and paper), the meta-analysis results found that using mobile technology had a medium positive overall effect on student learning, including cognitive, affective, and behavioral learning outcomes. These findings suggest that there is no doubt that integrating mobile technology in primary and secondary education does improve student learning despite the potential negative effects, and it is time for policymakers to decide to scale up the use of technology in education to improve student learning. Results showed that effects varied significantly in three categories, i.e., student factor, learning process, and study quality. With regard to cognitive learning outcomes, five moderators were identified (i.e., socioeconomic status (SES), hardware used, student-to-hardware ratio, learning topic/ content equivalence, and procedure of effect size extraction). Due to the small number of studies on non-cognitive learning outcomes and missing information about the potential moderators, we only found that learning topic/ content equivalence was a significant moderator for affective learning outcomes and software/ tool equivalence was a significant moderator for behavioral learning outcomes. As a result, we recommend that future studies consider including affective and behavioral learning outcomes and provide more details, including educational and methodological information, which are essential for meta-analysis.

Chapter 6: Relations among teacher beliefs, classroom process quality, and student engagement

The findings from the study in chapter 5 indicated that students had higher cognitive learning outcomes when they used their own handheld devices with multiple-functions for learning. Therefore, we have purposefully selected teachers and students using their own tablets in smart classrooms, and all participants should at least have some experience with smart classrooms. Mobile technology alone cannot achieve effective teaching and learning in the absence of instructional quality factors, such as cognitive activation, supportive climate, and classroom management. Hence, we adopted the use of technology together with the three global dimensions that represented the classroom process quality and investigated the relationships among teacher beliefs, classroom process quality, and student engagement in smart classrooms in secondary education. We focussed on secondary education because secondary school students often have a low level of engagement because they face self-regulation challenges, especially in Asian educational systems with teacher-centered teaching practices. Data was collected from a set of teacher and student questionnaires. The teacher questionnaire collected data on teacher background information and general beliefs about teaching and learning in smart classroom learning environments, while the student questionnaire collected information on student demographic information and their perceptions of classroom process quality (i.e., cognitive activation, connectedness, classroom management, and the use of technology) and engagement during one lesson taught in the smart classroom. Because the data was considered hierarchical, with students nested in classes, multilevel regression analyses and a multilevel mediation analysis for a 2-2-1 mediation design were performed.

The findings indicated that teacher beliefs had no effects on factors of classroom process quality, including cognitive activation, connectedness, and the use of technology. Instead, teacher degree that is among teacher background factors showed significant positive effects on all classroom process quality factors. This might imply that it is teacher degree related characteristics such as the actual knowledge and experience in teaching and technology, rather than general views related to smart classroom learning environments, contribute to a higher level of instructional quality and the use of technology in smart classrooms. These insights allow for the recommendation that teacher education and professional development programs need to focus on developing teachers' personal quality. Furthermore, the classes taught by female teachers perceived a significantly higher level of cognitive activation and the classes in higher grades perceived a significantly higher level of the use of technology. With regard to student engagement, the learning environment, including high levels of cognitive activation, connectedness, and the use of technology, tended to improve student engagement most. Moreover, teachers' background characteristics (i.e., teacher degree and teaching year) were related to student engagement. However, the results show that boys perceived more engagement than their peers did. Among the factors influencing student engagement, it was found that connectedness was the most important predictor. The results suggest that classroom process quality factors, as well as teacher and student background factors, all have the potential to enhance learning, but connectedness requires great attention in smart classrooms. Finally, the mediation analysis results show that teachers owing higher degrees contributed to higher student engagement by facilitating a higher level of connectedness and the use of technology. The role of teachers and their teaching is highlighted in this study, which deserves significant investments and support in future teacher professional development.

Chapter 7: General discussion

In chapter 7, a general discussion on studies in this dissertation is provided. This chapter starts with a short introduction and a summary of main findings from the five studies. Next, we present the main discussion in terms of teacher practices and student outcomes, the strengths and reflections of these findings, and directions for future research. The chapter ends with providing practical implications for policymakers, teacher education and continuing training, school leaders, and teachers.

In conclusion, the current dissertation deepens our knowledge on (1) the available evidence for the impact of ICT policy plans, school context, and teacher-related factors on teacher practices with technology, and (2) the effects of technology integration, including but not limited to mobile technology usage, on student outcomes. First, we discuss factors influencing teachers' pedagogical practices with technology. Chapters 2 to 4 show how different variables from different levels influence teacher practices in the rural school context. Most importantly, more attention needs to be paid to teacher-related factors, such as expertise, self-efficacy, knowledge and skill, motivation, attitude, and teacher degree. Moreover, the role of these variables may differ in different contexts. Teacher practices are also influenced by school context or ICT policy plans, although their effects seem to be relatively small. Second, we discuss factors influencing student outcomes in mobile learning environments. When looking at the overall effects of mobile technology usage, finding in chapter 5 suggest that students from middle or high SES background gain higher cognitive learning outcomes when they use multifunctional mobile devices by their own. In respect to student engagement within tablet-integrated classrooms in the

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context of one-to-one technology initiative, results in chapter 6 indicate that not only the use of technology, but also instructional quality (i.e., connectedness and cognitive activation) and background factors of teacher and student can influence student engagement.

We believe that both researchers and practitioners will benefit from this research, because it not only presents an overview of conceptual model for technology integration in education with a list of key determinants for teacher practices and student learning, but also highlights the necessity of continuous efforts regarding future research and practices on technology integration. However, some caution is warranted because of not using representative samples and the nature of data collection in this dissertation.

