Faculty of Educational Sciences
University of Helsinki

Fostering distributed leadership and collective innovation practices in a primary school's makerspace

A sociocultural investigation

Jasmiina Leskinen

ACADEMIC DISSERTATION

To be presented, with the permission of the Faculty of Educational Sciences of the University of Helsinki, for public discussion in Banquet Room 303, Unioninkatu 33, on Friday September 1st, 2023, at 1 p.m.

Helsinki 2023

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ISBN 978-951-51-9409-1 (pbk.)
ISBN 978-951-51-9410-7 (PDF)
ISSN 1798-8322 (pbk.)
ISSN 2489–2297 (PDF)

PunaMusta
Helsinki 2023

Abstract

This doctoral dissertation generates new knowledge about distributed leadership and collective innovation practices in a primary school makerspace. Several educational policy documents have called for students' leadership and innovation skills in basic education to be promoted. Concurrently, it has been argued in research that makerspaces hold great potential in answering such calls, and schools across the globe have been introducing makerspaces in their educational programs. However, research to date has neglected leadership and innovation practices in school makerspace contexts. Based on previous research, the dissertation argues that the dynamics of leadership are shifted in makerspaces as students gain more opportunities to influence their learning activities. The dissertation also posits that the opportunities to take leadership promotes students' opportunities to innovate.

The dissertation consists of three original research articles. The first two focus on leadership and conceptualize it as a social process involving negotiations between multiple individuals. The first article unravels the social dynamics of distributing leadership between teachers and students in the makerspace. The second article examines how students influence their peers and negotiate leadership during collaborative making activities. The article provides enlightenment about the consequences of socially emergent leadership for creative collaboration. The third article explains how teachers' and students' recurring actions construct collective innovation practices that support students' learning to innovate. The study highlights how the makerspace context allows the development of such practices.

Video and interview data that were gathered over one academic year at two Finnish primary schools were used in the dissertation. A narrative approach was used to analyze the teacher interviews. The analysis considered the stories told by teachers to describe the dynamics of distributing leadership between them and their students. The analysis of the video data used interaction analysis and video data analysis to unravel how the students' and teachers' interactions took part in constructing distributed leadership and innovation practices. Overall, the analyses were guided by a sociocultural understanding of leadership and innovation practices as socially situated phenomena. The analyses thus considered how the makerspace context (i.e., the space, materials, and individuals) mediated the participants' actions. The role of historical and institutional contexts in leadership and innovation practices was also considered.

The results highlight that teacher-led, student-led, and distributed leadership practices coexisted in the makerspace. Although the makerspace context provided opportunities for students' leadership and innovation practices, the students' needed their teachers' support in taking part in such practices. The dissertation highlights that the creative and open-ended projects and collective interaction as salient aspects of learning in makerspaces, enabled leadership and innovation practices to develop and promoted the students' learning to lead and to innovate. The sociocultural approach of this study showed that the leadership and innovation practices were mediated by the pedagogical and physical setting of the

makerspace, the participants' histories, and their expectations for the future. Specifically, the pedagogical setting provided room for the students' imagination and creative engagement, fostering leadership and innovation practices. Access to leadership and innovation practices were mediated by using the available materials. The participants' past experiences of formal schooling, their current experiences, and their aspirations for the future posed opportunities and tensions for distributed leadership and innovation practices.

The dissertation contributes to a growing understanding of the educational potential of makerspaces to foster the development of distributed leadership and innovation practices. The dissertation shows that taking part in leadership and innovation practices can promote students' learning of leadership and innovation skills needed in the 21st century. However, the sociocultural approach revealed that it demands collective efforts from students and teachers to learn how to distribute leadership and innovate in the formal school context of the makerspace. The results inform pedagogical practice in school makerspaces and in teacher training by showing how the teachers' orientation plays a pivotal role in leadership and innovation practices.

Keywords: leadership, innovation, makerspace, primary school, sociocultural theory

Acknowledgements

This dissertation would not be what it is today without the people whose expertise and support helped me in completing it. First and foremost, I would like to express my deepest gratitude to my wonderful supervisors Professor Kristiina Kumpulainen and Professor Anu Kajamaa. Words cannot express how much your guidance has impacted my work and growth as a researcher. Kristiina, this dissertation would not have been written without your encouragement. Thank you for your inspirational guidance and insightful discussions along the way. Your support in networking at the University of Helsinki, and abroad has been invaluable. Anu – thank you for your warm and cordial support during this journey. Thank you for so generously providing knowledge and expertise, your constructive and encouraging feedback has challenged me intellectually and pushed me forward. I am also deeply indebted to Antti Rajala, whose support as a co-author, a colleague, and a mentor in academia has been vital over the years.

I am extremely grateful to the pre-examiners of my dissertation, Anna Keune and Anniken Furberg. Sincerest thank you for your insightful and constructive feedback, that has tremendously improved my dissertation. I would also be remiss in not acknowledging the irreplaceable work of the reviewers of the original articles as well as the editors of the "*Nordic Childhoods in the Digital Age*" book, in which I was privileged to have contributed a chapter. I would like to express my deepest appreciation to Ian Dobson for your work in language editing the articles that constitute this dissertation, as well as this dissertation summary. Writing this dissertation and completing my PhD would not have been possible without the funding received from the SEDUCE doctoral program and travel support from the HYMY doctoral school. The early stages of this PhD project were funded by the Academy of Finland funded project "Learning by Making: The educational potential of school-based makerspaces for young learners' digital competencies (PI: Kristiina Kumpulainen).

In 2018 I had the privilege to visit the Creativity Labs at Indiana University (IU). This visit turned out to be an adventure that truly inspired my maker-related research and had a great impact on my dissertation methodologically and theoretically. I am thankful to Kylie Peppler for providing the opportunity to dive into the depths of research around making and getting to know so many talented scholars in this research area. A thousand thanks to Karen Wohlwend for mentoring me during my visit. Thank are also due to Anna Keune, Naomi Thompson, Joey Huang, and Suraj Uttamchandani, for being party to intriguing discussions during my visit to IU and during our conference adventures in Lyon and Toronto. And many, many thanks to all the other amazing scholars I had the pleasure to meet and have discussions with while visiting IU. I would also like to acknowledge and thank Angela Wiseman, who invited and hosted me at the NC State University in fall 2018.

I am thankful to my thesis committee members Kaiju Kangas and Leenu Juurola for sharing your expertise and supporting me in this project. I would also like to extend my sincere thanks to Pirita Seitamaa-Hakkarainen for your aid in connecting with the extended research network of Maker@STEAM and for invaluable support in combining research work and family life. I am also grateful to all my colleagues and fellow doctoral students who have been an inseparable part of this journey. A heartfelt thanks goes to my dear colleagues Heidi Sairanen, Noora Bosch, Alexandra Nordström, Jenny Byman, Jenny Renlund, and Chin Chin Wong. And many thanks for all of you wonderful, and intelligent researchers that took part in our What's Up PhD group, giving moral and professional support. Deepest thanks to the researchers in my 'intellectual home', EARLI SIG 10 (Social Interaction in Learning and Instruction), especially my co-coordinators Valérie Tartas, Jelena Radišić, and Nathalie Muller Mirza. My thanks should also go to members of the Playful Learning Center, the Learning, Culture, and Interventions expert group and its visitors, and the editorial board of the European Journal of Psychology of Education for inspiration and intellectual challenge. Many thanks to all the people working in the EWE space community for a warm, welcoming, and inspirational atmosphere, long lunches, and much needed coffee breaks.

Getting through my dissertation required more than academic support. I'd like to thank my parents Virpi and Matti Korhonen. Your loving support has kept me going during these years. Warmest thanks to my siblings and extended family Mikko and Elina, Milla and Ilkka, Jaana and Marko, Timo and Mervi, and Emmi and Jesse. Thank you for your support and encouragement to my dearest friends – you know who you are. And of course, '*opetytöt*' not only for invaluable support and encouragement, but for reminding me why educational research matters. Finally, I express my gratitude to my husband and my children. Juuso, my beloved partner, thank you for sharing the emotions, the ups and downs along the way. Thank you for being so loving, patient, and understanding. Mette and Nooa, thank you for reminding me what is truly important. And for bringing me so much joy each and every day. I love you.

Joensuu, July 18th, 2023
Jasmiina Leskinen

Contents

List of original publications

This thesis is based on the following publications:

I Leskinen, J., Kumpulainen, K., Kajamaa, A. (2022). Finnish teachers' leadership narratives in a school's makerspace. In K. Kumpulainen, A. Kajamaa, O. Erstad, Å. Mäkitalo, K. Drotner, & S. Jakobsdóttir (Eds.), *Nordic Childhoods in the Digital Age: Insights into contemporary research on communication, learning and education* (pp. 117–127). Routledge. https://doi.org/https://doi.org/10.4324/9781003145257

II Leskinen, J., Kumpulainen, K., Kajamaa, A., & Rajala, A. (2021). The emergence of leadership in students' group interaction in a school-based makerspace. *European Journal of Psychology of Education,* 36(4), 1033–1053. https://doi.org/10.1007/s10212-020-00509-x

III Leskinen, J., Kajamaa, K., Kumpulainen, K. (2023). Learning to innovate: students and teachers constructing collective innovation practices in a primary school's makerspace. *Frontiers in Education,* vol. 7, p. 1039. https://doi.org/10.3389/feduc.2022.936724

The publications are referred to in the text by their roman numerals.

1 Introduction

Over recent years, there has been a significant rise in the uptake in the number of makerspace learning environments in schools nationally (Juurola & Wirman, 2019; Kumpulainen et al., 2020) and globally (Halverson & Sheridan, 2014; Martin & Dixon, 2016; Peppler et al., 2016b). This is due to the growing understanding of the importance of providing students with opportunities to develop themselves as individual beings and empowering them to become authors of their learning (Biesta, 2020). Recent research on learning environments that foster students' personal and creative engagement in learning has shown that allowing students to take ownership of their projects and encouraging them to self-regulate their activities can have a positive effect on their motivation, participation, and learning in formal school environments (Fields et al., 2018; Halverson & Sheridan, 2014; Sedláček & Šeďova, 2020). In makerspaces students are offered a variety of creative activities, ranging from traditional arts and crafts to working with novel technologies (Hsu et al., 2017). Students are invited to make personal sense of the creative activities, to explore and tinker with their projects, and to engage in community interaction by sharing their projects with others (Brahms & Crowley, 2016). Previous research posits that making can provide a pathway to foster students using their personal skills and expertise in the various learning activities and expressing their learning through the act of creating tangible or digital artifacts (Dougherty, 2012). Making can also provide access to tools and technologies to students who are typically underrepresented in particular fields (Halverson & Sheridan, 2014).

As makerspaces have been increasingly introduced in formal educational contexts, they have attracted research attention in recent years (Rouse & Rouse, 2022). It has often been argued that meta-disciplinary skills (such as 21st century skills) are one of the more important things learned in makerspaces (Dougherty, 2016; Ramey, 2017). Consequently, previous research on school makerspaces has focused on themes such as students' knowledge and knowledge creation, student agency, and equality and inclusivity in makerspaces (Rouse & Rouse, 2022). Yet, meta-disciplinary skills such as leadership and innovation skills have received limited research attention. There are several 21st century skill frameworks with varying emphases on specific skills, but many of these frameworks highlight leadership (Chalkiadaki, 2018) and innovation skills (European Commission, 2019; Vincent-Lancrin et al., 2019) as being important to ensure success in the 21st century. Such

frameworks stress that schools should provide students with opportunities to enact their self-motivations, take initiative, and make decisions (Binkley et al., 2012; Chalkiadaki, 2018). Moreover, to innovate, students should learn how to acknowledge problems, critically reflect on various perspectives and to mobilize resources – including people and things – to tackle emerging problems (European Commission, 2019; Marin-Garcia et al., 2016; Vincent-Lancrin et al., 2019). Taken together, to lead and to innovate, students need to learn how to influence others and their environment in a variety of situations and for different purposes (Binkley et al., 2012).

Previous research has suggested that makerspaces have the potential to create opportunities for students to take leadership and to innovate. Whereas school learning is typically based on linear pedagogy with pre-established goals and content, educational activities in makerspaces demand nonlinear pedagogical approaches due to the fundamental nature of making, in which the process and outcomes of activities are on many occasions unknown or unexpected prior to the activity (Kajamaa et al., 2020; Riikonen et al., 2020). It might therefore be culturally challenging to introduce makerspace activities in school settings that align with its non-linear approach.

Furthermore, nonlinear pedagogical approaches empower students to take control over their educational activities (Holbert, 2016; Laurell et al., 2021), which changes the traditional classroom dynamics between students and teachers. For instance, students are expected to make choices over their projects, including what, where, how, and with whom to work with (Kariippanon et al., 2018). Setting goals for individual and joint work, developing strategies for activities, and reciprocal social scaffolding (i.e., requesting help and helping others) are salient dimensions of learning in makerspaces (Wilkinson et al., 2016). Typical learning projects in makerspaces also allow and require students and teachers to share and build new knowledge collectively (Kajamaa et al., 2020; Kajamaa et al., 2018; Martin, 2015). Consequently, students have opportunities to take a variety of roles (Heath, 2012; Sheridan et al., 2013), as learners, experts, or leaders depending on their knowledge and skills related to a specific project (Leskinen et al., 2021; Leskinen, 2022; Sheridan et al., 2013; Vossoughi & Bevan, 2014). As students are offered opportunities to engage in personal learning projects and to take more leadership over their activities, students also have opportunities to innovate (Gantert et al., 2022). The students' options to deviate from their established social roles can particularly enhance the construction of community knowledge (Oswald & Zhao, 2021), the exchange of ideas, information, and resources, promoting innovative outcomes (Beltagui et al., 2021). In addition, students' access to rich social, technological, and other material resources can encourage them to innovate (Gantert et al., 2022). Making also fosters participants' socialization, experimentation, and play, which can promote innovation (Halbinger, 2018).

Learning to take leadership and to innovate are pivotal for working in today's knowledge society (Ananiadou & Claro, 2009). Moreover, 21st skills are not just competencies required to enter today's workforce, but they are pivotal for individuals' capacities to learn throughout their life. In turn, lifelong learning can enhance one's feeling of fulfillment when entering the world not only as workers and experts, but also as citizens (European Commission, 2019). Opportunities to take the lead and to innovate can promote one's ability to persist through challenges and feel encouraged when facing emerging problems, which contributes to one's social-emotional competence (Regalla, 2016). Moreover, opportunities to take leadership and to innovate can enhance the ability to see themselves in relation to others (Davies, 2006). Specifically, students can learn how to know and recognize roles in joint work, to locate and leverage their individual strengths and the strengths of others, be open and responsive to new and diverse perspectives, and to use influence and power in an ethical way (Binkley et al., 2012). Providing opportunities to lead also promotes students' competence to act in the future (Hasslöf & Malmberg, 2015). To tackle current and future societal, economic, and environmental challenges, society demands individuals who are capable of participating in the creation of innovations (Bocconi et al., 2012; OECD, 2019). Basic education has to promote students' learning to communicate, share and use various types of information, and to innovate as circumstances change and new demands arise (Binkley et al., 2012).

Taken together, several policy documents stress that students need to acquire leadership and innovation skills while participating in basic education. Concurrently, available research knowledge posits that makerspaces hold great potential in answering such calls (Dougherty, 2012; Halverson & Sheridan, 2014). Despite this understanding, research to date has neglected leadership and innovation practices in school makerspace contexts. Moreover, it has been argued that makerspaces would create physical, mental, and social conditions to foster students learning to lead and to innovate (see Dougherty, 2016; Gantert et al., 2022). Yet, research knowledge about how such conditions are created in practice remains limited. As makerspaces are increasingly implemented in Finnish schools (Juurola & Wirman, 2019), it has become crucial to understand the development of such conditions. It is known that more open learning environments, such as makerspaces, can pose multidimensional demands and tensions for teacher-student interactions (Kajamaa et al., 2020) and to student-student interactions (Leskinen et al., 2021) in formal educational contexts (see also Dougherty, 2012). Therefore, the core aim of my doctoral dissertation is to provide research knowledge about the conditions that can foster (or challenge) students' leadership and innovation activities in a school makerspace.

