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

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.