Involving both teacher and student perspectives can enrich our understanding of technology integration practices in education. First, future research of technology integration in education should focus on enhancing teacher practices in a deeper and broader sense. For example, examining teacher behavior in terms of both quantity and quality of technology integration, and add other data collection methods such as classroom observations and/ or interviews with students. Second, when examining the underlying relationships among various factors from different levels, further studies can deepen our understanding of student learning in research by considering the hierarchical structure of data in which students are nested with classes, classes are nested within schools, and schools are nested with local authorities. Third, greater importance should be placed on whether learning with technology benefits certain student groups to provide evidence on challenges and opportunities related to digital equity.

For practices, there are some suggestions for different educational stakeholders. First, we highlight that policymakers need to work with researchers to develop ICT policy plans. The policymaking process should be iterative, requiring efforts to learn from others and pay special attention to disadvantaged student groups. Secondly, it is critical to provide teachers with many professional learning opportunities, emphasizing improving pre-service and in-service teachers' specialist knowledge, attitudes, and technology skills, and providing opportunities to apply what they have learned in training programs to their own teaching practices. Next, school leaders should improve their leadership of technology integration practices first and then develop a school policy based on school context, involving teachers' efforts, and including all elements contributing to effective technology integration in schools. Also, it is necessary for school leaders to create communities or networks and offer collaboration opportunities for teachers to connect both within and across schools, which might help long-term technology integration development. Finally, teachers need to be prepared for technology integration. For example, introducing our model in chapter 7 can give teachers an overview of the whole process of their practices and provide information on which elements have the potential to improve their teaching in technology-integrated learning environments.

Nederlandse samenvatting

Hoofdstuk 1: Introductie

Het gebruik van technologie bij het lesgeven en leren in het basis- en voortgezet onderwijs wordt gezien als veelbelovend voor het bereiken van meer gelijke kansen in het onderwijs, schoolverbetering en verbetering van de kwaliteit van onderwijs en leren. Hoewel het gebruik van technologie bij lesgeven en leren in de afgelopen jaren een hoge vlucht heeft genomen, wordt technologie nog vaak op ontoereikende wijze en zonder duidelijke doelstellingen ingezet. Effectieve inzet van technologie in het onderwijs houdt in dat meer wordt gedaan dan alleen het aanbieden van op internet aangesloten computers in de klas en het gebruik van technologie ter vervanging van meer traditionele vormen van onderwijzen en leren. Technologie in het onderwijs met het oog op optimale ondersteuning van leerprocessen vereist langdurige en aanhoudende gerichtheid op verbetering van het onderwijs. Ofschoon in veel onderzoek het belang van de inzet van technologie met het oog op gelijke kansen in het onderwijs wordt benadrukt, zijn er nog veel tekortkomingen in de manier waarop technologie-integratie wordt benaderd in beleidsplannen, in de manier waarop technologie wordt geïmplementeerd in de onderwijspraktijk en in hoe technologie wordt gebruikt door leraren en leerlingen.

De inzet van technologie in het onderwijs wordt gezien als complex en veelzijdig. Technologie-integratie omvat een diversiteit aan sociale, organisatorische, persoonlijke, contextuele en technologische factoren, die in de loop van de tijd kunnen veranderen. Er zijn in het recente verleden verschillende conceptuele modellen ontwikkeld, die behulpzaam kunnen zijn voor onderzoek. Daarmee kunnen factoren in kaart worden gebracht die van invloed kunnen zijn op het gebruik van technologie in het onderwijs. Deze conceptuele modellen bevatten vaak diverse variabelen en meerdere niveaus. Voortbouwend op reeds beschikbare conceptuele modellen en rekening houdend met specifieke contextuele aspecten, zijn in dit proefschrift diverse factoren op verschillende niveaus onderzocht. Deze kunnen de praktijk van leraren in het primair en secundair onderwijs mogelijk beïnvloeden waar het gaat om het gebruik van technologie.

Wat betreft technologische innovatie en integratie in het onderwijs is de beschikbare kennis over hoe leraren reageren op nieuwe programma's of innovaties (zoals de integratie van mobiele technologie in het onderwijs) enigszins gefragmenteerd en bovendien inconsistent. Onderzoek naar de huidige stand van zaken met betrekking tot technologie-integratie in het onderwijs is daarom van cruciaal belang met het oog op beslissingen van beleidsmakers, schoolleiders en lerarenopleiders waar het gaat om investeringen in de technologische infrastructuur in het onderwijs, professionele ontwikkeling van leraren en de logistieke ondersteuning daarvan. Om een breder perspectief en een diepgaander begrip van het leren van leerlingen met mobiele technologie te bieden, zijn in dit proefschrift de effecten van het gebruik van mobiele technologie in het basis- en voortgezet onderwijs onderzocht. Daarbij wordt aandacht besteed aan onderliggende relaties tussen factoren die van invloed kunnen zijn op het gebruik van technologie in het onderwijs, alsmede aan de kwaliteit van leerprocessen en de betrokkenheid van leerlingen bij hun eigen leerproces.