The doctoral thesis consists of three original research articles that focus on the following phenomena: Study I focuses on the ways in which students and teachers collaborate to distribute leadership – that is how they coordinate their work and

decision making in the makerspace (Gumus et al., 2018; Ho & Ng, 2017). Study II unravels students' daily interactions that constitute their emergent leadership. Study II also highlights the opportunities and tensions in socially emergent leadership practices. Study III explains how students and teachers collectively construct practices that foster students' learning to innovate. Moreover, Study III discloses some of the underlying mechanisms in makerspaces that are conducive for such innovation practices. Sociocultural theorizing was applied in all three studies. The theoretical lens, depicted in Chapter 2, guided my understanding of leadership and innovation practices as socially situated phenomena. Specifically, the analyses of leadership and innovation practices considered the ways in which actions were mediated by the makerspace environment, including its tools, materials, and individuals (Vygotsky & Cole, 1978). The studies also consider the role played by cultural, historical, and institutional contexts in leadership and innovation practices (Wertsch, 2007).

In chapter 3, I describe the three studies in more detail. Sections 3.1 and 3.2 are dedicated to the study objectives and research questions. In Section 3.3, I introduce the FUSE Studio makerspace (Stevens et al., 2018), in which video and interview data were collected over one academic year, to trace leadership and innovation practices. In Sections 3.4 and 3.5, I explain the methodological approach and present the analysis methods used in my dissertation. Specifically, I explain how the narrative analysis (Study I), interaction analysis (Study II), and video data analysis (VDA) (Study III), brought important knowledge about the dynamics and consequences of distributed leadership, students' emergent leadership, and collective innovation practices in a school makerspace. The results presented in Chapter 4 and discussed in Chapter 5, shed light on some of the mechanisms of the FUSE Studio that enable (and require) leadership and innovation practices to develop. The results also demonstrate that the learning activities in the FUSE Studio contribute to students' learning leadership and innovation skills. By bringing out the social practices related to leadership and innovations, the results show how the social practices have consequences for students' access to learning these important skills. Finally, the results shed light on some pedagogical practices that can help develop and sustain productive leadership and innovation practices in school makerspaces and other learning environments alike.

2 Key Concepts

Within this chapter, I define the key concepts of my dissertation: distributed leadership, emergent leadership, and innovation practices. I begin the subsections by reviewing previous research on distributed leadership, emergent leadership, and activities that support innovation creation in makerspaces. Based on this previous research, I explain how the key concepts are used to examine the three phenomena in the school makerspace context. Finally, I explain how sociocultural theorizing directed my thinking and using the key concepts of this study.

2.1 Distributed leadership

In this PhD dissertation leadership is conceptualized and understood as being distributed between individuals. Existing conceptualizations of distributed leadership presuppose that not only those in formal leadership roles hold and exercise leadership, but that influence and agency (i.e., leadership) can be widely shared within a community (Harris & DeFlaminis, 2016). The concept of distributed leadership has been widely used in the field of educational research (Harris & DeFlaminis, 2016; Spillane & Orlina, 2005), mainly to examine and explain teachers' decision-making at school (Gumus et al., 2018). Although definitions of distributed leadership often emphasize that leadership should be distributed between all stakeholders at all levels of the school (Gronn, 2002), research about distributed leadership in schools has so far focused on staff communities, including teachers and principals, neglecting communities comprised of teachers and students (see e.g., Gumus et al., 2018; Hartley, 2010).

Makerspaces in principle challenge the traditional roles of teachers and students and shift the dynamics of leadership from more teacher-led pedagogical approaches to student-led ones. This is because students have access to various learning projects, with opportunities and responsibilities to make choices about what to work on and how to proceed with the chosen projects and who to collaborate with (Kariippanon et al., 2018). The teacher is also no longer viewed as the sole expert of learning activities, but knowledge and expertise are more widely shared within a community of teachers and students. At the same time, research in makerspaces has shown that students need their teachers' support to pursue maker activities and engage in learning (Kajamaa et al., 2020), suggesting that more student-led and

teacher-led approaches co-exist in makerspaces. Therefore, students and teachers need to have the opportunities to take part in decision making, ideate, and share their expertise together (Gumus et al., 2018).

Previous research has stated that distributed leadership is an outcome of emergent and dynamic interactional processes among individuals (Gronn, 2000; Ho & Ng, 2017). These interactional processes require individuals to collaborate to coordinate work and decision-making (Gumus et al., 2018). According to Gronn (2002), central to distributed leadership is that labor is divided between multiple individuals. This division of labor essentially consists of two dimensions: technical and social dimensions of labor division. Specifically, individuals need to negotiate the tasks to be worked on and how everyone can contribute to the completion of those tasks (technical). They simultaneously need to negotiate individual values, interests, and preferences for how certain tasks are to be completed (social dimension). Further, previous research about distributed leadership has posited that distributed leadership emerges in situated agency-structure dynamics, in which the process of distributing leadership is influenced and shaped by the activity of individuals and the social and material context within which the leadership activity arises (Gronn, 2000; Spillane & Orlina, 2005). Leadership activities within these social and material structures can either reproduce or transform existing power relations among actors (Gronn, 2000; Harris & DeFlaminis, 2016).

Leadership can also occur at many levels simultaneously (Gronn, 2002). Conceptualizations of distributed leadership do not place more emphasis on certain forms of leadership, but rather they acknowledge that all members of a community may be leaders at varying points across time (Wenger, 2010). Following Hairon & Goh (2015), in my doctoral research I centralized bounded empowerment in perceiving distributed leadership between teachers and students in a makerspace. According to these researchers, bounded empowerment means that not all control over decisions is relinquished to the students. Teachers still hold formal authority over the students but attempt to encourage students to take more ownership and responsibility for their learning activities. Although acknowledging the boundaries of leadership distribution, Wenger (2010) proposes that distributed leadership can lead to conjoint agency, in which individuals influence others and are reciprocally influenced by these others. Achieving conjoint agency through distributed leadership promotes individuals in being aware of their personal aspirations, the aspirations of others, and it promotes individuals in synchronizing their actions (Gronn, 2002). At best, attaining conjoint agency can strengthen the way individuals are able to synergize their efforts, goals, and resources for the good of the group or community (Gronn, 2002).

All things considered, I posit that the way learning is organized in makerspaces supports leadership, and to an extent requires it to be distributed between teachers and students. Previous research has also pointed out that allowing students to make

choices and take leadership of their learning activities can positively affect their participation and motivation (Fields et al., 2018; Halverson & Sheridan, 2014). In addition, it can lead to more meaningful learning experiences (DiGiacomo et al., 2020) and promote students in pursuing their interests, organizing their own learning, and cultivating new interests and learning in particular science, technology, engineering, arts, and mathematics (STEAM) fields (Ramey & Stevens, 2019). Despite the opportunities and benefits of distributed leadership in makerspaces, this aspect of school makerspaces has so far remained under-researched. I acknowledge that students do not automatically take up leadership in makerspaces, which in turn would lead to distributed leadership (Mulcahy et al., 2015). I also recognize that the teacher still holds a central role in students' making activities (Rajala & Kumpulainen, 2017). It can even be quite difficult for teachers to find ways to empower students to take responsibility and control over their work (Liu et al., 2021). Hence, the shifts in the social dynamics of school makerspaces bring new opportunities and tensions to existing school practices (Martin, 2015). However, tensions and opposing forces such as dissent and consent can be an important source for developing distributed leadership practices and enhancing collective learning (Kajamaa & Tuunainen, 2022). Therefore, being one of the first studies to use the concept of distributed leadership to examine joint leadership practices of teachers and students, my PhD dissertation will add important knowledge of the dynamics, efforts, and consequences of distributed leadership in a school makerspace.

2.2 Interactionally constituted, emergent leadership

As noted in Section 2.1, I understand leadership as an interactionally constituted social process, involving multiple individuals. The above-described research that specifically investigates distributed leadership in school contexts, has so far focused on leadership of adults in school communities. However, there is a body of research that has explored children's leadership, particularly children's emergent leadership in early education and school contexts. This body of research argues that when children play or work in groups, some individuals emerge to lead the group (e.g., Mawson, 2011; Yamaguchi, 2001). These individuals are generally described as someone who becomes influential or relevant to others (Badura et al., 2021). They take an active role in the group to influence the behavior of others (Pescosolido, 2001) by taking actions that matter to the others in the group (Badura et al., 2021).

Studies analyzing leadership emergence have been conducted in various early years educational contexts (Lee et al., 2005; Mawson, 2011; Mullarkey et al., 2005) and in multiple school learning settings, including collaborative mathematical problem-solving (Mercier et al., 2014; Yamaguchi, 2001), collaborative reasoning discussions (Li et al., 2007; Sun et al., 2017), and educational online environments (Siewiorek et al., 2012). In early years' educational contexts, children have exhibited

leadership by directing play themes or their conduct (Lee et al., 2005; Mawson, 2011; Mullarkey et al., 2005). Similarly, studies in the various school contexts have shown that students' emergent leadership comprises managing the roles and tasks of others and monitoring group work (Li et al., 2007; Sun et al., 2017; Yamaguchi, 2001), managing the routines of group activities, and generally controlling the direction of group work (Kantor et al., 1993; Mawson, 2011; Yamaguchi, 2001). Emergent leaders also appeared to reflect a high awareness of the group activity and showcased a sense of ownership over it (Pescosolido, 2002; Shin et al., 2004).

Common to all these studies is that leadership appears to be a relational construct that emerges in interactions between multiple individuals (Gronn, 2000; Shin et al., 2004). During this social process, certain individuals make active attempts to influence group activity (Li et al., 2007; Mercier et al., 2014; Sun et al., 2017). More specifically, in learning settings in which no formal group leader is appointed, some students actively bid to take responsibility and initiative over the group work (Li et al., 2007). These bids, also called leadership moves, have a contributory role in the socially situated leadership process (Li et al., 2007; Mawson, 2011; Sun et al., 2017). Moreover, the leader's role is legitimized by other students by interaction that follows the bids to take the lead (i.e., leadership moves) (Li et al., 2007). The legitimization of leadership through following leadership moves can happen either implicitly or explicitly (Badura et al., 2021). These leadership moves not only construct evolving roles of emergent leaders, but they have a pivotal impact on the process and outcomes of group work (Li et al., 2007; Mercier et al., 2014; Sun et al., 2017). This is because leadership research points to the fact that leadership centrally contributes to the structuring of group work and driving its direction, in turn affecting students' opportunities to learn (Li et al., 2007; Sun et al., 2017; Yamaguchi, 2001).

The studies that have specifically focused on students' leadership moves show that the moves can impact group work intellectually and emotionally. In their study in a collaborative reasoning discussion context, Li et al. (2007) found that students' leadership moves can control which topics are discussed and promote the development of group members' arguments. Adding to this understanding of the intellectual importance of emergent leaders, Mercier et al. (2014) found moves that introduced new ideas during group work, which drove the group forward intellectually. Similarly, Sun et al. (2017) found that in addition to proposing new solutions, emergent leaders made attempts to justify their own or their peers' solutions. Their study also highlighted the emergent leaders' role in integrating the various perspectives of group members and reaching consensus among group members. Further, emergent leaders are responsible for allocating tasks within the group, which in turn can pivotally mediate individuals' opportunities to participate in joint work (Li et al., 2007). Reaching consensus during group work and members' equal capacity to participate are features that have been acknowledged as being important for productive

collaboration (see e.g., Barron, 2003). This highlights the important role of emergent leadership for collaborative productivity. From an emotional perspective, Pescosolido's (2001) study showed that emergent leaders can manage the group's emotional state, by affecting group members' perceptions of their abilities to succeed in the group task. Based on their study, Sun et al. (2017) also argued that emergent leaders can enhance the group's positive emotional state by using leadership moves, which carry an inclusive tone, respectful attitude to others, and open-mindedness to alternative perspectives.

Similarly with the conceptualizations of distributed leadership, the studies on children's and students' leadership posit that emergent leaders can change over time and leadership can be distributed and shared between group members (e.g., Lee et al., 2005; Volet et al., 2017; Yamaguchi, 2001). Leadership moves and the extent to which they are followed by others are negotiated in situ, and thus, I conceptualized emergent leadership as an outcome of emergent and dynamic interactional processes (Gronn, 2000; Ho & Ng, 2017). Highlighting the central role of negotiation in this process, Badura et al. (2021) argue that group members' perceptions of who is leading the group work may vary between individuals. Further, an individual can emerge as a leader, even without all group members granting leadership to them.

The social processes connected to leadership are often complex and can emerge in tension-laden social dynamics. Despite the many opportunities, students' initiatives to take leadership might meet material or social resistance from the environment in which they act (Biesta, 2020). For instance, Yamaguchi's (2001) study from a primary school setting showed that sometimes one leader can emerge to dominate group work by overpowering the contributions of others. Dominant emergent leaders can ignore other members, reject alternative ideas, and physically control equipment that is to be used in a shared task (Buchholz et al., 2014). Such domination can lead to ineffective communication between group members and threaten collaboration (see also Barron, 2003). In contrast, sharing leadership within a group can enhance prosocial leadership and group productivity, and hence can be of benefit to collaborative learning (Yamaguchi, 2001). According to Volet et al. (2017) the more flexibly students can alternate between leading and following, the more advanced their collaboration will be, and the more productive the students will become. In addition, when students are oriented towards learning new skills together, it often advances democratic engagement and promotes students' engagement in collaborative activities (Yamaguchi, 2001).

Overall, recent research has clearly shown that emergent leadership can positively affect group interaction and learning (Sun et al., 2017; Yamaguchi, 2001). Moreover, Yamaguchi and Maehr (2004) argue that understanding emergent leadership in student groups is critical for understanding how groups become effective and achieve their goals. Recent research has shown that students who emerge as

leaders are more likely to engage in learning (Sedláček & Šeďova, 2020) and leadership can also positively affect other group members' engagement in joint learning situations (Leeming, 2019). Despite the acknowledgement of the importance of understanding students' leadership, empirical research that specifically focuses on social interactions and processes that constitute emergent leadership have so far been limited (Badura et al., 2021). In addition, most of the studies that focus on emergent leadership have been conducted in structured collaborative settings in which group composition, tasks, and goals have been pre-defined by teachers or researchers. Yet, there is research evidence that shows that leadership can be an important feature of open-ended making activities, affecting students' opportunities to participate and engage in learning-by-making in educational settings (Buchholz et al., 2014). As makerspaces are increasingly implemented in formal education, it has become imperative to gain research understanding about the processes and consequences of emergent leadership in school makerspace settings. My dissertation will thus contribute to a growing understanding of the meaning and consequences of students' emergent leadership for students' learning activities in school makerspaces.

2.3 Innovation practices in makerspaces

As argued above, students' opportunities to take authority and leadership of their learning, work on personally meaningful projects, and engage in learning based on individual interests are fundamental aspects of school makerspaces (DiGiacomo et al., 2020; Peppler et al., 2016b). According to previous research, these opportunities also increase students' opportunities to innovate (Gantert et al., 2022). Students' opportunities to gain more autonomy over their work at school can promote their agency (Clapp et al., 2016), and even transformative agency, which can encourage students to transform their learning activities and contexts to better fit their personal aspirations (Kajamaa & Kumpulainen, 2019). Inevitably, such opportunities increase students' options to pursue innovative ideas. Furthermore, in their study conducted in an educational makerspace, Hilppö and Stevens (2021) contended that appreciating students' own choices in circumstances in which students have access to rich tangible and digital resources can create fruitful conditions for innovative learning projects. Similarly, Gantert et al. (2022) proposed that a social climate that supports the use of makerspace's rich technological and other resources is key in creating the innovative potential of makerspaces.

