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

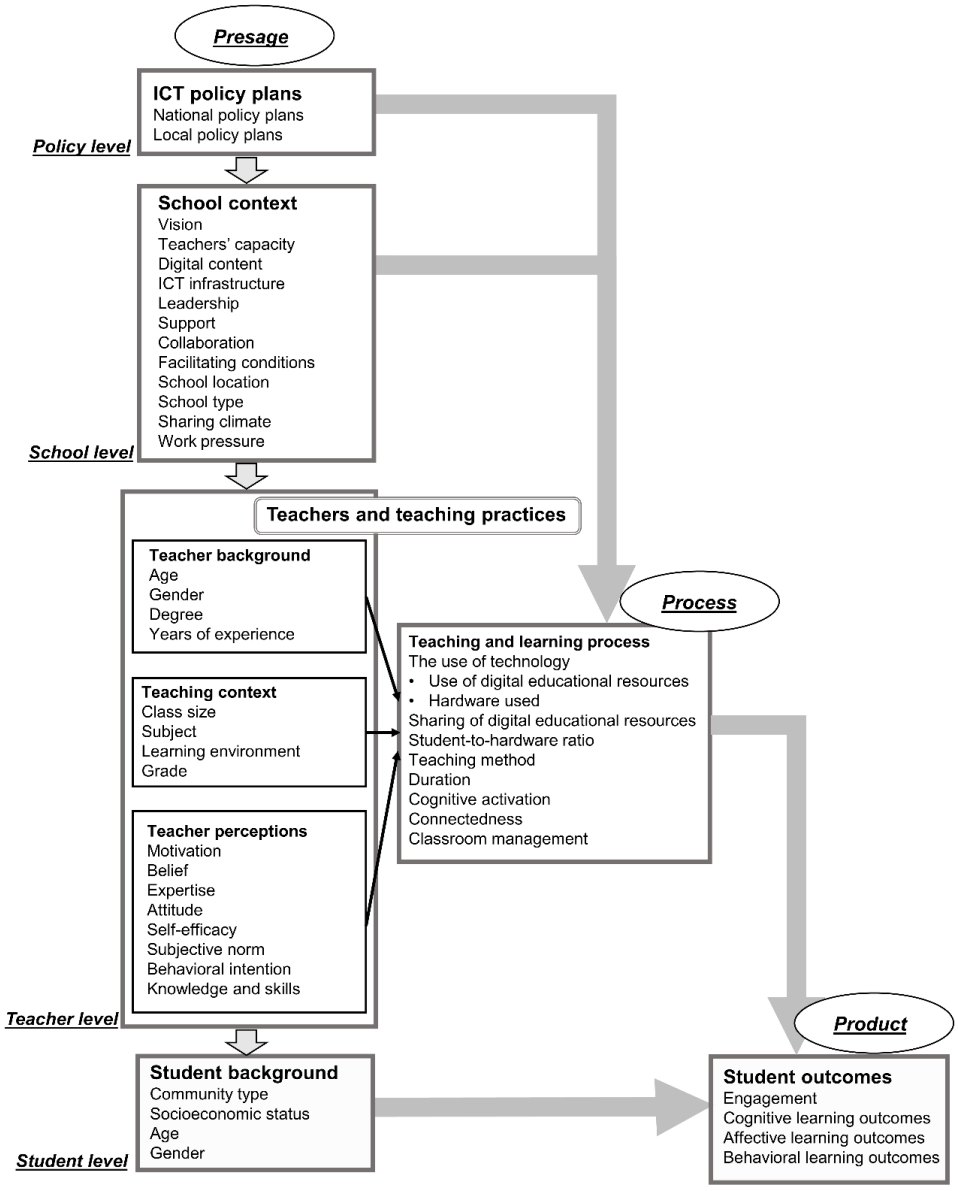

Figure 7.1. An overview of conceptual model for technology integration in education.

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.