Het verbeteren van de onderwijspraktijk is een thema dat wereldwijd aandacht krijgt. Het huidige onderzoek richt zich op het onderwijs in China, vooral in de rurale gebieden. De Chinese context biedt een voorbeeld van nieuw opkomende economieën, maar de bevindingen van de empirische studies in dit proefschrift zouden ook kunnen worden toegepast in bredere contexten. Er hebben lange tijd aanzienlijke verschillen bestaan tussen het onderwijs in oostelijke en westelijke gebieden en tussen stadsscholen en scholen in rurale gebieden in China. De Chinese overheid heeft daarom sinds het begin van de 21ste eeuw speciale fondsen en projecten verstrekt voor scholen in westerse en rurale gebieden in China, in de hoop dat de inzet van technologie in het onderwijs kansarme groepen kan ondersteunen en meer gelijke onderwijskansen kan bieden. Kennis over onderwijs en technologie stroomt in China voornamelijk vanuit de meer welvarende oostelijke regio's naar de minder welvarende westelijke regio's en van de stedelijke gebieden naar de rurale gebieden. Omdat connectiviteit prioriteit kreeg boven potentiële pedagogische en onderwijskundige veranderingen, zijn in veel reeds uitgevoerde initiatieven de beoogde educatieve doelen niet gerealiseerd. Om hiermee verder te komen zijn diverse nationale ict-beleidsplannen ontwikkeld. Intussen zijn door lokale overheden in China en op verzoek van de centrale overheid lokale beleidsplannen geformuleerd en geïmplementeerd op basis van de nationale beleidsplannen. Het centrale idee achter deze ict-beleidsplannen was om verder te gaan dan alleen traditionele vormen van onderwijs en een verschuiving te bewerkstelligen naar vormen van lesgeven en leren met behulp van nieuwe technologieën, vormgegeven vanuit meer een studentgecentreerde manier van werken.

Dit onderzoek is erop gericht rijkere kennis te verwerven over het gebruik van technologie ten behoeve van onderwijzen en leren in het basis- en secundair onderwijs, rekening houdend met de gezichtspunten van diverse belanghebbenden en bezien vanuit de onderwijspraktijk. We richten ons daarbij vooral op de relatie tussen ict-beleidsplannen en ict-praktijken op scholen in rurale gebieden in China, op de praktijken van leraren in rurale gebieden met betrekking tot het gebruik van digitale leermiddelen en op het leren van leerlingen met behulp van mobiele technologie. Vanuit de genoemde doelstelling zijn vijf deelonderzoeken uitgevoerd die in deze samenvatting achtereenvolgens worden besproken.

Hoofdstuk 2: De integratie van ict op scholen in rurale gebieden in China

In dit hoofdstuk wordt gerapporteerd over een verkennend onderzoek waarin het doel was om meer te weten te komen over de vraag of en hoe lokale ict-beleidsplannen verband houden met de praktijk van ict-gebruik in de context van het onderwijs op scholen in rurale gebieden in China. Om meer inzicht te geven in de complexe en dynamische aard van de inzet van technologie in het onderwijs richt deze studie zich op de vraag hoe deze praktijken van technologie-integratie in het onderwijs op scholen in rurale gebieden gerelateerd zijn aan bredere politieke, culturele en sociale invloeden op het lesgeven. Daartoe is het Four in Balance (FIB/ 'Vier in balans') -model gebruikt als raamwerk om de inhoud van ict-beleidsplannen van lokale onderwijsafdelingen te

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analyseren en om na te gaan hoe schoolleiders en leraren de praktijk van ict-gebruik op hun scholen ervaren. Het FIB-model heeft als uitgangspunt dat technologie-integratie in de klas wordt bepaald door vier essentiële elementen (visie, deskundigheid, digitale inhoud toepassingen en ict-infrastructuur) en door leiderschap, ondersteuning en samenwerking. De volgende twee onderzoeksvragen stonden centraal: (1) Hoe worden de diverse elementen van ict-integratie op scholen gerepresenteerd in lokale ict-beleidsplannen? (2) Wat is, bezien vanuit het perspectief van zowel schoolleiders als leraren, de aard van de praktijk van ict-gebruik in het onderwijs op scholen in rurale gebieden? Het onderzoek werd uitgevoerd door middel van een mixed-methods benadering, waarbij 25 scholen in rurale gebieden in drie regio's in West-China betrokken waren. De onderzoeksgegevens werden verkregen uit verschillende bronnen (beleidsdocumenten, interviews met schoolleiders, focusgroepinterviews met leraren, klasobservaties, een ict-inventarisatie en een vragenlijst onder leraren). Op basis van inhoudsanalyse zijn drie lokale ict-beleidsplannen geanalyseerd. De andere bronnen (interviews met schoolleiders, focusgroepinterviews met leraren, observaties in de klas en de ict-inventarisatie) werden geanalyseerd met behulp van binnen- en cross-case analyses. De docentenenquête werd geanalyseerd met behulp van beschrijvende statistiek.

Uit de resultaten bleek dat alle elementen uit het FIB-model terugkwamen in de lokale ict-beleidsplannen, en dat het gebruik van ict door leraren voor lesgeven en leren was gerelateerd aan deze factoren. Het is vermeldenswaard dat de scholen die het meest effectief waren in het integreren van innovatieve ict-benaderingen, de proefscholen waren waar de meeste materialen voorhanden waren (zoals voorstellen voor de werkwijze in proefscholen en jaarverslagen) en waar men een gedeelde visie had op het innovatief gebruik van ict, en het gebruik van 1: 1 mobiele technologie (zoals clickers en tablets) in zogenaamde 'smart-classrooms'. Bij het vergelijken van praktijken voor onderwijzen en leren met behulp van ict op proefscholen en andere scholen in rurale gebieden, werd duidelijk dat het belangrijk is om bij de introductie van nieuwe technologieën in het onderwijs rekening te houden met het lokale beleid en de schoolcontext. Bovendien onderstreept deze studie het belang van competenties van leraren in rurale gebieden met betrekking tot de integratie van innovatieve technologie. Voor leraren die niet op proefscholen werken, kan het stimuleren van meer samenwerking tussen leraren, rekening houdend met hun behoeften en de omgeving waar zij gestationeerd zijn, waardevol zijn om leraren toe te rusten op het gebied van ict-integratie op scholen in rurale gebieden. De bevindingen in deze verkennende studie hebben drie soorten uitdagingen aan het licht gebracht met betrekking tot ict-integratie op scholen in rurale gebieden: (1) begeleiding en leermogelijkheden als politieke uitdaging, (2) solide ict-infrastructuur en geschikte digitale inhoud als technische uitdaging, en (3) lerarenopleiding en technische ondersteuning als een sociale uitdaging. Deze uitdagingen zijn van belang voor zowel beleidsmakers als voor praktisch betrokkenen die zich bezighouden met verbetering van het onderwijs in rurale gebieden door middel van ict-integratie.