As I described in Section 2.1 Distributed leadership, makerspaces alter the traditional teacher-student dynamics, in which teachers are considered to be experts and those responsible for planning students' learning activities and their organization. In makerspaces, students have increased opportunities to shape their activities, and expertise is understood as being shared among teachers and students (Kajamaa et al., 2020; Stevens et al., 2018). Further, Stevens et al. (2018) argue that

a core aim of makerspaces is that students gain opportunities to develop their expertise across STEAM disciplines further, as they are given opportunities to make interest-based choices in maker projects. Students' options to employ their personal expertise enables them to act as mentors and tutors to their peers, and consequently, to deviate from their established social roles (Sheridan et al., 2013). In turn, this can contribute to a brisk exchange of ideas, information, and resources (Beltagui et al., 2021), to building community knowledge (Oswald & Zhao, 2021), and to creating an innovative culture (Farritor, 2017) – all pivotal aspects of innovation creation.

Research about makerspaces and innovation creation often emphasizes the importance of the community aspects of makerspaces and its meaning for participants' actions and learning. Specifically, previous research posits that participants' sense of community can promote collaboration (Gantert et al., 2022; West & Hannafin, 2011), which is understood as being pivotal for innovative outcomes (Gantert et al., 2022; Halbinger, 2018; Vinodrai et al., 2021). A frequent form of collaboration in makerspaces is peer collaboration, which is supported by social companionships and tutoring and mentoring practices typical for makerspaces (Gantert et al., 2022). In addition to peer collaboration, the social setting in educational makerspaces can encourage teachers to collaborate. Teacher collaboration, including co-teaching practices, can promote teachers' ability to notice students' needs and encourage teachers to learn from one another, which contributes to teachers' ability to support their students on creative tasks (Jaatinen & Lindfors, 2019). Appreciating multiple sources of knowledge and expertise can also contribute to fruitful forms of teacher-student collaboration (Chng et al., 2022; Kajamaa et al., 2020). For instance, collaboration between students and teachers can allow the exploration of unknown aspects of projects, which can lead to innovative outcomes (Chng et al., 2022). The research discussed here thus shows that compared to more traditional learning environments, makerspaces can promote various forms of collaboration, each of which promises to support students' engaging in innovation creation in school makerspaces.

Collaboration in makerspaces can reflect more traditional forms of collaboration in which the group composition remains the same for longer periods of time (Kajamaa & Kumpulainen, 2019; Leskinen et al., 2021; Wright et al., 2021). It can also display divergent forms of collaboration, in which students work on separate projects, but gather together at times to collaborate in tackling emerging issues in their maker projects (Chng et al., 2022; Martin, 2015). Such momentary collaborations can allow participants to support each other's work and thinking and model strategies for pursuing various projects (Tissenbaum et al., 2017). Such divergent collaborative interactions, including collaboration with teachers and peers with varying degrees of proficiency in skills related to specific projects, are important for students' learning in makerspaces (Chng et al., 2022). Divergent collaborative

interactions can also boost the remixing of existing ideas, which is understood as being important during innovation creation (Bull et al., 2017). Overall, some the forms of collaboration discussed above are close to open collaboration (OC), in which more loosely coordinated individuals interact to create an artifact. In the economic world, open collaboration is known to benefit innovation creation (Levine & Prietula, 2014). Although the goal in school makerspaces is rarely aimed at producing a product or service of economic value, based on previous research, makerspaces carry the potential to enhance students' learning to use skills pivotal to such forms of collaboration and joint innovation creation.

A key priority in makerspaces should be to promote the so-called maker mindset (Dougherty, 2013), which is also fruitful for students' engagement in innovation activities. The maker mindset places play, fun, and interest at the heart of any making activity (Martin, 2015). A study by West and Hannafin (2011) showed that participants' playful engagement and interaction around projects is an important factor in contributing to innovation creation. In addition, the maker mindset can support the students in seeing themselves as someone who is able to make technological things (Chu et al., 2015). In turn, this is pivotal in encouraging students to seek and learn necessary skills and knowledge to succeed in innovative projects. Further, the maker mindset celebrates failure (Martin, 2015), which is important in the process of innovating (Geser et al., 2019; Hilppö & Stevens, 2020a). More specifically, repeated iterations during projects are viewed in a positive light, and related failures are framed as significant learning opportunities and as productive for the process of making (Hilppö & Stevens, 2020a; Rieken et al., 2019).

Within this section, I have described aspects of makerspaces that are potentially conducive for students' innovation activities. In addition to these aspects, pursuing making projects requires students to use skills that have been recognized in previous research as important during innovation creation. As students collaborate in makerspaces, they can learn to see each other's problem spaces, which can help them to locate the parts of projects they need help with and to recognize when their own expertise could benefit others (Tissenbaum et al., 2017). Becoming aware of one's own and others' problem spaces requires students to learn how to network and how to mobilize people to make use of all available help and resources. Networking and mobilizing others to use available resources have been recognized as core innovation skills in previous research (Marin-Garcia et al., 2016; OECD, 2019; Vincent-Lancrin et al., 2019). Further, the just-described situations enhance divergent and momentary collaborations in makerspaces, which can support students in recognizing when others are doing something they are not, but that could benefit them in pursuing their personal projects (Tissenbaum et al., 2017). Modeling strategies to pursue maker projects can also help students to introduce new ideas, evaluate advantages and disadvantages, estimate risks, make decisions, and carry out

actions, all recognized as core innovation skills (Marin-Garcia et al., 2016; OECD, 2019; Vincent-Lancrin et al., 2019).

Finally, I wish to highlight how I conceptualized 'innovation' in the context of innovation practices. In principle, makerspaces promote students' creative engagement in STEAM learning activities (Sheridan et al., 2014). Thus, makerspace projects enable students to develop ideas that are unique, novel, or fresh. Following (Csikszentmihalyi, 2015), such ideas become creative through social processes in which others evaluate and acknowledge the ideas as creative. In turn, such socially accepted creative ideas can become drivers of innovation (McCharen et al., 2011). Creativity is thus an inseparable part of innovation creation (Sarooghi et al., 2015). Fundamentally, the creative ideas become innovations when implemented in practice and transformed into new or improved products (Baregheh et al., 2009; West, 2009; West & Hannafin, 2011). Within this dissertation, I followed a line of research that took a holistic stance on innovation and focused on innovating as a phenomenon and as a process (e.g., Bjornali & Anne Støren, 2012; Hughes et al., 2018; Marin-Garcia et al., 2016). I view innovation processes as nonlinear, interpersonal and practical processes, and thus focus on the everyday interactions between students, teachers, and their social context – the makerspace learning environment. I argue that understanding the social dynamics and interactions around innovation practices is pivotal to support students' learning to innovate in school makerspaces.

Promoting students' opportunities and abilities to innovate individually and with others is pivotal for tackling current and future societal, and economic challenges (Keinänen et al., 2018; OECD, 2019). Despite the fact that innovation competence is set as a learning objective for basic education nationally and globally (FNAE, 2014; OECD, 2019), and makerspaces are recognized as potential sites for fostering such competence (e.g., Gantert et al., 2022), recent research still lacks an understanding of the conditions and social dynamics that support innovation practices in school makerspaces, particularly in the K–12 context (see also Rouse & Rouse, 2022). Hence, one of the aims of my PhD dissertation was to capture such conditions and dynamics, to provide theoretical explanations for how some of the features of educational makerspaces support innovation practices (see also Gantert et al., 2022; OECD, 2019).

2.4 Theoretical orientation: the sociocultural perspective to leadership and innovation practices in makerspaces

In my PhD dissertation, I applied sociocultural theorizing to conceptualize and analyze leadership and innovation activities in a school's makerspace. Therefore, the core focus is on the social interactions and participation processes that are connected to leadership and innovation as socially situated phenomena. According to

socio-cultural theorizing, the interactions under study, whether connected to leadership or innovation, are mediated and socially contextualized (Vygotsky & Cole, 1978). More specifically, individuals' actions are mediated by explicit or implicit signs, that in the makerspace context include cultural tools such as digital technologies, tangible materials (explicit), and language (implicit) (Wertsch, 2007). Therefore, the tools and materials (explicit signs) provided in the makerspace and the interactions between peers and teachers (i.e., implicit signs) are resources that mediate the participants' thinking and acting (Vygotsky & Cole, 1978). Moreover, following Wertsch (2007). I posit that students internalize and utilize the various mediational means in specific cultural, historical, and institutional contexts. More specifically, these contexts are seen as complex places in which particular cultural and historical dimensions frame what a participant is expected or entitled to do (Engeström, 1999). Hence, the affordances of the makerspace environment as well as the students' former experiences in school or out-of-school learning contexts play a role in how the participants take leadership or engage in innovation activities (see also Seitamaa-Hakkarainen et al., 2022)

From the sociocultural perspective, I view leadership and innovation practices not only as social practices constructed in situ, but also as cultural practices in which individuals' and communities' histories play a significant role. When individuals observe or participate in particular cultural practices in situ, they develop a repertoire of ways to participate (Gutiérrez & Rogoff, 2003). Following Wertsch (2007), I understand that these repertoires are developed through the other participants they interact with as other participants introduce new cultural tools to the ongoing stream of activity. In addition to gaining new cultural tools in interaction, students also gain an understanding of more sophisticated forms of using mediational means that already exist within the participants' activity (Wertsch, 2007). This typically happens when existing cultural tools become integrated with other forms of the students' personal motives and goal-directed behavior (Engeström, 1999; Wertsch, 2007). Therefore, the repertoires of participation develop one's understanding and use of interactions that take part in co-constructing leadership and innovations in the makerspace. As I argued above, the repertoires are not only constructed in situ, but are mediated by individuals' personal interests, prior experiences, and their knowledge of their own and their community's history (Gutiérrez & Rogoff, 2003). Therefore, the students' and teachers' prior experiences of taking leadership or innovating are integrated in their repertoires of participation. The repertoires, including the students' and their communities' histories, affect the ways students and teachers engage in taking leadership and innovating in the school makerspace environment.

In makerspaces, students take part in creating so-called emergent objects (Seitamaa-Hakkarainen et al., 2022) as the making process and its outcomes are often unknown prior to the activity (Kajamaa et al., 2020; Riikonen et al., 2020).

Engaging in such processes requires students to negotiate their individual ideas and visions, monitor and use their own and each other's expertise, and to develop an understanding of how various tools, materials, and the space itself can be used in the process of creating artifacts (Seitamaa-Hakkarainen et al., 2022). I argue that it is particularly within these emergent processes in which leadership and innovation practices are enacted and constructed. I followed a line of research that views leadership and innovation processes as social and cultural practices that are constructed across time, in interactions between individuals and their sociocultural environment (see e.g., Bjornali & Anne Støren, 2012; Gronn, 2000; Ho & Ng, 2017; Hughes et al., 2018). Applying sociocultural theorizing, I conceptualize practices as clusters of actions that are ongoing in nature, regardless of spatial or temporal gaps (Schatzki, 2019). Multiple individuals take part in constructing the social practices of leadership and innovation, as their recurring, mediated actions become interconnected across time (Castanheira et al., 2000; Green & Bridges, 2018). Participants in makerspace environments – students and teachers – negotiate their actions in specific cultural, institutional, and historical settings, which I depicted in more depth above. Their culturally mediated and historically contextualized leadership or innovation actions can take part in either reproducing or transforming the existing sociocultural setting (Wertsch, 1994). In my PhD dissertation I argue that using sociocultural theorizing to interpret leadership and innovation processes as socially constructed, situated, and contextualized practices, contributes to an understanding of the very much stressed community aspects of learning in makerspaces (Sheridan et al., 2014). Further, the theoretical approach applied in this study will promote research understanding about how individual actions become interconnected across time, and how such socially constructed practices contribute to students' learning necessary 21st century innovation and leadership skills (European Commission, 2019).

3 The research design

I begin this chapter by presenting the main objectives of the dissertation and posing research questions for each study. I then move on to describing the context of my dissertation research, the FUSE Studio makerspace (FUSE, 2022). The data for the study were gathered in two FUSE Studios, located in two Finnish schools. Because the schools had autonomy over how they wished to implement the FUSE Studio as part of their local curriculums, I highlighted some of the differences between these two FUSE Studios. I continue with some reflection on how the case study approach promoted a deep understanding of leadership and innovations as social and cultural practices. As my dissertation presents a case study of a particular type of a school makerspace, I consider the relationship this case study has with school makerspaces more widely. The chapter continues with an explanation of how collecting the video and interview data was conducted. I also explain how the research objectives and questions guided the organization and selection of data for in-depth analyses. I then present the methods of analysis in each study and examine the ways in which these methods helped me in fulfilling the study objectives and deepen my understanding of the leadership and innovation practices in the FUSE Studio. Also, being one of the first studies to examine leadership and innovation practices in a makerspace context, I considered how the concepts were operationalized and used in interpreting the video and interview data. In addition, I explain how sociocultural theorizing guided my thinking with the data. The final subsection is dedicated to ethical considerations, particularly from the perspective of video research with primary school aged children.

3.1 Study objectives

Objective 1: to gain knowledge about distributed leadership in a school's makerspace

School makerspaces alter the traditional teacher-student dynamics in formal school environments, in which the teacher is viewed as the knowledgeable expert, and as the one who leads the students' activities (e.g., Sheridan et al., 2013). This is because in school makerspaces students are typically allowed to take leadership in planning and designing their own learning projects and in choosing who to

collaborate with, and are expected to do so (Kariippanon et al., 2018). Despite the emerging research findings about these issues, recent research has not specifically focused on researching leadership in school makerspaces. Recent research thus falls short in understanding the conditions, opportunities, and tensions of leadership in school makerspaces.

Thus, the first objective of my dissertation was to bring research knowledge about how a primary school's makerspace, the FUSE Studio, allows leadership to be distributed between teachers and students. Specifically, using a narrative analytical approach, the dissertation sheds light on how Finnish primary school teachers frame distributed leadership practices, as these relate to their teaching in the FUSE Studio makerspace context. The study brings out the dynamics between teachers' and students' leadership in the FUSE Studio context.

Objective 2: to show how students construct leadership in their everyday interaction in a school's makerspace

Even though research to date has underlined the core role of leadership for successful collaboration (e.g., Li et al., 2007; Sun et al., 2017; Yamaguchi, 2001), research understanding about students' leadership in school makerspaces remains limited. Moreover, leadership is depicted as a skill needed in the 21st century (European Commission, 2019), but research has yet to produce an understanding of how makerspaces create a space for students to practice important leadership skills. Thus, the second objective of my PhD was to show how leadership emerges in primary school students' group interactions as they collaborate in their school makerspace, the FUSE Studio. The study will also generate empirical research knowledge about the consequences of emergent leadership for the outcomes of students' creative collaboration.

Objective 3: to shed light on how a school's makerspace enables teachers and students to construct innovation practices

Students' innovation competence is set as a key priority in formal education in various national and international educational policy documents (Bocconi et al., 2012; FNAE, 2014; OECD, 2019), and makerspaces are offered as a potential platform to advance students' learning how to innovate (Hughes & Morrison, 2020; Oswald & Zhao, 2021). Yet, innovation activities in school makerspaces remain under-researched. Specifically, although research has highlighted some of the aspects of makerspaces that can support innovation creation, there has been a lack of theoretical explanation of how these aspects are connected to teachers' and students' everyday interactions around innovation creation in school makerspaces (Gantert et al., 2022; Oswald & Zhao, 2021). Therefore, the third objective of my dissertation

was to demonstrate the interaction that takes place when students create innovations in the makerspace. Further, the objective was to show these interactions, entangled within the makerspace environment, construct innovation practices between teachers and students.

3.2 Research Questions

The following research questions were posed to find answers to the objectives of the dissertation:

STUDY I

How do teachers narrate the distribution of leadership between them and their students in a school's makerspace, the FUSE Studio?

STUDY II

What leadership moves emerge in students' group interactions in the makerspace?

How is students' leadership related to their collaboration?

STUDY III

Which actions take place when students create innovations in the FUSE Studio?

What are the collective innovation practices that emerge from these actions?

3.3 Research setting: the FUSE Studio

The data used in this dissertation were gathered during a research project conducted between 2016 and 2020 (Kumpulainen, 2017) during which two Finnish schools introduced a new school makerspace, called the FUSE Studio, into their educational programs. Both schools decided to offer the FUSE Studio as an elective course to students in grades one to six. In Finland, students' ages in these grades range from seven to 12 years. Prior to the uptake of the FUSE Studio, the teachers took part in a two-day training session about the FUSE Studio concept. Both schools are in the capital area in Finland. School 1 is a primary school with 251 students and 16 teachers. School 2 is a comprehensive school that provides primary and secondary level education. The school hosts 535 students and 28 teachers at the primary level. The students in both schools come from a range of language and socio-economic backgrounds.

According to the FUSE Studio developers (FUSE, 2022). The FUSE Studio is a makerspace model created at Northwestern University, Illinois USA in 2011. Its original purpose was to "reinvent STEAM education to appeal to all learners" in out-of-school settings and in elementary, middle, and high schools across the USA and internationally. The FUSE Studio model comprises a digital platform and separate tool kits to be used in completing various making projects. Figure 1 shows the student view of the FUSE Studio digital platform. On the platform, students have access to approximately 30 maker projects with varying themes. Some of the projects are fully digital, and in some, students use a range of tangible materials. The digital projects include designing homes or jewelry, coding games, and producing music. The projects that require the use of tangible materials include constructing roller coasters, game controllers, and solar-powered miniature cars.

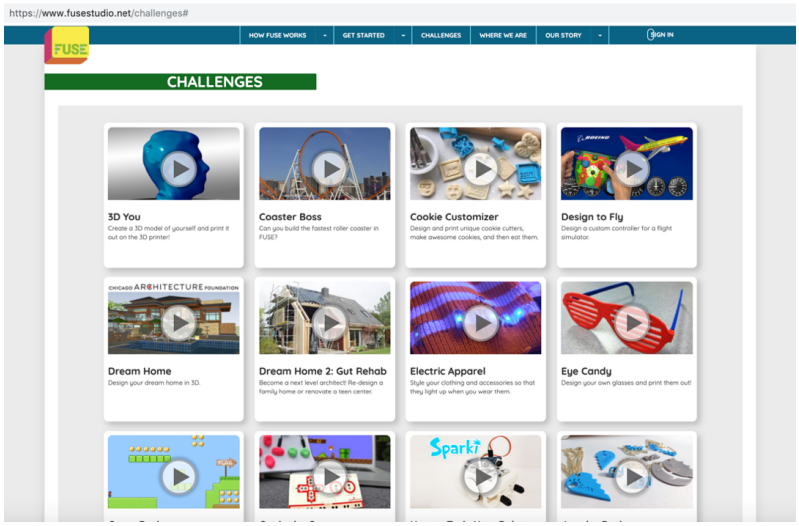

Figure 1 A screenshot of how the students access the STEAM projects on the FUSE Studio digital platform.

When choosing a project, students have access to written instructions and video tutorials to support the students in completing the projects. In addition, the students can use the digital platform to locate peers who might be experts in their chosen projects. The students are thus encouraged to develop personal expertise and tutor each other in the makerspace. The teacher's role is to act as a facilitator of the students' making projects, supporting the students in using the various digital and tangible tools, materials, and equipment. Although the FUSE Studio is based on ready-designed projects, students are encouraged to make personal interpretations and customize the challenges to fit their personal interests better. Students are also allowed to use the FUSE Studio materials to design their own projects. In addition to choosing a project, students are free to choose whether to work individually or in a group and who to collaborate with. Taken together, the FUSE Studio is an

educational space that combines elements of more open activities, that give room for the students' creativity and imagination, and structured elements, such as the ready-designed making projects.

As mentioned above, the schools had autonomy in how they implemented the FUSE Studio as part of their daily school activities. Although both schools decided to offer the FUSE Studio as an elective course, the schools had slightly different approaches in how they organized the makerspace and its activities. School 1 decided to mix grade levels in a way that the older students acted as tutors for the younger ones. The school dedicated one classroom (see figure 2) with easily movable furniture to act as the physical studio. The students were free to move in the space and used laptops to access the FUSE Studio platform. At the beginning of data collection at School 2 in fall 2016, the school's physical FUSE Studio consisted of a computer lab (figure 3), a classroom with more easily movable furniture (figure 4) and a hallway (figure 5). The students thus used desktop computers or laptops to access the FUSE Studio digital platform. The school re-organized the FUSE Studio for the spring term 2017 to fit their needs better. The new makerspace consisted of two similar spaces with movable furniture and laptops for the students use (figure 6)

Figure 2 The FUSE Studio space at School 1.

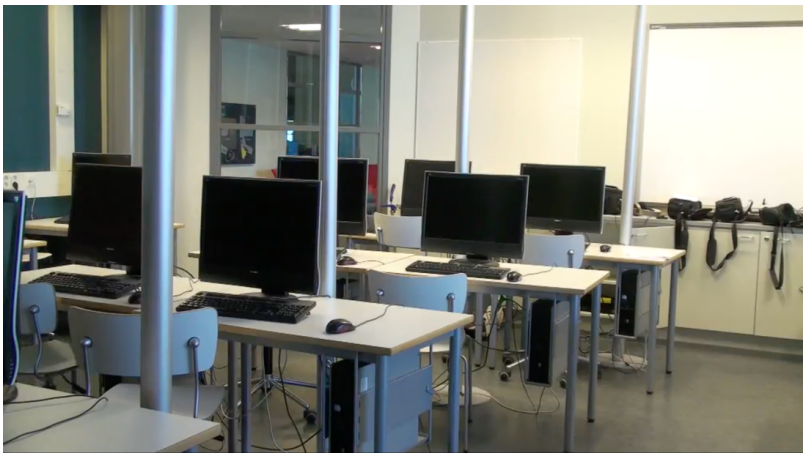

Figure 3 The FUSE Studio computer lab at School 2.

Figure 4 Students working in the classroom at School 2.

Figure 5 Students and a teacher working in the hallway at School 2.

Figure 6 The FUSE Studio in Spring 2017 at School 2.

3.4 The case study approach

My doctoral dissertation presents a case study of leadership and innovation practices in a particular type of a primary school makerspace, the FUSE

Studio. Case studies are often presented as methodologically well fit to enhance research understanding about individuals, communities, and their contexts (Hamilton & Corbett-Whittier, 2012). Overall, the methodological approach was tightly entangled with the study's sociocultural theoretical frame, which highlights the role of the interplay between individuals and their social context (see e.g., Engeström, 1999; Vygotsky & Cole, 1978; Wertsch, 2007).

In this case study, I centralized individuals' activities and interactions to construct knowledge about how the research participants socially constructed

leadership and innovation practices in their sociocultural context – the school makerspace. Therefore, the case study approach enabled an in-depth analysis of how the makerspace environment contributed to leadership and innovation as historically contextualized social and cultural practices. Specifically, in this case study I considered the nature and form of the cultural tools in use and social relationships between participants, to understand how students, with their teachers, might learn how to lead and innovate (Gutiérrez & Rogoff, 2003). Moreover, paired with the sociocultural theoretical frame, the case study approach was used to capture how leadership and innovation practices invited particular types of participation within the everyday interactions in the FUSE Studio makerspace. (See Danish & Gresalfi, 2018). In addition, with the sociocultural theoretical lens, the case study approach promoted the examination of how the social context came to be and how it could change over time (Danish & Gresalfi, 2018).

Case studies are always detailed and thus bounded presentations of certain levels of social organization (Green & Bridges, 2018). Yet, as a bounded unit, a case study can promote the development of a deep understanding of the circumstances under which a presented theory might apply (Hamilton & Corbett-Whittier, 2012; VanWynsberghe & Khan, 2007). Such boundedness is often posed as a key feature of case studies (Stake, 2005). Moreover, Willis et al. (2007) argue that human behavior is best understood as a lived and situated experience. A case study is always bounded and specific, but it also approaches phenomena holistically, aiming to grasp the phenomena being studied in all its complexities, including a rich understanding of the social context. Although my case study represents a single case it involves interaction and a relationship with a wider world (Hamilton & Corbett-Whittier, 2012). Even if it is bound to a specific social context, the FUSE Studio, the case study can potentially illuminate the opportunities and challenges in leadership and innovation practices in school makerspaces more widely (VanWynsberghe & Khan, 2007). Therefore, the case study has the potential to advance research understanding of supporting students learning of important leadership and innovation skills in school makerspaces.

3.5 Data collection, selection, and management

As is typical for a case study (VanWynsberghe & Khan, 2007), my dissertation research used rich data, including videos and interviews, collected in an academic year (2016–2017) in the two schools under study. Within this section, I first describe how the video and interview data were collected. I then move on to depicting how the data were managed and how parts of the data were chosen for a closer, in-depth analysis.

The data consist of 152 hours or video data. I took part in collecting the data with a research group as part of a larger research project (Kumpulainen, 2017). A total

of 124 students and 11 teachers took part in this study. Data collected at School 1 consist of 67 hours of videos. In this school, 30 students and three teachers participated in the FUSE Studio elective course. The students took part in the activities in two smaller groups, each of which one 60-minute session per week. The school decided to mix grade levels in the two groups, and hence, the students' grade levels in these two groups ranged from first to sixth (7 to 12 years old). At School 2, 85 hours of video data were collected. In this school, 94 students and eight teachers took part in the FUSE Studio elective course. This school decided to divide the students into three groups, based on the grade level they attended at the time of data collection. One of the groups consisted of fourth graders (10–11 years old), one of fifth graders (11–12 years old), and one of sixth graders (12–13 years old). Each group worked in the FUSE Studio for 60 minutes once a week. Two video cameras were used at School 1 and four at School 2 to capture the activities of the students and teachers in the makerspace. Wireless microphones were used to improve the capture the participants' talk. The main principle that guided the decisions regarding the focus of the cameras was the need to form a comprehensive picture of all types of activities that occurred in the FUSE Studio. For these reasons, some of the cameras were typically set to film the students and some to film the teachers in the two FUSE Studios.

In addition to collecting video data, the teachers who worked in the two FUSE Studios under study were also interviewed. Eight teachers took part in the semi-structured interviews. In spring semester 2017, after the teachers had worked in the FUSE Studio for one academic semester, they were interviewed individually at their schools. Interviews lasted from ten to 45 minutes and were transcribed verbatim. The interviews were thematically structured and addressed the following themes: the teachers' experiences of the FUSE Studio and its design principles; the students participating in the activities in the FUSE Studio; FUSE and pedagogy; school culture and leadership; and the curriculum reform that was underway when the data were collected. Although none of the themes addressed leadership specifically, the teachers reflected on the opportunities and challenges of leadership and its distribution in the FUSE Studio environment. The teachers who took part in the interviews had diverse teaching backgrounds. Besides teaching in the FUSE Studio, four of these teachers were working as class teachers in grades one to four. In the Finnish context, this typically means that the one teacher teaches all school subjects to their own class. The four other teachers worked as subject teachers, three of them at the secondary level (grades 7–9) and one in the primary and secondary level (grades 3–9). These teachers taught crafts, biology and geology, and English.

I now move on to describing some of the steps that were taken to organize the data and make them manageable. As there were only eight interviews and they were all used for analysis in Study I, I focus here on how the video data were managed. Essentially, video data are rich and typically well suited to capturing situational dynamics in individuals' daily interactions (e.g., Nassauer & Legewie, 2021). Yet, in all

their richness, they can be challenging to manage. To form a comprehensive view, I used Excel to organize the video data. The data corpus was first viewed to produce a spreadsheet that identified who and what was filmed on each piece of video recording. This information included the number of students and/or teachers, their grade levels, and the FUSE Studio projects that the students had chosen to work on during each session. This spreadsheet supported the selection of smaller data sets to be analyzed in depth in Study II and Study III. Following Green and Bridges (2018), I posit that from a methodological perspective, the smaller data sets used in all three Studies represent configurations of actors, times, and events. Moreover, from a sociocultural perspective, the configurations also account for the sociocultural and historical context (Danish & Gresalfi, 2018). Analyzing such configurations as they evolve over time enabled analysis of how leadership and innovation practices were constructed across time in the FUSE Studio context.

3.6 Analysis methods

In this section, I describe the smaller data sets that were chosen for each study and outline the analytical procedures in each study. My overall objective in choosing the data sets for the studies was to find 'telling cases', which answered each detailed research question in depth, and enabled the analysis of how these cases became connected across time (Green & Bridges, 2018). This enabled the analysis of how both practices were simultaneously constructed across time. Three analytical approaches were used in analyzing the data. These each had distinctive features that shed light on leadership and innovation practices on various dimensions. The three distinct analytical approaches were chosen to capture the participants' activity in all its complexity – including participants' actions in situ, the means that mediated their actions, as well as the cultural and historical contexts in which the practices emerged.

3.6.1 Study I: The Narrative analytic approach

Study I was set to develop understanding about the opportunities and challenges in the ways teachers and students distributed leadership within the FUSE Studio. I was interested to know how these opportunities and challenges occurred in the FUSE Studio at the time of data collection. In addition, I wanted to understand the historical context and how distributed leadership could develop over time. For these reasons, I chose to analyze the teachers' reflections of their work in the FUSE Studio and to apply narrative thinking in the analysis.

Narratives are viewed as pivotal processual tools for individuals to make sense of their own and other peoples' experiences, actions, and intentions (Clandinin & Connelly, 2000; Czarniawska, 2007). Although only teacher interviews were used,

Czarniawska (2007) argues that multiple voices are present in narratives, and they mediate much knowledge. Narratives can therefore be used as a tool to grasp the actions of all those who are present in the told narratives. As people tell narratives, they simultaneously construct ways of action in certain settings, which is why narratives can grasp aspects of a context as a socially constructed story (Clandinin & Connelly, 2000). Narratives typically enable a researcher to interpret and analyze individuals' knowledge, experiences, actions, and the social elements of human life in all its complexities (Czarniawska, 2004). Narratives have also been used in previous leadership research (see e.g., Johnson, 2009), which is why I saw narratives as an appropriate lens through which to examine practices of distributed leadership in the makerspace environment.

As previously mentioned, all eight teacher interviews were included in the narrative analysis. To answer the research question, *how do teachers narrate the distribution of leadership between them and their students in a school's makerspace, the FUSE Studio,* I began the analysis by identifying the teachers' narrative accounts of leadership during the interviews. The analysis thus began by locating the parts of the interviews when the teachers were describing their experiences of leadership in the FUSE Studio learning environment. Based on previous distributed leadership research, leadership was operationalized as responsibility and control over learning activities in the FUSE Studio (Gumus et al., 2018; Hairon & Goh, 2015). These accounts were classified into thematic categories based on who enacted leadership within the teachers' accounts. The thematic categories produced in this initial phase of analysis were teacher-led, student-led, and distributed accounts of leadership in the FUSE Studio.

After thematically grouping the teachers' accounts, the analysis continued with a narrative analysis of the accounts. This phase of the analysis was guided by an understanding that the teachers shape their daily teaching in the FUSE Studio by evaluating stories of who they and their students are (see Connelly & Clandinin, 2006). Specifically, the analysis focused on the accounts of leadership from the perspective of how the teachers reflected their past and current experiences of taking and/or distributing leadership in the school and makerspace context. In addition, the attention was directed towards parts of the teachers' stories in which they envisioned their own and their students' leadership in the FUSE Studio in the future. Placing the teachers' leadership accounts on a storied, temporal trajectory allowed the analysis of social practices of leadership, as the teachers' experiences were viewed as forming sequences of connected events. Moreover, this final phase of the analysis included analyzing the ways in which the three types of narrative accounts – teacher-led, student-led, and distributed – reflected the broader sociocultural context of formal schooling (see also Wiles et al., 2005).