Hoofdstuk 3: Het gebruik van digitale leermiddelen door leraren in rurale gebieden

In dit hoofdstuk wordt een kwantitatieve studie beschreven waarin is onderzocht wat voor typen digitale leermiddelen leraren gebruiken bij het lesgeven, alsmede factoren op het niveau van de school en de leraar die bepalend kunnen zijn voor het gebruik van digitale leermiddelen door leraren. Het onderzoek richtte zich op leraren die werkzaam zijn in rurale gebieden in drie regio's in West-China die vanuit nationaal en lokaal beleid werden gestimuleerd om digitale leermiddelen te gebruiken. Het Integrative Model of Behavior Prediction (IMBP / Integratieve model voor het voorspellen van gedrag) werd als raamwerk gebruikt om mogelijke verbanden tussen factoren op het niveau van de leraar (zoals attitude, self-efficacy, subjectieve norm, intenties voor gedrag, kennis en vaardigheden en faciliterende omstandigheden) en de frequentie van het gebruik van digitale leermiddelen door deze leraren te onderzoeken. Tevens werden de schoollocatie en het schooltype als variabelen op schoolniveau in het analysemodel opgenomen. Met behulp van een vragenlijst werd informatie verzameld over het gebruik van digitale leermiddelen door leraren in rurale gebieden en over de opvattingen van leraren met betrekking tot variabelen

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op het niveau van de school en van de leraar die van invloed kunnen zijn op het gebruik van digitale leermiddelen. Aan het onderzoek namen 462 leraren deel, afkomstig van 25 scholen in zowel primair als voortgezet onderwijs. De gegevens werden geanalyseerd met behulp van multilevel-analyse.

De bevindingen laten zien dat verschillende soorten digitale leermiddelen werden gebruikt, maar dat traditionele digitale leermiddelen (zoals digitale lesplannen en multimediacursusmateriaal) veel vaker werden gebruikt dan meer complexe digitale leermiddelen (zoals digitale software en tools). De resultaten laten verder zien dat de meeste variatie voor het verklaren van verschillen in het gebruik van digitale leermiddelen door de deelnemende leraren kon worden toegeschreven aan variabelen op docentniveau. Aangezien schooltype en schoollocatie geen significante voorspellers bleken te zijn voor van het gedrag van leraren, is meer onderzoek nodig naar factoren op schoolniveau die het gedrag van leraren met betrekking tot het gebruik van digitale leermiddelen zouden kunnen verklaren. Enigszins verrassend was dat veronderstelde relaties in het IMBP-model, zoals tussen self-efficacy, subjectieve norm en intenties om technologie te gebruiken enerzijds en het gebruik van digitale leermiddelen anderzijds, niet werden ondersteund door de onderzoeksresultaten. Voor wat betreft attitude, kennis en vaardigheden, en faciliterende omstandigheden werd echter een significant positieve relatie gevonden met het gebruik van digitale leermiddelen, waarvan faciliterende omstandigheden de zwakste schakel bleken te zijn. Met het oog op het stimuleren van gebruik van digitale leermiddelen door leraren, is het daarom van belang aandacht te geven aan de attitude en de kennis en vaardigheden van leraren op dit gebied. De bevindingen suggereren verder dat docentfactoren een belangrijke rol spelen bij het begrijpen van hun gedrag inzake het gebruik van digitale leermiddelen. Daarom zouden toekomstige studies gericht kunnen zijn op docentfactoren, zoals motivatie voor het gebruik van technologie en algemene opvattingen van leraren over lesgeven en leren.

Hoofdstuk 4: Het delen van digitale leermiddelen door leraren op scholen in rurale gebieden

In hoofdstuk drie is besproken welke factoren het gedrag van leraren met betrekking tot het gebruik van digitale leermiddelen verklaren; in dit hoofdstuk verschuift de focus naar gedragingen van leraren op het gebied van het delen van digitale leermiddelen. Om tot een beter begrip te komen van wat leraren doen op het gebied van het delen van digitale leermiddelen, is het van belang om rekening te houden met de motivatie om zulke informatie te delen, en om een onderscheid te maken tussen typen contexten, namelijk het delen van digitale leermiddelen binnen en buiten de schoolcontext. De primaire onderzoeksvraag is 'Hoe is de motivatie van leraren gerelateerd aan het binnen en buiten de scholen delen van digitale leermiddelen?'. Om de onderliggende relaties te onderzoeken, werden de kernvariabelen in het Integrative Model of Behavior Prediction (IMBP) (attitude, self-efficacy, subjectieve norm, en intenties voor het delen van digitale leermiddelen) opgenomen en werd de lijst met determinanten uitgebreid met motivatie als de aanjager van gedrag. Daarnaast bevatte het voorgestelde analysemodel twee omgevingsvariabelen (het klimaat binnen de school met betrekking tot het delen van digitale leermiddelen en de ervaren werkdruk op school) die van invloed kunnen zijn op het gedrag van leraren inzake het delen van digitale leermiddelen. Leraren die werkzaam zijn op scholen in rurale gebieden in het zuidwesten van China werden uitgenodigd voor deelname aan een online enquête. In totaal zijn 709 geldig ingevulde vragenlijsten verzameld en geanalyseerd met behulp van structurele padmodellen in Mplus 8.3. Uit de resultaten komt naar voren dat de intrinsieke en extrinsieke motivatie van leraren voor het delen van digitale leermiddelen de algemene motivatie van leraren op dit gebied weerspiegelt. De variabele 'subjectieve norm' werd op grond van de resultaten uit het structurele analysemodel weggelaten.