3.6.2 Study II: Interaction Analysis

The purpose of Study II was to analyze how the students in the FUSE Studio socially constructed leadership in situ. The analysis therefore relied on the video recordings of the students' work. The research questions concerned the students' use of leadership moves and the relationships between students' socially constructed leadership and their creative collaboration (see section 3.2 for the specific questions). To answer these questions, the following criteria were used to select videos for in-depth analysis: 1) the videos displayed students who collaborated in making a shared artifact, and 2) the videos displayed students who collaborated for an entire 60-minute FUSE Studio session. Five hours of video data were analyzed in depth in Study II. These videos were filmed at School 2 and the groups represented all three grade levels. One of these groups consisted of fourth graders, three of fifth graders, and one of sixth grade students. In each of the videos analyzed, one camera was set to film the group for the duration of the session. There researchers adjusted the cameras according to the students' movement in the Studio. In addition, each group had a wireless microphone that captured what the students said better.

I used the MAXQDA program to bring the data to an analyzable and organizable form. To support the analysis, I created detailed written transcriptions of all videos and imported these transcriptions into the MAXQDA along with the original videos. The transcriptions were iteratively corrected by reviewing the videos several times during the transcribing process. Techniques of interaction analysis (Jordan & Henderson, 1995) were then employed to analyze the social construction of leadership in the students' interaction. The overall analytical approach can be described as abductive, as the analyzing process involved repeated iterations between previous leadership research and my data (Timmermans & Tavory, 2012).

To seek answers to the first research question about the students' use of leadership moves, leadership moves were first operationalized as the students' active attempts to influence the behavior of others and/or the groups' activity (Li et al., 2007). Following the conduct of Jordan and Henderson's (1995) interaction analysis, the analysis continued by looking for leadership moves in the students' verbal interactions, gestures, movement in space and manipulations of the physical FUSE Studio materials. As is typical for abductive analytical approaches, the first phase of many iterations of coding was guided by Li et al.'s (2007) coding scheme of leadership moves. Their scheme includes turn management, argument development, planning and organizing, topic control, and acknowledgement. However, to understand the students' leadership in the makerspace setting, it was necessary to adjust the categories to describe leadership in the makerspace better. The final categories were a result of iterative rounds of coding (see also Srivastava & Hopwood, 2009). The final typology of leadership moves included the following moves: coordinating tasks, exploring new ideas, seeking out resources, and offering guidance and support to others.

The analysis continued to answer the second research question, regarding how socially constructed leadership was related to the students' creative collaboration. Attention was first turned to how leadership was distributed among the students. Hence, the analysis focused on the frequencies of leadership moves by each student and considered how often their leadership moves were followed by others. This phase of analysis allowed the dynamics of leadership taking and leadership legitimization in each group to be grasped. Previous research has clearly pointed out that flexibility in alternating between leading and following and group members' equal opportunities to participate promote collaboration (Li et al., 2007; Mercier et al., 2014; Volet et al., 2017). Attention was thus turned to two groups that had a notable difference in the extent of symmetricity between the students' leadership moves and conducted a deeper analysis of these two groups' interaction. The number of leadership moves by individual students was uneven in the first group. Moreover, it appeared that the leadership moves of only one student were generally followed by the others. In contrast, in the second group, all group members performed leadership moves relatively evenly, their moves were equally followed by others, and they thus had equal opportunities to lead joint work. Taking a closer look at these two seemingly different groups in terms of their leadership allowed for the capture of how leadership was constructed in these two groups and what consequences it had for their creative collaboration.

3.6.3 Study III: Video Data Analysis (VDA)

Although the same video data for the analysis were used in Studies II and III, I chose to use a different analytical approach than the one I had used in Study II. I chose Video Data Analysis (VDA) as proposed by Nassauer and Legewie (2021) as it allowed me to delve deeper into the sociocultural context of the work of all participants (i.e., students and their teachers) in the FUSE Studio. As with interaction analysis (Jordan & Henderson, 1995), VDA also allows close examination of the situational dynamics of the researched phenomenon, and interpretation of the consequences of the dynamics for social outcomes (Nassauer & Legewie, 2021). It is a combination of several methodological approaches. From a methods perspective, VDA includes methods of Interaction Analysis, as interactions are viewed as a layer of analysis. However, VDA adds context as another layer of analysis, which in my view, provides a fruitful platform for an interplay between the analytical approach and sociocultural theory. VDA defines context as dynamic and posits that actions carry different meanings depending on the context (also Heath et al., 2010). Nassauer and Legewie (2021) have stated that 'context' contains physical and social dimensions that reflect individuals' actions and social roles. From the sociocultural perspective, I view these as dimensions that allow the analysis of how available

cultural tools and the socio-historical context mediate the participants actions (Vygotsky & Cole, 1978; Wertsch, 1994).

When it comes to selecting a smaller data set for an in-depth VDA, the selection process was similar to the one in Study II. As my core interest was to understand the social practices that were connected to the creation of innovations, I chose videos in which I could observe the students' work for an entire 60-minute session. This meant that those videos in which the camera moved in the space following the teachers' activities were excluded from the data set. I only used such teacher videos to support interpretations when momentary teacher-student interactions were seen and/or heard better from these videos. The videos in the smaller data set subjected to a deeper analysis account for 19 hours of data.

To support the analysis, I imported the videos into the ATLAS.ti program for closer analysis. To answer the first research question regarding the actions the participants took when making innovations in the FUSE Studio (please see section 3.2 for the specific questions), innovations were operationalized as participants' implementation of novel and creative ideas in practice (Halbinger, 2018; West & Hannafin, 2011). The innovations located in this phase of the analysis were the following:

1) Installing multiple capacitors to maximize the power stored by a solar-powered car.
2) Combining paper and a lamp to create an effective charger for a solar-powered car.
3) Using furniture and foam rubber to create a fast roller coaster for a small marble.
4) Constructing a kinetic game controller for a Google game.
5) Constructing house models using spaghetti and marshmallows.

After locating episodes of the videos in which innovations were produced, the analysis continued by examining the students' and teachers' interactions during the episodes. In addition to VDA, I turned to Green and Bridges' (2018) Interactional Ethnography to support the abductive coding procedure. Following this approach, all actions taken by the individuals were first interpreted and given descriptive cover terms. Following the conduct of VDA, the coded actions included the participants' verbal communication, use of materials and technologies, and movement in space (see also Jordan & Henderson, 1995).

After this microanalytical phase of analyzing the participants' actions in situ, the analysis continued with an analysis of chains of participants' interactions. Analyzing such chains of interactions allowed for the second research question regarding the innovation practices that emerged from the individuals' situated actions to be

answered. In this phase of the analysis, attention was turned to what Green and Bridges (2018) call 'part-whole relationships (also Bridges et al., 2012). Specifically, the analytical focus was on actions that recurred across the episodes analyzed, and were thus organized and ongoing in nature, reflecting emerging social practices (Schatzki, 2019). These recurring actions were thematically grouped, resulting in a typology of innovation practices in the makerspace: taking joint action to innovate, navigating a network of resources, and sustaining innovation activities. As mentioned earlier in this section, the data were also coded in terms of contextual features of the innovation creation. This allowed for a deeper analysis of the interrelationships between the participants' actions and the sociocultural setting (Wertsch, 1994). The codes used for the contextual dimension included the individuals present in the videos, their social roles, as well as tools, materials, and equipment used during the participants' interaction.

3.6.4 Ethical considerations

This dissertation follows the general guidelines of the Finnish Advisory Board on Research Integrity (Varantola et al., 2012). The research project team obtained research permission from local authorities in the city in which the researched schools are located and sought institutional permission from both schools. Prior to data collection, written informed consent was obtained from all participating teachers, children, and their legal guardians. The research project followed the principles of the EU General Data Protection Regulation (EU, 2016). All written research material and audio recordings of the teacher interviews were stored and managed in a secured online cloud space. The video data were stored on the research team's external hard drives that were always kept in a locked space. As video data are rarely anonymous (Derry et al., 2010), the videos were always kept separate from any other research material that contained the participants' personal data. All research data were destroyed after completion of the project according to the GDPR guidelines. All names mentioned in this dissertation, including its sub-studies, are pseudonyms.

As the research followed the principle of voluntary participation, the individuals recorded were always asked for their oral permission to record prior to recording their work. The research team attempted to make sure that the participants always had an opportunity to ask us not to record or to stop recording at any time. However, to an extent, there is always a power imbalance between children and adult researchers in school contexts (Hamilton & Corbett-Whittier, 2012; Nassauer & Legewie, 2021). It is possible that the students adapted their actions and behavior according to their impressions of what is expected of them. The participants might also feel that the cameras were obtrusive (Heath et al., 2010), highlighting the need for sensitivity in recording an individual's work, regardless of their age or role in

the research environment. It is also worth noting that as participants are constantly recorded, they might do or say things that they did not intend to share with the researchers (Hilppö & Stevens, 2020b). The data also included recording the teachers and students using digital platforms that required participants to log in, bearing the risk that their login information might be caught on record. Such aspects of video research demanded that the researchers be sensitive to the recorded activities and to alter the placement of cameras or by muting microphones, when necessary. Although ethical responsibility over the research always rests with the researcher, a study by Hilppö and Stevens (2020b) on children's ethical agency showed that researched students themselves actively regulate boundaries of their privacy and take measures to adjust their participation while being recorded. Also in this study, the children sometimes asked us to stop recording or momentarily moved away from the scope of the cameras. According to Flewitt (2006) ethical conduct of research evolves in response to the relationships between a participant and the researcher and ethical dilemmas must be solved as they emerge. Our research team attempted to enhance communication between the research participants by openly discussing the participants' activities and feelings regarding the research process during data collection. We attempted to be sensitive to the actions of participants to regulate their privacy and to respond to these actions accordingly.

A project in which data are collected weekly for an entire academic year can be a burden to participating students and teachers. Hence, it is worth considering the balance between such a burden and the impact of the research on the stakeholders' lives (Alderson & Morrow, 2020). My research on socially constructed leadership and innovation practices is only a small part of all the research that has been conducted as part of the larger research project. However, I did my best to bring out some of the best practices and challenges faced by my research participants, to influence children and youth's opportunities to learn useful 21st century skills through personally meaningful projects and therefore to make my research worthwhile.

4 Main findings

My dissertation comprises three sub-studies, of which the first two focus on leadership distribution and the social emergence of leadership (studies I and II, respectively). Study III highlights how innovation practices, enabled by leadership distribution, are collectively constructed in the research participants' interaction. In this chapter, I summarize the findings of the three studies as they relate to the research questions.

4.1 Study I: Teachers' narratives of leadership in the school makerspace

The purpose of Study I was to gain knowledge about the ways in which teachers and students distribute leadership within the FUSE Studio makerspace. To answer the research question, *How do teachers narrate the dynamics of leadership in a school's makerspace, the FUSE Studio?* teachers' accounts of leadership in the makerspace were analyzed. The focus of analysis was on how the teachers framed their accounts of leadership on a temporal trajectory. Specifically, the analysis focused on the ways in which the teachers framed their experiences of leadership and its distribution based on their prior teaching experiences, their experiences from the FUSE Studio, and in their visions of the future of the learning environment.

Overall, the results of the study showcased three narrative accounts of leadership in the FUSE Studio: teacher-led, student-led, and distributed accounts of leadership. All three narrative accounts shed light on the dimensions of distributed leadership and reflected how the socio-historical context mediated these dimensions. I describe these three types of narratives in the three following subsections.

4.1.1 Teacher-led narratives of leadership

The teacher-led narratives of leadership reflected more traditional roles of teachers and students in formal schooling, in which the teacher is responsible for organizing the students' work. These narratives highlighted that they were part of a larger cultural change in formal schooling and saw the FUSE Studio as an arena in which this change was encountered. In their narrative accounts, they recognized a common goal in their school to move towards more student-led ways of learning

and saw potential in the FUSE Studio to enact such a goal. Yet, the change involved many tensions, which stemmed from the teachers' and their students' past experiences in the formal school context.

First, they felt that their students did not have the necessary skills to take leadership of organizing their work fully. More specifically, they saw that the students needed the teacher to take the lead in managing their attention in a very stimulating environment. The FUSE Studio was equipped with new equipment and materials that could draw the students' attention to a 'wrong' direction and make the work chaotic. They recognized that the students needed time to acquire such skills, but also noted that teacher-led ways of working always exist in a primary school context. Second, the teachers expressed the view that as the students were not accustomed to taking leadership over their work, they brought past teacher-led ways of working into the FUSE Studio, expecting the teacher to take the lead.

Overall, the teacher-led narratives of leadership emphasized that the cultural change at school is something that the teachers encountered with their students. The cultural change entailed constant negotiation between the teachers and students about how much, when, and how responsibility can be relinquished to students.

4.1.2 Student-led narratives of leadership

Some of the narratives of the teachers expressed student-led forms of leadership in the FUSE Studio. Within these narratives, the teachers depicted their actions and objectives as stepping back and encouraging their students to take responsibility for personal projects. Within the narratives, the teachers reflected on their past as teachers. Specifically, the teachers reflected on how their orientation in teaching over the years had developed from more traditional forms of schooling to facilitating students' projects. They had developed such an orientation prior to the uptake of the FUSE Studio but saw the environment as quite naturally allowing them to develop and implement their orientation to teaching further.

The teachers hoped that their students would develop relative expertise and would use that to take leadership in the FUSE Studio. Although they saw much potential in the FUSE Studio in this regard, they also felt that the students relied on the ready-made FUSE Studio projects more than they would have liked them to. They were concerned that the students would bring a 'copy-culture' into the FUSE Studio, copying and making projects that someone else had designed. However, they attempted to encourage their students to reflect on the skills and expertise they had acquired during the ready-made projects and to use such expertise to develop projects of their own and act as mentors for their fellow students.

To summarize, the student-led narratives of leadership showcased moments in the FUSE Studio in which students take leadership of their learning projects and teachers were there to facilitate. Yet, the narratives highlighted tensions in the leadership opportunities provided by the FUSE Studio environment and the students sticking to the ready-made projects in the FUSE Studio concept. However, these tensions allowed the teachers to reflect on the development of their teaching orientation and how that could be further developed in the FUSE Studio. In their student-led narratives, the teachers reflected on some steps that could be taken in the future to enact students' leadership.

4.1.3 Narratives of distributed leadership in the FUSE Studio

The narratives of distributed leadership represented ways to bridge the gap between formal teacher-led schooling and students' leadership over personal projects. Specifically, the teachers thought that the technological infrastructure encouraged students to develop personal skills and expertise and use the expertise of others. This in turn, was seen to prompt the distribution of leadership. Specifically, they saw that the technological infrastructure enabled distributed leadership by providing a platform on which students could acquire expertise in a particular field. Moreover, they saw potential in the FUSE Studio to create a 'field of expertise' which would allow the students to be dynamic in taking leadership into their projects. Yet, as the students might not naturally take such leadership and might rely on the leadership and expertise of their teacher, the digital platform was used as a tool for students to learn how to take leadership and for teachers to practice facilitation of students' projects. In the narratives of distributed leadership, this collective learning process involved dynamic shifts in leadership among the teachers and the students, with an aim to promote students' learning to take leadership in the future.

4.2 Study II: The emergence of leadership in students' group interaction in the school makerspace

The purpose of Study II was to examine how students take leadership over collaborative projects and to understand the consequences of students' leadership for collaborative outcomes. The study focused on students' leadership moves during collaborative activities. In addition, the study examined the consequences of socially constructed leadership for the outcomes of students' creative collaboration.

4.2.1 Students' leadership moves in the FUSE Studio

In Study II, the collaborative work of five student groups was analyzed. The analysis resulted in a typology of leadership moves found in the students' group

interaction: *coordinating joint work, exploring new ideas, seeking out resources, and giving guidance and support to other group members*. Each type of leadership move represented the functions the moves had within the students' work. At the same time, the typology of the leadership moves depicts the dimensions of creative collaboration in the FUSE Studio context, that enable and require students' leadership.

Coordinating joint work

In the FUSE Studio, students engaged in projects which they had chosen for themselves and that were emergent in nature. By emergent projects I refer to projects in which the process and outcomes are unknown prior to the activity. Such projects required the students to take leadership in coordinating their joint work. Coordination of joint work included managing tasks within the group and managing the use of the various technologies and materials. In addition, with these leadership moves, the students coordinated the conduct and process of the joint activity, ensuring that all necessary tasks were attended to.

Exploring new ideas

The process and outcomes of the students' projects were typically unknown to the students when they began their collaborative work. Hence, the students quite often encountered situations in which they either had the opportunity to alter the course of their joint activity or were required to do so. Such situations offered opportunities for students to emerge to lead the work, and exploring new ideas were typical leadership moves with which the students influenced the course of the activity. These leadership moves included the students' initiations to change the materials used in their project or adjusting the materials they used to fit the group's needs better, and suggestions to make changes to their initial design.

Seeking out resources

The students frequently encountered challenges that required them to alter the course of their joint activity. Consequently, the students often needed external resources to overcome such challenges. In the FUSE Studio, external resources were manifold, including the FUSE Studio digital platform, teachers, and peers. Thus, making use of these resources required students to step up and take the lead. The leadership moves in this category hence influenced the extent to which the students used the various available resources in the learning environment.

Giving guidance and support to other group members

The aim of the FUSE Studio design principles is to develop students' relative expertise, also encouraging them to act as mentors for their peers (Stevens et al., 2018). Taking such a role required the students to monitor the work of the other group members, to influence their activities, and thus take leadership in the joint work. With these leadership moves, the students helped their peers in using the FUSE Studio digital platform, including its instructions, giving guidance in using the materials and technologies, and providing support in designing and envisioning the shared artifact. These leadership moves were important in the sense that they promoted all group members' participation in creative collaboration.

4.2.2 The dynamics and consequences of students' emergent leadership during creative collaboration

To answer the second research question, regarding how socially constructed leadership was related to students' collaboration in the FUSE Studio, the analysis focused on the evolving interaction of two groups in more detail. In the first group, the students had unequal opportunities to lead joint work. In the other group, such opportunities were more equal among the students. Moreover, the interaction in the two groups appeared to construct two different modes of leadership, which had consequences for the students' collaboration.

The interaction in the first group constructed a dominant mode of leadership. This mode of leadership consisted of one student overpowering the others by ignoring and rejecting their contributions or bids to take the lead. The others also let this one student dominate their work. Such dynamics of the students' emergent leadership resulted in asymmetric opportunities to contribute to the joint work and created interactional tensions. Moreover, the dominant mode of leadership restrained the group from reflecting on and including multiple perspectives and ideas in the process of creating a joint artifact.

In the second group, a shared mode of leadership was constructed in the evolving interaction between the group members. This mode of leadership consisted of symmetrical opportunities to lead the joint work, flexible shifts in leading and following, and combining multiple perspectives and ideas during the activity. The interaction analysis also showed that within this group, leadership moves that gave guidance and support to others advanced the joint work and promoted all group members' ability to take initiative and leadership in the group work. Overall, the shared mode of leadership had positive consequences for the students' collaboration.

Overall, the dynamics of emergent leadership, specifically the modes of leadership that were constructed in the students' interaction had consequences for how STEM-related knowledge was co-constructed within the group – a dominant mode

of leadership created obstacles as a shared mode promoted the co-construction of such knowledge. In addition, the shared mode of leadership created a space for the students to envision how things could be and promoted the students' opportunities to incorporate their knowledge creatively in the joint project, promoting joint creative thinking.

4.3 Study III: The collective construction of innovation practices in the school makerspace

Study III focused on innovation practices in the FUSE Studio makerspace. By analyzing the videoed interaction of the students and teachers in the two FUSE Studios, an aim of the study was to shed light on social practices that support innovation creation. The analytical focus was on the actions the participants took when creating innovations and on the collective innovation practices that were constructed from these individual actions.

As a result of a detailed micro-analysis, three distinct innovation practices were found: *taking joint action to innovate; navigating a network of resources; and sustaining innovation practices*. These three practices were an outcome of verbal and non-verbal actions, mediated by the affordances of the environment that recurred in the interactions of teachers and students across the episodes analyzed. Importantly, although innovations were an outcome of students' personal projects, they were also an outcome of collective practices. More specifically, the processes of innovation creation involved joint efforts from others and engaged other members in the community in celebrating the process and outcomes of innovation creation. I now move on to depict the three types of innovation practices in more detail.

4.3.1 Taking joint action to innovate

Students' innovation creation in the FUSE Studio was sparked by *taking joint action to innovate*. Typically, the students' innovations were driven by situations in which they encountered a technical problem. In addition, some innovations were driven by the students' personal aspirations to extend the ready designed FUSE Studio projects. Moreover, the students' agentic actions, coupled with a teachers' sensitivity to support such actions enhanced the students' opportunities to innovate.

The actions that constituted these practices consisted of acknowledging a joint aim, evaluating central concerns and actions to be taken, gathering materials, peers, and teachers around the project, and encouraging the students to innovate. Although the innovations were created by individual students or small student groups, we could observe collective practices that supported the students' innovating. It was typical in the FUSE Studio that teachers and other students gathered around the innovations that were being created – either spontaneously or by invitation. Such

collective movements around the innovations were seen as empowering students to deviate from the ready-made FUSE Studio projects and to innovate. Moreover, gathering around the innovations enabled the students and teachers to collaborate and together evaluate core issues and actions to be taken. Tackling the difficulties together encouraged the students to persist with their innovation projects. Overall, the students' and teachers' collective engagement was seen as central for innovation creation in the FUSE Studio.

4.3.2 Navigating a network of resources

Taking joint action to innovate often resulted in *navigating a network of resources*. The students' and teachers' actions that constituted this innovation practice included creative explorations to use the tools and materials available in the space and using teachers' and other students' expertise to find alternative solutions to encountered problems. Thus, the participants' actions included verbal communication, but were further mediated by the materials, tools, and technologies of the environment. The materials, tools, and technologies used to construct this innovation practice consisted of the FUSE Studio material kits and other materials available to the participants.

As was the case in the previous innovation practice, navigating a network of resources was also a collective endeavor of multiple teachers and students. Figure 7 shows how the participants gathered to collaborate. Their interaction around the technical issue was mediated by the materials, combined from various sources. The students' and teachers' joint attempts to think with and use the materials, tools, and technologies available in the FUSE Studio allowed the use of all available knowledge. The study argues that this was a key factor in innovation creation.

The teachers' sensitivity to students' actions was the key to taking joint action to innovate. Similarly, the teachers' pedagogical approaches were seen to promote the students' innovating. It was evident that bringing the teachers' knowledge into the collective interaction, yet simultaneously giving room for the students' skills and knowledge promoted the participants' joint engagement and co-construction of knowledge, contributed to innovation creation.

4.3.3 Sustaining innovation practices

The third type of innovation practice constructed in collective interactions between students and teachers we call *sustaining innovation practices*. The actions that constituted this practice were mediated by the space, the materials, and verbal communication. As was the case in the two other innovation practices, the students and teachers typically gathered around the created innovations. In this innovation practice the gathering was driven by celebrating the innovators' accomplishments.

The gathering further enabled the other participants' collective involvement in the innovations, as they shared the tangible materials to test and play with the created innovations. Sharing and collectively celebrating the innovations also allowed the participants to ideate modifications and future use to the created innovations.

Sustaining innovation practices consisted of actions that were connected to the creation of innovations, and further contributed to a culture in which students are encouraged to innovate and their innovative creations are collectively valued. Mainly, this was practiced through gathering around the innovations that were created. Gathering around the innovations allowed other students to relate to innovation creation, potentially inspiring them to innovate. Moreover, the gathering enabled the teacher and the students to imagine ways in which the innovation projects could be further developed as part of other school activities, including arts and crafts classes. The study thus argues that this innovation practice could help sustain innovation activities at school and promote students' learning to innovate. Based on the analyses, sustaining innovation practices requires collective efforts from the teachers and students working in the makerspace environment. The teachers' support in giving room for students' innovation and underlining the students' ownership over their projects was particularly pivotal. The collective interactions around innovations in the FUSE Studio created a climate that was fruitful for creating innovations.

Figure 7 Six Students and a teacher have gathered to overcome a technical issue with a solar-powered miniature car. Their interaction is mediated by several FUSE Studio material kits and a lamp.

5 Discussion and conclusions

This dissertation investigated how students' leadership and innovation practices can be fostered in a primary school makerspace. Although leadership and innovation skills are important in succeeding in the 21st century (Binkley et al., 2012; Chalkiadaki, 2018), research on students' opportunities to develop these skills has been limited. Moreover, although makerspaces are known to promote student initiative in personal projects (Dougherty, 2012; Hilppö & Stevens, 2021; Peppler et al., 2016b) and to foster innovation creation (Farritor, 2017; Gantert et al., 2022), these aspects of school makerspaces so far have not been explored. Hence, the aim of my dissertation was to investigate the conditions and social dynamics that support distributed leadership and innovation practices in a primary school's makerspace, the FUSE Studio. By focusing on distributed leadership and innovation as social practices, my doctoral dissertation makes an important sociocultural research contribution to the field. Specifically, the dissertation makes the following main contributions: 1) it extends current research knowledge on leadership and innovation practices, by studying teachers' and students' collective interactions that foster or challenge their development, 2) contributes to sociocultural approaches in makerspace research by shedding light on the conditions of a school makerspace that shape leadership and innovation practices, and 3) informs practice by explaining the teacher's role in the construction of leadership and innovation practices. The discussion will focus on these research contributions, consider the limitations of the study, and provide some directions for practice and future research.

5.1 Implications for research on leadership and innovation practices

Being one of the few studies that have investigated primary school students' leadership and innovation practices in a makerspace context, my dissertation contributes to research knowledge about leadership and innovation practices. Specifically, as schools are increasingly extending their learning environments to include makerspaces, the results of my doctoral dissertation contribute to a growing understanding the educational potential of makerspaces educational to foster the development of leadership and innovation creation. The results demonstrate ways in which students working in makerspaces gain opportunities to learn how to lead and

to innovate, both of which have been presented as key 21st century skills in several educational policy documents (e.g., Binkley et al., 2012; Chalkiadaki, 2018; European Commission, 2019).

Echoing previous research, the results of all three sub-studies point to the fact that makerspaces can promote students' opportunities to take the lead over their projects (Sheridan et al., 2013) and foster the creation of innovations (Gantert et al., 2022). Adding to the existing research, my dissertation sheds light on how some of the salient aspects of makerspaces enable leadership and innovation practices to develop. Specifically, the dissertation shows how the creative and open-ended projects and community interaction – of which I use the term collective interaction – create a space for leadership and innovation practices to be socially constructed (see e.g., Sheridan et al., 2014). In addition, the dissertation extends current research knowledge by showing how the distributed leadership and collective innovation practices are connected to students acquiring related 21st century skills.

First, Study II showed that students' opportunities to work on creative projects required them to self-organize their activity, including who to work with and how to carry out joint projects. Moreover, the open-ended nature of the makerspace activities required students to lead their activities by coordinating joint work, making use of the resources in the makerspace environment, exploring alternative ideas, and supporting peers during the learning projects. Previous research has noted that creating emergent objects in makerspaces requires students to negotiate individual ideas and visions and deal with various issues as they emerge during joint work (Seitamaa-Hakkarainen et al., 2022). Such negotiations can be quite demanding for the students. Based on Study II, socially constructed leadership appeared to provide structure for the students' work on such emergent objects. Socially constructed leadership helped students to attend to the details of creative work, manage the use of tools and materials, and promoted the groups' ability to follow and monitor the overall processes of their activity. These all contributed to productive joint work.

Second, Studies 2 and 3 pointed out that students' and teachers' collective interaction around the students' projects created a platform for the social construction of leadership and innovation practices. Importantly, such collective interactions shaped the participants' interaction around new ideas, contributing to collaborative learning during making projects. This is because previous research has shown that such interaction can promote knowledge construction, develop new understandings and ways of thinking, and can enhance envisioning alternative outcomes (Miell & Littleton, 2004; Rojas-Drummond et al., 2008; Rojas-Drummond et al., 2014; Shin et al., 2004). The results of Studies II and III clearly show that these pivotal aspects of collaborative learning were promoted in more traditional collaboration by a shared mode of leadership in Study II, and during momentary, divergent collaboration between students and teachers through collective innovation practices in Study III.

The studies of this dissertation also showed that when taking part in leadership and innovation practices, the participants took actions that resemble skills regarded as important for productive leadership and innovation creation. Therefore, I argue that the making activities provided opportunities for students to practice such skills. In the groups we analyzed in Study II, the students needed to communicate their ideas to others clearly and effectively to influence the group work. This included presenting and promoting new ideas, formulating arguments, considering the arguments of others, and managing the group work by planning, monitoring, and setting goals. Group management also included leveraging the strengths of others to accomplish the common goals. The students thus practiced leadership skills often depicted in various 21st century skills frameworks (Binkley et al., 2012; Chalkiadaki, 2018). Their collective interactions also promoted the students' acknowledging problems, critically reflecting on alternative perspectives, and networking to find solutions, all regarded as important innovation skills (Marin-Garcia et al., 2016; Vincent-Lancrin et al., 2019). In addition, as leadership and innovations were collectively practiced between students and teachers, the practices enabled the participants to learn from one another. Studies 2 and 3 pointed out that when collaborating with others – whether in more traditional form (Study II) or during divergent collaboration (Study III) – the interactions promoted the students' awareness of what others are doing, often depicted as a core leadership skill (Pescosolido, 2001; Shin et al., 2004). During collaboration, the students (Study II) or students and teachers (Study III) supported each other's work by providing instructions, supported the use of tools and materials, and modeled ways to solve problems, all considered to be leadership skills in previous research (Lee et al., 2005; Shin et al., 2004).

Although the learning conditions (the space, the materials, the interactions) in the FUSE Studio clearly provided opportunities for students to practice leadership and innovation, it was at times demanding for students to take part in such social practices. Previous research has stressed the role of participants' individual trajectories in influencing their interactions (Barron, 2003; Eteläpelto, 2017). Such trajectories were also visible in the three studies that constitute this dissertation. Both the students' and teachers' trajectories – including their orientations to the activity – had a pivotal role in the construction of leadership and innovation practices, as the individual trajectories shaped the participants' opportunities to take part in the learning activities. Specifically, the students' trajectories in Study II constructed dominant and shared modes of leadership, which in turn, resulted in qualitatively different forms of creative collaboration. The dominant leadership mode created obstacles for the students' participation in STEM knowledge creation and creative collaboration as the students had conflicts, discussed fewer ideas, and had asymmetrical opportunities to contribute to creative collaboration. In contrast, the shared leadership mode invited the students to co-construct knowledge and to take

part in leading creative collaboration jointly. Similarly, the results from Study III revealed that the teachers' orientation to the activity promoted sharing responsibility between teachers and students. The sharing of responsibility enhanced the integration of knowledge from various sources, providing equal opportunities to take part in innovation. Based on these results, I argue that paying attention to how leadership and innovation are collectively practiced can help promote the educational objectives of makerspaces, such as equity and inclusivity (Giusti & Bombieri, 2020). To support makerspaces as democratic learning environments, it is important that the social situations in makerspaces are open to shared leadership and collective innovating (see also Skåland, 2022).