Terwijl de resultaten die in hoofdstuk drie werden gerapporteerd lieten zien dat attitude de sterkste voorspeller was voor het gebruik van digitale leermiddelen door leraren, laten de bevindingen in dit hoofdstuk voor attitude een negatief verband zien met de gedragingen van leraren ten aanzien van het delen van digitale leermiddelen buiten de school. Deze resultaten wijzen erop dat de rol van de variabelen in het onderzoeksmodel verschillend kan uitpakken en dat dit afhankelijk is van de context. Evenzo bleken intenties voor delen en het klimaat binnen de school met betrekking tot het delen van digitale leermiddelen alleen gerelateerd te zijn aan het delen van digitale leermiddelen buiten de school, maar niet binnen de school. Een onverwachte bevinding was dat de ervaren werkdruk op school geen invloed bleek te hebben op het delen van digitale leermiddelen binnen of buiten de school. Met betrekking tot motivatie bleek intrinsieke motivatie positief, maar extrinsieke motivatie negatief gerelateerd te zijn aan het delen van digitale leermiddelen binnen en buiten de school. De bevindingen suggereren dat extrinsieke motivatie (zoals de perceptie van verwachtingen van anderen over het delen van digitale leermiddelen) leraren kan ontmoedigen om digitale leermiddelen te delen, maar intrinsieke motivatie (zoals persoonlijke interesse in en persoonlijke waarden met betrekking tot het delen van digitale leermiddelen) leraren juist kan aanmoedigen om digitale leermiddelen met elkaar te delen. Een andere belangrijke factor was self-efficacy, die een positieve en significante voorspeller bleek te zijn voor zowel de intenties om digitale leermiddelen te delen als voor gedragingen met betrekking tot het delen van digitale leermiddelen binnen en buiten de school. Wat de samenhang tussen intrinsieke motivatie en intenties betreft, was de belangrijkste bevinding dat self-efficacy zowel binnen als buiten de school een mediërende rol speelde. Hoe hoger de intrinsieke motivatie van de deelnemende leraren en hoe hoger hun self-efficacy, hoe meer zij geneigd zijn digitale leermiddelen te delen. Deze bevinding suggereert dat de prioriteit zou moeten worden verlegd van verwachtingen van anderen naar intrinsieke motivatie en van het ontwikkelen van een positieve attitude naar het ontwikkelen van een sterkere self-efficacy om het delen van digitale leermiddelen door leraren op scholen in rurale gebieden te bevorderen.

Hoofdstuk 5: De effecten van het gebruik van mobiele technologie op leerresultaten

Na de integratie van technologie in het onderwijs te hebben geïdentificeerd in termen van de technologische toepassingen die door leraren worden gebruikt, de wijze waarop leraren deze technologieën in hun onderwijspraktijk gebruiken en de factoren die van invloed kunnen zijn op het gebruik van technologie in de onderwijspraktijk van leraren, wordt in dit hoofdstuk ingegaan op technologische toepassingen in het onderwijs in termen van het gebruik van mobiele technologie door leerlingen. De bedoeling is voorbeelden te geven van aan elkaar gerelateerde elementen in toepassingen van mobiele technologie die kunnen bijdragen aan hogere leerresultaten bij leerlingen. Het doel van de studie die wordt beschreven in dit hoofdstuk is om te onderzoeken of interventies met mobiele technologie kunnen bijdragen aan verbetering van diverse typen leeruitkomsten van leerlingen in het basis- en voortgezet onderwijs. Om de algehele effectiviteit van toepassingen van mobiele technologie met het oog op leren te kwantificeren en te kunnen onderzoeken welke factoren eventuele verschillen in leerresultaten verklaren, is een meta-analyse uitgevoerd om leereffecten van toepassingen met mobiele technologie te vergelijken met meer traditioneel onderwijs. In tegenstelling tot eerdere meta-analysestudies, was dit onderzoek niet beperkt tot cognitieve leeruitkomsten, maar omvatte het ook affectieve en gedragsmatige leeruitkomsten. Tevens werd in de analyses een reeks moderatoren meegenomen naar aanleiding van zowel onderwijskundige als methodologische kenmerken van de opgenomen onderzoeken in de meta-analyse. Ten behoeve van de meta-analyse werden gepubliceerde onderzoeken over het gebruik van mobiele technologie door leerlingen die gepubliceerd waren tussen 2014 en 2020 en een experimenteel of quasi-experimenteel design hadden, systematisch geanalyseerd. Op basis van inclusie- en exclusiecriteria werden 61 studies opgenomen in de meta-analyse. Deze studies waren afkomstig uit 56 artikelen die gepubliceerd zijn in peer-reviewed tijdschriften. Het random effects model werd gebruikt om de gemiddelde effectgroottes te berekenen en bovendien werden moderatoranalyses en gevoeligheidsanalyses uitgevoerd en werd de publicatiebias getoetst.

Op basis van de uitkomsten van de meta-analyse kan gezegd worden dat, vergeleken met het gebruik van niet-mobiele technologie of het niet gebruiken van enige technologie, de inzet van mobiele technologie over het geheel genomen een positief effect heeft op het leren van leerlingen en dat dit geldt

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voor zowel cognitieve, affectieve als gedragsmatige leeruitkomsten. Deze bevindingen suggereren dat er geen twijfel over hoeft te bestaan dat toepassingen van mobiele technologie in het basis- en voortgezet onderwijs ertoe kunnen bijdragen dat het leren van leerlingen verbetert, ondanks mogelijke negatieve bijkomende effecten. De resultaten geven aanleiding om het beleid ten aanzien van het gebruik van technologie in het onderwijs op te schalen met het oog op verbetering van leerprocessen van leerlingen. De bevindingen naar aanleiding van de moderatoranalyses tonen aan dat de effecten significant varieerden in drie categorieën: de achtergrond van de leerling, het leerproces en de kwaliteit van de desbetreffende interventiestudie. Met betrekking tot cognitieve leerresultaten werden vijf moderatoren geïdentificeerd, namelijk sociaaleconomische status (SES), gebruikte hardware, de beschikbare hardware ten opzichte van het aantal leerlingen, de mate waarin het onderwerp en de inhoud van het onderwijs overeenstemmen en de in het onderzoek gebruikte procedure voor het bepalen van de effectgrootte. Vanwege het kleine aantal beschikbare onderzoeken naar niet-cognitieve leerresultaten en het ontbreken van informatie over potentiële moderatorinvloeden, kon alleen worden vastgesteld dat de mate van overeenstemming tussen het onderwerp van de lesstof en de inhoud van de les een significante modererende invloed heeft op affectieve leeruitkomsten en dat overeenstemming tussen de gebruikte software en tools een belangrijke moderator was voor gedragsmatige leeruitkomsten. Het is daarom raadzaam om in toekomstige onderzoeken naar het gebruik van mobiele technologie in het onderwijs te overwegen ook affectieve en gedragsmatige leerresultaten op te nemen als variabelen. Tevens kan worden aanbevolen dat in publicaties over onderzoek naar het gebruik van mobiele technologie in het onderwijs meer details worden verstrekt ten aanzien van onderwijskundige en methodologische kenmerken van interventies. Dergelijke informatie is essentieel voor het vergelijken van uitkomsten uit verschillende onderzoeken op dit gebied.

Hoofdstuk 6: De relatie tussen de opvattingen van leraren, de kwaliteit van de instructie en de betrokkenheid van leerlingen bij hun leerproces

De bevindingen van het onderzoek in hoofdstuk 5 duiden erop dat leerlingen hogere cognitieve leeruitkomsten bereiken wanneer ze de beschikking hebben over eigen mobiele apparaten die meerdere functies bieden om te leren. Daarom zijn voor het onderzoek dat wordt gerapporteerd in dit hoofdstuk doelgericht leraren en leerlingen geselecteerd die hun eigen tablets gebruiken in zogenaamde slimme klaslokalen ('smart classrooms') en die op zijn minst enige ervaring hebben opgedaan met het werken en leren in dergelijke contexten. Mobiele technologie alleen kan niet tot effectief lesgeven en leren leiden bij afwezigheid van kenmerken die cruciaal zijn voor goede instructie, zoals cognitieve activatie, klassenmanagement en een ondersteunend leerklimaat. In deze studie richtte het onderzoek zich op de relaties tussen de opvattingen van leraren, de kwaliteit van instructie in slimme klaslokalen en de betrokkenheid van leerlingen bij hun eigen leerproces in slimme klaslokalen in het secundair onderwijs. Het voortgezet onderwijs werd gekozen, omdat middelbare scholieren, zeker in Aziatische onderwijssystemen met doorgaans een overwegend docentgecentreerde manier van werken, vaak een lage mate van betrokkenheid bij hun eigen leerproces hebben doordat ze moete hebben met de zelfregulatie van hun eigen leerproces. De gegevens werden verzameld door vragenlijsten af te nemen onder leraren en leerlingen. De vragenlijst voor leraren bevatte behalve vragen over achtergrondkenmerken ook items over de algemene opvattingen over lesgeven en over het leren in slimme klaslokalen. De leerlingenvragenlijst bevatte vragen over de demografische achtergrond en hun percepties inzake de kwaliteit van instructie in slimme klaslokalen (cognitieve activatie, gevoel van verbondenheid, klassenmanagement, en het gebruik van technologie) en over de betrokkenheid bij het eigen leerproces zoals ervaren in een les die in het slimme klaslokaal werd gegeven. Op de verzamelde gegevens werden multilevel regressieanalyses en multilevel mediatie-analyses uitgevoerd.

De bevindingen laten zien dat de opvattingen van leraren geen effect hadden op de gepercipieerde kwaliteit van instructie door leerlingen; ook niet

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wat betreft cognitieve activatie, het gevoel van verbondenheid en het gebruik van technologie. Het opleidingsniveau van de leraar vertoonde echter wel significante positieve effecten op alle kwaliteitsindicatoren voor de kwaliteit van instructie. Dit wijst erop dat vooral kenmerken die verband houden met de opleiding van leraren, zoals hun feitelijke kennis van de lesstof en hun ervaring met lesgeven en technologie, bepalend zijn voor de kwaliteit van instructie en het gebruik van technologie in slimme klaslokalen en niet zozeer de algemene opvattingen van leraren over onderwijs in slimme klaslokalen. Deze inzichten bieden aangrijpingspunten voor de ontwikkeling van programma's in lerarenopleidingen en voor doorgaande professionele ontwikkeling. Klassen die les hadden van vrouwelijke leraren, rapporteerden een significant hoger niveau van cognitieve activatie. Verder bleek dat hogere klassen een significant hoger niveau van het gebruik van technologie rapporteerden. De meeste verbetering op het gebied van betrokkenheid van leerlingen bij hun eigen leerproces lijkt te kunnen worden bereikt in leeromgevingen waar cognitieve activatie, het gevoel van verbondenheid en het gebruik van technologie door leerlingen hoog scoren. Bovendien werd een relatie gevonden tussen de achtergrondkenmerken van leraren (hun opleidingsniveau en hun ervaring met lesgeven) en de betrokkenheid van leerlingen bij hun leerproces. Jongens rapporteerden een hogere betrokkenheid bij hun leerproces dan hun vrouwelijke leeftijdsgenoten. Van de factoren die de betrokkenheid van leerlingen bij hun leerproces beïnvloeden, bleek het gevoel van verbondenheid de belangrijkste voorspeller te zijn. De resultaten suggereren dat factoren die bepalend zijn voor de kwaliteit van instructie, evenals de achtergrondkenmerken van leraren en leerlingen, allemaal in potentie invloed hebben op de betrokkenheid van leerlingen bij hun eigen leerproces in slimme klaslokalen, maar dat het gevoel van verbondenheid van leerlingen in slimme klaslokalen de meeste aandacht vereist. Wat betreft de samenhang tussen het opleidingsniveau van de leraar en de betrokkenheid van leerlingen bij hun leerproces, bleek het gevoel van verbondenheid en het gebruik van technologie een mediërende rol te spelen. Leraren met een hoger opleidingsniveau kunnen klaarblijkelijk een grotere betrokkenheid van leerlingen bij hun eigen leerproces bereiken dan leraren met een lager opleidingsniveau door het stimuleren van een gevoel van verbondenheid bij leerlingen en door de manier waarop zij technologie inzetten. Aandacht voor de manier waarop leraren hun rol vervullen in slimme klaslokalen is dan ook belangrijk voor de toekomstige professionele ontwikkeling van leraren.