5.2 Implications for sociocultural approaches in the research of social practices in makerspaces

Makerspaces are commonly described as constructionist learning environments (Halverson & Sheridan, 2014; Keune & Peppler, 2019; Peppler et al., 2016b; Sheridan et al., 2014). The constructionist theoretical perspectives that mainly rely on Papert's (1991) work have thus greatly influenced the theoretical approaches applied in previous makerspace research. In addition, there is a growing research strand that has investigated learning activities in makerspaces from socio-material perspectives (e.g., Kumpulainen & Kajamaa, 2020; Mehto et al., 2020). Yet, sociocultural theorizing has also proved to be a fruitful theoretical lens through which to understand learning in a school makerspaces context (see e.g., Kajamaa & Kumpulainen, 2019, 2020). My study therefore contributes to the (so far) less used sociocultural theoretical approaches in makerspace research. The theoretical approach applied in all three studies contributes to research knowledge of the greatly emphasized community aspects of learning in makerspaces (Sheridan et al., 2014). Overall, the findings of my dissertation underscore that leadership and innovation were collectively practiced in interactions between teachers and students. In addition, the sociocultural theoretical approach helped to reveal some conditions within which the FUSE Studio environment mediated the participants' interactions contributing to the leadership and innovation practices. The theoretical lens also shed light on how leadership and innovations as social and cultural practices could reproduce or challenge the existing ways of being and interacting in a formal school context (see Wertsch, 1994).

All three studies point to the fact that the participants' interactions were mediated by the available tools and materials and the pedagogical setting (including open-ended projects and the technological infrastructure). In Study II, the materials used by the students mediated the students' access to leadership roles in creative collaboration particularly through coordinating the use of the materials, using the materials to explore alternative ideas, and using the materials to support peers

during the learning projects. Moreover, in Study III, the materials available in the makerspace inspired the students and teachers to create innovative designs and technical solutions in their learning projects. In the teachers' narratives analyzed in Study I, the teachers saw the pedagogical setting of the FUSE Studio environment as quite naturally allowing them to facilitate students' personal projects. For example, the teachers felt that the students' leadership of projects was supported by the digital FUSE Studio platform as it prompted the students to use various sources of expertise. In addition, the FUSE Studio model in principle encourages students to make personal sense of the projects available (Stevens et al., 2018). Researchers also argue that as in makerspaces, students' personal projects are valued (Dougherty, 2012; Peppler et al., 2016b), students can develop ownership of projects (Fields et al., 2018; Sheridan et al., 2013) and can be encouraged to innovate (Gantert et al., 2022). The results from Study III are evidence that the open-ended nature of activities gave room for the students' imagination and creative engagement in the learning projects. Moreover, adding to existing research, Study III showed how the above-mentioned potential of makerspaces is realized through emergent social practices. For instance, gathering around the students' projects appeared to promote the students' sense of ownership over their projects and showed appreciation for modifying the projects to fit personal aspirations. When gathering around the projects, the students and teachers took joint action to innovate, together they learned to use all available resources, and created practices that could help sustain student-led innovation activities in the school more widely.

My socioculturally oriented doctoral dissertation also shows that it was useful to examine leadership and innovation practices as connected to the participants' histories, their present actions, and anticipated futures in the formal school context. It is evident that there are aspects of makerspaces that create opportunities for students to take the lead and to innovate. Yet, the results of Studies 1 and 3 highlight that despite the opportunities the makerspace environment offers for distributed leadership and innovation practices, makerspaces do not automatically foster such practices. The narrative analysis particularly showed that it requires collective efforts from the teachers and students to learn how to work within a novel, more open learning environment, and make use of the opportunities offered by it. For example, even though the FUSE Studio design principles aim to support the use of all available expertise and peer tutoring (Stevens et al., 2018), in Studies I and III students tended to rely on the expertise of the teacher and expected the teacher to take the lead of their learning activities. This underscores that it can be difficult for the students and teachers to transform the sociocultural setting of formal school by breaking away from the well-established ways of interacting at school. To make use of the opportunities for students to grow as leaders and innovators in their own learning, it is necessary for students and teachers to be willing to change their roles at school, and to collaborate to lead and innovate together in the makerspace.

5.3 Implications for reconstructing practice

The results of my doctoral dissertation also have implications for practice in school makerspaces. Overall, the results of the three studies undertaken as part of this dissertation highlight that learning to take leadership and to innovate entails collective efforts from teachers and students. Consequently, as a final contribution of this dissertation, I wish to discuss the teacher's role in leadership and innovation practices. Specifically, the results of my dissertation show that the teachers' pedagogical orientation plays a pivotal role in leadership and innovation practices.

First, the teachers' narratives in Study I highlighted that distributing leadership in the makerspace environment is a collective learning endeavor of the teachers and students. The narratives of student-led leadership particularly suggested that a teacher's orientation to facilitate students' projects could encourage students to take more leadership in the FUSE Studio. The results from Study II also underscored that taking leadership in joint work was challenging and the students needed their teachers' support in constructing inclusive and productive leadership practices. Second, Study III revealed that the way the teachers enacted their orientation to the making activities, i.e., how they made sense of the learning environment and made choices in their interactions with the students (see Eteläpelto, 2017), had visible consequences for the students' engagement in the innovation practices. For instance, although the students at times relied on the teachers' expertise in tackling technical issues, the teacher played a pivotal role in recognizing the students' expertise and encouraging students in using that expertise. I argue that the dynamic integration of teacher and student expertise potentially contributed to the students learning to innovate in these types of interactional processes. It was also evident in Study III that the teachers' orientation to the students' making activity allowed the teachers to let go of the boundaries set by the ready-made FUSE Studio project instructions. In turn, this enabled the teachers to facilitate the students' innovation processes. The sustaining innovation practices in Study III also showcased how an orientation towards facilitating students' innovation projects allowed the teacher to think about extending the students' projects outside the FUSE Studio makerspace.

Existing research evidence shows that makerspaces can promote teachers' rethinking their pedagogical practices (Becker & Jacobsen, 2020). For example, a study by Rajala and Kumpulainen (2017) showed that teachers' agentic orientations affect the extent to which they promote students' personal aims and authority over learning projects or reinforce more traditional ways of teacher-student interaction. Although I did not specifically focus on teachers' agentic orientations in my dissertation, I argue that the teachers' agentic orientations and their enactment could play a role in how manifold sources of expertise are valued and used, how students' leadership is supported, and how students' innovation projects are supported in the formal school context.

5.4 Study limitations, directions for future research, and concluding remarks

My dissertation has limitations that require consideration. First, the research relies on video and interview data. Such data are affected by researchers' choices, such as the placement and focusing of the cameras (Heath et al., 2010) and by the themes chosen for the semi-structured interviews. Therefore, important aspects of leadership and innovation practices might have happened outside the scope of our recordings or might not have come to light due to the themes discussed during the interviews. I also wish to highlight that the results of my dissertation research rely solely on my interpretations and those of the research team, of the video and interview data. Such interpretations can always be otherwise as it is the researcher who places the actions of individuals in a meaningful context (Clandinin & Connelly, 2000; Richardson, 1990). The research participants rarely showcased leadership or innovations by explicitly stating that they will lead, let others lead, or that they are working on an innovation. The analyses rely on interpretations as well as on the theoretical understanding of leadership and innovations as social and cultural practices. Future research should focus on developing research methods that could help track and analyze students' leadership and innovation practices, including students' own perspectives, in makerspaces and other environments alike.

I also acknowledge that my dissertation research was restricted to a specific makerspace, the FUSE Studio, and to the specific contexts at two Finnish schools. There are many other types of makerspaces, such as other kinds of school makerspaces, online makerspaces, and out-of-school makerspaces (Peppler et al., 2016a) that each have individual characteristics. Moreover, particularly the repertoire of materials in the participants' use shapes their interactions and learning activities in these various types of makerspaces (Keune & Peppler, 2019). I also recognize that contextual features such as school culture and the support the participants receive play a major role in their activities. It would therefore be important to investigate other social practices at the school level and how school level practices can support the collective construction of leadership and innovation practices. The research participants were also new to the FUSE Studio environment, so it is possible that the participants' experiences and actions took new forms once they became more accustomed to working in the makerspace. Although I believe that analogous practices emerge in other similar learning environments, it is possible – even likely – that other forms of leadership and innovation practices would also emerge in different makerspace and school contexts. Makerspaces are increasingly introduced in formal educational contexts (Juurola & Wirman, 2019) and best practices for teaching in makerspaces are still emerging (Rouse & Rouse, 2022). This dissertation provided some insights into how students leadership and innovation practices could be fostered in school makerspaces. However, it would be important for future research

to focus on leadership and innovation practices in other types of school makerspaces to enrich the research understanding about these important issues.

This dissertation has shown that there is much potential in school makerspaces to promote students in learning to take leadership and to innovate. The sociocultural theoretical approach of this dissertation helped reveal the conditions of the FUSE Studio that promoted the construction of leadership and innovation practices. In addition, the sociocultural theoretical orientation provided a lens through which to understand that it demands collective efforts from students and teachers to learn how to distribute leadership and innovate in the formal school context. Although the established ways of being and interacting at school may challenge the distributed leadership and collective innovation practices, the teachers and students of the FUSE Studio together were making efforts to increase the students' authority and control over their making and learning in the future. This ongoing interactional process was seen to be important for the students' learning to lead and to innovate, as advocated by various 21st century skills frameworks. Considering these results, future research should focus on how leadership and innovation skills are developed longitudinally across K-12 education and in different types of school makerspaces. It would also be important for institutions offering teacher training to develop their programs to increase the teachers' knowledge of the social conditions and collective interactions that can support students' learning of necessary 21st century skills.

It has been argued that schools should offer learning situations in which students learn to lead, to communicate, and to think creatively and innovatively. This is because for many, schools are the only place to learn such skills (Binkley et al., 2012). Promoting students' opportunities to lead and to innovate can enhance students' engagement in various learning situations (Sedláček & Šeďova, 2020). It can also help students identify what they have learned, promoting their understanding of their personal capacities and competencies (Biesta, 2020). This dissertation contributes to the understanding of the opportunities and tensions in leadership and innovation practices in a primary school makerspace. Thus, the research insights will be useful to researchers, practitioners, and policy makers interested in developing similar educational contexts. The dissertation has opened discussions regarding the importance of understanding leadership and innovation practices in the makerspace context and provided some directions on how these phenomena could be considered in future research. Moreover, the dissertation has highlighted how sociocultural theorizing can deepen research understanding of how the makerspace environment can promote students' learning to lead and to innovate. The research insights inform practitioners and policy makers by showing how the social circumstances and teachers' and students' collective interactions could be considered when developing makerspace learning environments and designing teacher training.

References

Alderson, P., & Morrow, V. (2020). The ethics of research with children and young people: A practical handbook. Sage.

Ananiadou, K., & Claro, M. (2009). 21st century skills and competences for new millennium learners in OECD countries. OECD Education Working Papers, No. 41. OECD Publishing, Paris. https://doi.org/10.1787/218525261154

Badura, K. L., Galvin, B. M., & Lee, M. Y. (2021). Leadership emergence: An integrative review. Journal of Applied Psychology, 107(11), 2069–2100. https://doi.org/10.1037/apl0000997

Baregheh, A., Rowley, J., & Sambrook, S. (2009). Towards a multidisciplinary definition of innovation. Management decision, 47 (8), 1323–1339. https://doi.org/10.1108/00251740910984578

Barron, B. (2003). When smart groups fail. The journal of the learning sciences, 12(3), 307–359. https://doi.org/10.1207/S15327809JLS1203_1

Becker, S., & Jacobsen, M. (2020). Becoming a Maker Teacher: Designing Making Curricula That Promotes Pedagogical Change. Frontiers in Education, 5. https://www.frontiersin.org/article/10.3389/feduc.2020.00083

Beltagui, A., Sesis, A., & Stylos, N. (2021). A bricolage perspective on democratising innovation: The case of 3D printing in makerspaces. Technological Forecasting and Social Change, 163, 120453. https://doi.org/https://doi.org/10.1016/j.techfore.2020.120453

Biesta, G. (2020). Risking Ourselves in Education: Qualification, Socialization, and Subjectification Revisited. Educational Theory, 70(1), 89–104. https://doi.org/https://doi.org/10.1111/edth.12411

Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. (2012). Defining twenty-first century skills. In Assessment and teaching of 21st century skills (pp. 17–66). Springer.

Bjornali, E. S., & Anne Støren, L. (2012). Examining competence factors that encourage innovative behaviour by European higher education graduate professionals. Journal of Small Business and Enterprise Development, 19(3), 402–423. https://doi.org/10.1108/14626001211250135

Bocconi, S., Kampylis, P., & Punie, Y. (2012). Innovating Learning: Key Elements for Developing Creative Classrooms in Europe. EUR 25446 EN. Publications Office of the European Union. https://doi.org/10.2791/90566

Brahms, L., & Crowley, K. (2016). Making sense of making: Defining learning practices in MAKE magazine. In Makeology (pp. 13-28). Routledge.

Bridges, S., Botelho, M., Green, J. L., & Chau, A. C. M. (2012). Multimodality in Problem-Based Learning (PBL): An Interactional Ethnography. In S. Bridges, C. McGrath, & T. L. Whitehill (Eds.), Problem-Based Learning in

Clinical Education: The Next Generation (pp. 99-120). Springer Netherlands. https://doi.org/10.1007/978-94-007-2515-7_7

Buchholz, B., Shively, K., Peppler, K., & Wohlwend, K. (2014). Hands on, hands off: Gendered access in crafting and electronics practices. Mind, Culture, and Activity, 21(4), 278–297.

https://www.tandfonline.com/doi/abs/10.1080/10749039.2014.939762

Bull, G., Garofalo, J., Littman, M., Sherman, R., Hoffman, M., Grant, M. M., & Grier, A. (2017). Make to learn: invention through emulation. Smart Learning Environments, 4(1), 8. https://doi.org/10.1186/s40561-017-0047-5

Castanheira, M. L., Crawford, T., Dixon, C. N., & Green, J. L. (2000). Interactional Ethnography: An Approach to Studying the Social Construction of Literate Practices. Linguistics and Education, 11(4), 353–400. https://doi.org/https://doi.org/10.1016/S0898-5898(00)00032-2

Chalkiadaki, A. (2018). A systematic literature review of 21st century skills and competencies in primary education. International Journal of Instruction, 11(3), 1–16. https://doi.org/10.12973/iji.2018.1131a

Chng, E., Seyam, M. R., Yao, W., & Schneider, B. (2022). Toward capturing divergent collaboration in makerspaces using motion sensors. Information and Learning Sciences, 123(5/6), 276-297. https://doi.org/10.1108/ILS-08-2020-0182

Chu, S. L., Quek, F., Bhangaonkar, S., Ging, A. B., & Sridharamurthy, K. (2015). Making the Maker: A Means-to-an-Ends approach to nurturing the Maker mindset in elementary-aged children. International Journal of Child-Computer Interaction, 5, 11-19. https://doi.org/https://doi.org/10.1016/j.ijcci.2015.08.002

Clandinin, D. J., & Connelly, F. M. (2000). Narrative inquir: experience and story in qualitative research. Jossey-Bass.

Clapp, E. P., Ross, J., Ryan, J. O., & Tishman, S. (2016). Maker-centered learning: Empowering young people to shape their worlds. John Wiley & Sons.

Connelly, F. M., & Clandinin, D. J. (2006). Narrative Inquiry. In Handbook of complementary methods in education research. (pp. 477-487). Lawrence Erlbaum Associates Publishers.

Csikszentmihalyi, M. (2015). The systems model of creativity: The collected works of Mihaly Csikszentmihalyi. Springer.

Czarniawska, B. (2004). Narratives in social science research. Sage.

Czarniawska, B. (2007). Narrative inquiry in and about organizations. In D. Jean Clandinin (Ed.), Handbook of narrative inquiry. Mapping a methodology (pp. 383–404). Sage.

Danish, J. A., & Gresalfi, M. (2018). Cognitive and sociocultural perspectives on learning: Tensions and synergy in the learning sciences. In International handbook of the learning sciences (pp. 34–43). Routledge.