Hoofdstuk 7: Algemene discussie

In dit laatste hoofdstuk worden de bevindingen uit de verschillende hoofdstukken in samenhang besproken. Dit hoofdstuk begint met een korte inleiding en een samenvatting van de belangrijkste bevindingen uit de vijf deelonderzoeken. Vervolgens worden de belangrijkste discussiepunten in termen van praktijken van leraren en leerlingresultaten gepresenteerd. Tevens wordt gereflecteerd op deze bevindingen, en komen mogelijke richtingen voor toekomstig onderzoek aan de orde. Het hoofdstuk eindigt met praktische implicaties voor beleidsmakers en voor het opleiden van leraren en de doorgaande professionalisering van schoolleiders en leraren.

De bevindingen uit dit onderzoek bieden een verdieping en een aanvulling op de reeds bestaande kennis over (1) het beschikbare bewijs voor de impact van ict-beleidsplannen, schoolcontext en docentgerelateerde factoren op de onderwijspraktijk van leraren inzake het gebruik van technologie, en (2) de effecten van technologie-integratie, inclusief maar niet beperkt tot het gebruik van mobiele technologie, op de resultaten van leerlingen. Ten eerste worden factoren besproken die de lespraktijken van leraren met betrekking tot het verzorgen van onderwijs met technologie beïnvloeden. De hoofdstukken 2 t/m 4 laten zien hoe variabelen op verschillende niveaus het gebruik van technologie door leraren in het onderwijs beïnvloeden. Het is belangrijk meer aandacht te besteden aan docentgerelateerde factoren die hierbij een rol spelen, zoals expertise, self-efficacy, kennis en vaardigheid, motivatie, attitude en opleidingsniveau. Hierbij moet in ogenschouw worden genomen dat de rol van deze variabelen in diverse contexten kan verschillen. Het gebruik van technologie door leraren in de onderwijspraktijk wordt eveneens beïnvloed door de schoolcontext en door ict-beleidsplannen, hoewel de effecten ervan relatief klein lijken te zijn. Ten tweede worden factoren besproken die de leerresultaten

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van leerlingen in leeromgevingen met mobiele technologie beïnvloeden. De bevindingen in hoofdstuk 5 suggereren dat leerlingen met een gemiddelde of hoge sociaal-economische status (SES) hogere cognitieve leerresultaten behalen wanneer ze zelfstandig multifunctionele mobiele apparaten gebruiken. De in hoofdstuk 6 beschreven resultaten laten zien dat niet alleen het gebruik van technologie, maar ook de kwaliteit van instructie (het gevoel van verbondenheid en cognitieve activatie bij leerlingen) alsmede achtergrondkenmerken van leraren en leerlingen de betrokkenheid van leerlingen kunnen beïnvloeden.

Zowel onderzoekers als leraren en schoolleiders kunnen profiteren van de bevindingen uit deze dissertatie omdat het onderzoek niet alleen een overzicht biedt van een conceptueel model voor technologie-integratie in het onderwijs met een lijst van sleuteldeterminanten voor onderwijspraktijken, maar ook de noodzaak aangeeft van toekomstig onderzoek en onderwijspraktijken op het gebied van technologie-integratie. Enige voorzichtigheid is echter geboden vanwege de niet-representatieve steekproeven en de aard van gegevensverzameling.

Het betrekken van variabelen op het niveau van zowel de leraar als de leerling kan ons begrip van de inzet van technologie in het onderwijs verrijken. Ten eerste zou toekomstig onderzoek naar inzet van technologie in het onderwijs zich moeten richten op het verbeteren van de praktijk van leraren in zowel diepere en bredere zin. Bijvoorbeeld door het gedrag van leraren te onderzoeken in termen van zowel kwantiteit als kwaliteit van technologie-integratie, maar ook door andere methoden voor gegevensverzameling toe te voegen aan het onderzoek, zoals observaties in de klas en interviews met leerlingen. Ten tweede, bij het onderzoeken van de onderliggende relaties tussen verschillende factoren van verschillende niveaus, kan ons begrip van het leren van leerlingen verdiept worden door rekening te houden met de hiërarchische structuur van gegevens waarbij data van leerlingen zijn genest in klassen, klassen zijn genest in scholen en scholen zijn genest in regio's. Ten derde moet er meer belang worden gehecht aan de vraag of bepaalde groepen leerlingen meer profiteren van leren met technologie dan andere om bewijs te leveren over uitdagingen en kansen op het gebied van digitale gelijkheid.

Met het oog op de praktijk van de inzet van technologie in het onderwijs is het primair van belang dat beleidsmakers en onderzoekers samenwerken in de ontwikkeling van ict-beleidsplannen. Idealiter hebben beleidsprocessen immers een iteratief karakter en dat vergt de bereidheid van diverse belanghebbenden om inspanningen te leveren om van anderen te leren en speciale aandacht te besteden aan kansarme groepen leerlingen. Verder is het van cruciaal belang om leraren voldoende mogelijkheden te bieden voor professionele ontwikkeling, en daarbij rekening te houden met de specialistische kennis, attitudes en technologische vaardigheden van (aankomende) leraren, en om ook kansen te bieden het geleerde vervolgens toe te passen in de eigen onderwijspraktijk. Ook aan schoolleiders kunnen meer mogelijkheden worden geboden om zich te bekwamen als het gaat om hun rol bij het stimuleren van de inzet van technologie in het onderwijs. Bij de ontwikkeling van schoolbeleid op dit gebied zou door schoolleiders rekening moeten worden gehouden met de schoolcontext, maar is het minstens zo belangrijk om daarbij tevens de inspanningen van leraren te betrekken en rekening te houden met factoren waarvan bekend is dat die bijdragen aan effectieve technologie-integratie op scholen. Ook is het raadzaam om professionele leergemeenschappen of leernetwerken te creëren en te faciliteren en leraren mogelijkheden te bieden om zowel binnen scholen als tussen scholen meer samen te werken, omdat dit de ontwikkeling van het gebruik van technologie op de langere termijn ten goede kan komen. Ten slotte kunnen leraren meer worden voorbereid op het gebruik van technologie in hun onderwijspraktijk. Het model dat is gepresenteerd in hoofdstuk 7 kan ook daarbij behulpzaam zijn.

Curriculum Vitae

Jingxian Wang was born on November 3, 1990, in Chongqing. Since graduating from Chongqing Bashu Secondary School in 2009, she studied Electronics Information Science and Technology at Chongqing Normal University, obtaining a bachelors' degree in 2013. Subsequently, she completed a Master's degree in Educational Technology at the Center for Studies of Education and Psychology of Ethnic Minorities in Southwest China of Southwest University in 2016. After a year of working as a mathematics teacher at the Primary School Attached to Southwest University, she started her PhD project at Leiden University Graduate School of Teaching (ICLON) in September 2017. Her PhD research project focused on technology integration in education in primary and secondary education.

Publications and presentations

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Wang, J., Tigelaar, D. E., & Admiraal, W. (2021). Rural teachers' sharing of digital educational resources: From motivation to behavior. *Computers & Education, 161*, 104055. doi: 10.1016/j.compedu.2020.104055

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Wang, J., Tigelaar, D. E., & Admiraal, W. (2021). *Teacher beliefs, classroom process quality, and student engagement in the smart classroom learning environment: A multilevel analysis.* Manuscript submitted for publication.

Conference contribution

Wang, J., Tigelaar, D. E., & Admiraal, W. (2021, March). *Secondary schools teacher beliefs, classroom process quality, and student engagement in the smart classroom learning environment: A multilevel analysis*. Poster presentation at ICO International Spring School, 16-18 March, Online.

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Acknowledgements

First, I would like to express my heartiest gratitude to my supervisors, Prof. Dr. Wilfried Admiraal and Dr. Dineke Tigelaar. You provided the most significant support and valuable guidance throughout my PhD research project. Wilfried, I would like to thank you very much for giving me this opportunity to pursue my PhD and for your constant encouragement, feedback, and inspirations. Dineke, your insightful questions and constructive suggestions have always driven me to sharpen my thinking and brought my work to a higher level. I have learned a lot in collaboration with you, and it becomes evident to me how to become a qualified academic researcher. Many thanks to you for making my research easy and different!

Without the help of Prof. Dr. Jianghua Luo, my dearest master's thesis supervisor, I could not have completed my dissertation. Sincerely, I would like to say a big thank you for encouraging me to do research in the Netherlands. Thanks to you, it became possible to collect such a large amount of data in China. Thanks to our pleasant discussion about rural education and many educational technology issues, I became more aware of what I am doing and what I want to do. You are instrumental to my research career and I am lucky to have you as a teacher.

I would like to acknowledge all the participants in my research for your time and efforts to complete the questionnaires and/ or to be interviewed. I would also like to acknowledge the schools in Western China for their collaboration and engagement in the project. I give my special thanks to Haiying Tang, Junrong Zhang, Hai Jiang, Shiwei He, Cailiang Guo, Shengchang Duan and Yingdong Che and for their great assistance during the implementation of the study.

ICLON has been an excellent work environment, and I would like to thank my colleagues for your patient support and for the many opportunities to advance my research. I would like to express my gratitude to the research group and the fourth floor in particular for all the feedback and pleasant moments. Pengyue: Thanks for all the discussions and experience sharing. Xinglin: Thank you for the friendly chats and especially for your help with the interview data.

Kevin and Loes: Thank you for being my roommates that I can consult for advice on everything from research to life. Ben: Thank you for your special help in the final stage of my dissertation. Additionally, I would like to thank Kirsten and Karel for your assistance with my data collection and analysis.

Finally, I would like to thank my family and friends for your always love, care, and trust, but especially for always encouraging me to follow my heart and pursue my dreams. Without you, dearest Zhiqian, I will never reach there with happiness and fulfillment. Thank you for your accompany and pleasant distractions to rest my mind outside of my research. I appreciate all the wonderful moments we had. I love you three thousand times!

Jingxian Wang
Leiden, May 2021

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