Davies, B. (2006). Subjectification: the relevance of Butler's analysis for education. British Journal of Sociology of Education, 27(4), 425–438. https://doi.org/10.1080/01425690600802907

Derry, S. J., Pea, R. D., Barron, B., Engle, R. A., Erickson, F., Goldman, R., Hall, R., Koschmann, T., Lemke, J. L., & Sherin, M. G. (2010). Conducting video research in the learning sciences: Guidance on selection, analysis,

technology, and ethics. The journal of the learning sciences, 19(1), 3–53. https://doi.org/10.1080/10508400903452884

DiGiacomo, D. K., Van Horne, K., & Penuel, W. R. (2020). Choice and interest in designed learning environments: the case of FUSE Studios. Information and Learning Sciences, 121(3/4), 137–154. https://doi.org/10.1108/ILS-09-2019-0098

Dougherty, D. (2012). The maker movement. Innovations: Technology, governance, globalization, 7(3), 11–14. https://www.muse.jhu.edu/article/499244

Dougherty, D. (2013). The maker mindset. In Design, make, play (pp. 7–11). Routledge.

Dougherty, D. (2016). Foreword. In K. Peppler, E. R. Halverson, & Y. Kafai (Eds.), Makeology (Vol. 1). Routledge.

Johnson, G. C. (2009). Narrative inquiry and school leadership identities. International Journal of Leadership in Education, 12(3), 269–282. https://doi.org/10.1080/13603120902814664

Engeström, Y. (1999). Activity theory and individual and social transformation. Perspectives on activity theory, 19(38), 19–30.

Eteläpelto, A. (2017). Emerging Conceptualisations on Professional Agency and Learning. In M. Goller & S. Paloniemi (Eds.), Agency at Work: An Agentic Perspective on Professional Learning and Development (pp. 183-201). Springer International Publishing. https://doi.org/10.1007/978-3-319-60943-0_10

Regulation (EU) 2016/679 of the European Parliament and of the Council of 27th April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation), OJ 2016 L 119/1., (2016).

European Commission, Directorate-General for Education, Youth, Sport and Culture, (2019). Key competences for lifelong learning, Publications Office. https://data.europa.eu/doi/10.2766/569540

Farritor, S. (2017). University-Based Makerspaces: A Source of Innovation. Technology & Innovation, 19, 389–395. https://doi.org/https://doi.org/10.21300/19.1.2017.389

Fields, D. A., Kafai, Y., Nakajima, T., Goode, J., & Margolis, J. (2018). Putting Making into High School Computer Science Classrooms: Promoting Equity in Teaching and Learning with Electronic Textiles in Exploring Computer Science. Equity & Excellence in Education, 51(1), 21–35. https://doi.org/10.1080/10665684.2018.1436998

Flewitt, R. (2006). Using video to investigate preschool classroom interaction: Education research assumptions and methodological practices. Visual communication, 5(1), 25–50. https://doi.org/10.1177/1470357206060917

FNAE. (2014). National Core Curriculum for Basic Education. The Finnish National Agency for Education.

FUSE. (2022). Challenges. The FUSE Studio website. Retrieved 19.11.2022 from https://www.fusestudio.net/challenges/

Gantert, T. M., Fredrich, V., Bouncken, R. B., & Kraus, S. (2022). The moral foundations of makerspaces as unconventional sources of innovation: A study of narratives and performance. Journal of Business Research, 139, 1564–1574. https://doi.org/10.1016/j.jbusres.2021.10.076

Geser, G., Hollauf, E.-M., Hornung-Prähauser, V., Schön, S., & Vloet, F. (2019). Makerspaces as social innovation and entrepreneurship learning environments: The DOIT learning program. Discourse and Communication for Sustainable Education, 10(2), 60–71. https://doi.org/10.2478/dcse-2019-0018

Giusti, T., & Bombieri, L. (2020). Learning inclusion through makerspace: a curriculum approach in Italy to share powerful ideas in a meaningful context. The International Journal of Information and Learning Technology, 37(3), 73–86. https://doi.org/10.1108/IJILT-10-2019-0095

Green, J. L., & Bridges, S. M. (2018). Interactional ethnography. In International handbook of the learning sciences (pp. 475–488). Routledge.

Gronn, P. (2000). Distributed properties: A new architecture for leadership. Educational management & administration, 28(3), 317–338. https://doi.org/10.1177/0263211X000283006

Gronn, P. (2002). Distributed leadership as a unit of analysis. The Leadership Quarterly, 13(4), 423–451. https://doi.org/https://doi.org/10.1016/S1048-9843(02)00120-0

Gumus, S., Bellibas, M. S., Esen, M., & Gumus, E. (2018). A systematic review of studies on leadership models in educational research from 1980 to 2014. Educational Management Administration & Leadership, 46(1), 25–48. https://doi.org/10.1177/1741143216659296

Gutiérrez, K. D., & Rogoff, B. (2003). Cultural ways of learning: Individual traits or repertoires of practice. Educational researcher, 32(5), 19–25. https://doi.org/10.3102/0013189X03200501

Hairon, S., & Goh, J. W. (2015). Pursuing the elusive construct of distributed leadership: Is the search over? Educational Management Administration & Leadership, 43(5), 693–718. https://doi.org/10.1177/1741143214535745

Halbinger, M. A. (2018). The role of makerspaces in supporting consumer innovation and diffusion: An empirical analysis. Research Policy, 47(10), 2028–2036. https://doi.org/10.1016/j.respol.2018.07.008

Halverson, E. R., & Sheridan, K. (2014). The maker movement in education. Harvard educational review, 84(4), 495–504. https://doi.org/10.17763/haer.84.4.34j1g68140382063

Hamilton, L., & Corbett-Whittier, C. (2012). Using case study in education research. Sage.

Harris, A., & DeFlaminis, J. (2016). Distributed leadership in practice: Evidence, misconceptions and possibilities. Management in education, 30(4), 141–146. https://doi.org/10.1177/0892020616656734

Hartley, D. (2010). Paradigms: How far does research in distributed leadership 'stretch'? Educational Management Administration & Leadership, 38(3), 271–285. https://doi.org/10.1177/1741143209359716

Hasslöf, H., & Malmberg, C. (2015, 2015/02/17). Critical thinking as room for subjectification in Education for Sustainable Development. Environmental Education Research, 21(2), 239–255. https://doi.org/10.1080/13504622.2014.940854

Heath, C., Hindmarsh, J., & Luff, P. (2010). Video in qualitative research. Sage Publications.

Heath, S. B. (2012). Seeing our way into learning science in informal environments. Research on schools, neighborhoods, and communities: Toward civic responsibility (pp. 249-267). Rowman & Littlefield Publishers.

Hilppö, J., & Stevens, R. (2020a). "Failure is just another try": Re-framing failure in school through the FUSE studio approach. International Journal of Educational Research, 99, 101494. https://doi.org/10.1016/j.ijer.2019.10.004

Hilppö, J. A., & Stevens, R. (2020b). Students' ethical agency in video research. In Examining Ethics in Contemporary Science Education Research (pp. 177–189). Springer.

Hilppö, J., & Stevens, R. (2021). From short excursions to long-term projects: agency, interest and productive deviations in school. Education, 3-13, 51(3), 410–425. https://doi.org/10.1080/03004279.2021.1973530

Ho, J., & Ng, D. (2017). Tensions in distributed leadership. Educational Administration Quarterly, 53(2), 223–254. https://doi.org/10.1177/0013161X16681630

Holbert, N. (2016). The powerful ideas of making: Building beyond the curriculum. Journal of Innovation and Entrepreneurship, 5(1), 1–7. https://doi.org/10.1186/s13731-016-0058-4

Hsu, Y.-C., Baldwin, S., & Ching, Y.-H. (2017, 2017/11/01). Learning through Making and Maker Education. TechTrends, 61(6), 589–594. https://doi.org/10.1007/s11528-017-0172-6

Hughes, D. J., Lee, A., Tian, A. W., Newman, A., & Legood, A. (2018). Leadership, creativity, and innovation: A critical review and practical recommendations. The Leadership Quarterly, 29(5), 549–569. https://doi.org/https://doi.org/10.1016/j.leaqua.2018.03.001

Hughes, J. M., & Morrison, L. J. (2020). Innovative learning spaces in the making. Frontiers in Education, 5 (2020). https://www.frontiersin.org/articles/10.3389/feduc.2020.00089

Jaatinen, J., & Lindfors, E. (2019). Makerspaces for Pedagogical Innovation Processes: How Finnish Comprehensive Schools Create Space for Makers. Design and Technology Education, 24(2).

Jordan, B., & Henderson, A. (1995). Interaction analysis: Foundations and practice. The journal of the learning sciences, 4(1), 39–103. https://doi.org/10.1207/s15327809jls0401_2

Juurola, L., & Wirman, A. (2019). Tinkering to take on the world – joy and innovation in learning. City of Helsinki, Education Division. https://helsinkioppii.hel.fi/content/uploads/2022/02/tinkering_to_take_on_the_world.pdf

Kajamaa, A., & Kumpulainen, K. (2019). Agency in the making: Analyzing students' transformative agency in a school-based makerspace. Mind, Culture, and Activity, 26(3), 266–281. https://doi.org/10.1080/10749039.2019.1647547

Kajamaa, A., & Kumpulainen, K. (2020). Students' multimodal knowledge practices in a makerspace learning environment. International Journal of Computer-Supported Collaborative Learning, 15(4), 411–444. https://doi.org/10.1007/s11412-020-09337-z

Kajamaa, A., Kumpulainen, K., & Olkinuora, H. R. (2020). Teacher interventions in students' collaborative work in a technology-rich educational makerspace. British Journal of Educational Technology, 51(2), 371–386. https://doi.org/10.1111/bjet.12837

Kajamaa, A., Kumpulainen, K., & Rajala, A. (2018). A digital learning environment mediating students' funds of knowledge and knowledge creation. Studia paedagogica, 23(4), 49–66. https://doi.org/10.5817/SP2018-4-3

Kajamaa, A., & Tuunainen, J. (2022). Dialectics of distributed leadership in an interorganizational entrepreneurship hub. Leadership, 18(6), 17427150221130823. https://doi.org/10.1177/17427150221130823

Kariippanon, K. E., Cliff, D. P., Lancaster, S. L., Okely, A. D., & Parrish, A.-M. (2018). Perceived interplay between flexible learning spaces and teaching, learning and student wellbeing. Learning Environments Research, 21(3), 301–320. https://doi.org/10.1007/s10984-017-9254-9

Keinänen, M., Ursin, J., & Nissinen, K. (2018). How to measure students' innovation competences in higher education: Evaluation of an assessment tool in authentic learning environments. Studies in Educational Evaluation, 58, 30–36. https://doi.org/10.1016/j.stueduc.2018.05.007

Keune, A., & Peppler, K. (2019). Materials-to-develop-with: The making of a makerspace. British Journal of Educational Technology, 50(1), 280–293. https://doi.org/10.1111/bjet.12702

Kumpulainen, K. (2017). Learning by Making: The Educational Potential of School-based Makerspaces for Young Learners Digital Competencies (iMake). University of Helsinki. Retrieved 19.10.2022 from https://www.helsinki.fi/en/researchgroups/learning-culture-and-interventions/learning-by-making-the-educational-potential-of-school-based-makerspaces-for-young-learners-digital-competencies-imake

Kumpulainen, K., & Kajamaa, A. (2020). Sociomaterial movements of students' engagement in a school's makerspace. British Journal of Educational Technology, 51(4), 1292–1307. https://doi.org/10.1111/bjet.12932

Kumpulainen, K., Kajamaa, A., Leskinen, J., Byman, J., & Renlund, J. (2020). Mapping digital competence: Students' maker literacies in a school's makerspace. Frontiers in Education, volume 5. https://doi.org/10.3389/feduc.2020.00069

Laurell, J., Seitamaa, A., Sormunen, K., Seitamaa-Hakkarainen, P., Korhonen, T., & Hakkarainen, K. (2021). A Socio-Cultural Approach to Growth-Mindset Pedagogy: Maker-Pedagogy as a Tool for Developing the Next-Generation Growth Mindset. In Good Teachers for Tomorrow's Schools (pp. 296–312). Brill.

Lee, S. Y., Recchia, S. L., & Shin, M. S. (2005). "Not the same kind of leaders": Four young children's unique ways of influencing others. Journal of Research in Childhood Education, 20(2), 132–148. https://doi.org/10.1080/02568540509594557

Leeming, P. (2019). Emergent Leadership and Group Interaction in the Task-Based Language Classroom. Tesol Quarterly, 53(3), 768–793. https://doi.org/10.1002/tesq.506

Leskinen, J., Kumpulainen, K., Kajamaa, A., & Rajala, A. (2021). The emergence of leadership in students' group interaction in a school-based makerspace. European Journal of Psychology of Education, 36(4), 1033–1053. https://doi.org/10.1007/s10212-020-00509-x

Leskinen, J., Kumpulainen, K., Kajamaa, A. (2022). Finnish teachers' leadership narratives in a school's makerspace. In In K. Kumpulainen, A. Kajamaa, O. Erstad, Å. Mäkitalo, K. Drotner, & S. Jakobsdóttir (Eds.), Nordic Childhoods in the Digital Age: Insights into contemporary research on

communication, learning and education (pp. 117–127). Routledge. https://doi.org/https://doi.org/10.4324/9781003145257

Levine, S. S., & Prietula, M. J. (2014). Open collaboration for innovation: Principles and performance. Organization Science, 25(5), 1414–1433. https://doi.org/10.1287/orsc.2013.0872

Li, Y., Anderson, R. C., Nguyen-Jahiel, K., Dong, T., Archodidou, A., Kim, I.-H., Kuo, L.-J., Clark, A.-M., Wu, X., & Jadallah, M. (2007). Emergent leadership in children's discussion groups. Cognition and Instruction, 25(1), 1–2. https://doi.org/10.1080/07370000709336703

Liu, M., Shi, Y., Pan, Z., Li, C., Pan, X., & Lopez, F. (2021). Examining middle school teachers' implementation of a technology-enriched problem-based learning program: Motivational factors, challenges, and strategies. Journal of Research on Technology in Education, 53(3), 279–295. https://doi.org/10.1080/15391523.2020.1768183

Marin-Garcia, J. A., Andreu-Andrés, M. Á., Atares-Huerta, L., Aznar-Mas, L. E., Garcia-Carbonell, A., González-Ladrón-de-Guevara, F., Fleta, B. M., Perez-Peñalver, M. J., & Watts, F. (2016). Proposal of a framework for innovation competencies development and assessment (FINCODA). WPOM-Working Papers on Operations Management, 7(2), 119–126.

Martin, L. (2015). The promise of the maker movement for education. Journal of Pre-College Engineering Education Research (J-PEER), 5(1), 4. https://doi.org/10.7771/2157-9288.1099

Martin, L., & Dixon, C. (2016). Making as a pathway to engineering and design. In Makeology (pp. 183–195). Routledge.

Mawson, B. (2011). Children's leadership strategies in early childhood. Journal of Research in Childhood Education, 25(4), 327–338. https://doi.org/10.1080/02568543.2011.605207

McCharen, B., Song, J., & Martens, J. (2011). School innovation: The mutual impacts of organizational learning and creativity. Educational Management Administration & Leadership, 39(6), 676–694. https://doi.org/10.1177/1741143211416387

Mehto, V., Riikonen, S., Kangas, K., & Seitamaa-Hakkarainen, P. (2020). Sociomateriality of collaboration within a small team in secondary school maker-centered learning project. International Journal of Child-Computer Interaction, 26, 100209. https://doi.org/10.1016/j.ijcci.2020.100209

Mercier, E. M., Higgins, S. E., & Da Costa, L. (2014). Different leaders: Emergent organizational and intellectual leadership in children's collaborative learning groups. International Journal of Computer-Supported Collaborative Learning, 9(4), 397–432. https://doi.org/10.1007/s11412-014-9201-z

Miell, D., & Littleton, K. (2004). Collaborative creativity: Contemporary perspectives. Free Association Books.

Mulcahy, D., Cleveland, B., & Aberton, H. (2015). Learning spaces and pedagogic change: Envisioned, enacted and experienced. Pedagogy, Culture & Society, 23(4), 575–595. https://doi.org/10.1080/14681366.2015.1055128

Mullarkey, L. S., Recchia, S. L., Lee, S. Y., Shin, M. S., & Lee, Y. J. (2005). Manipulative managers and devilish dictators: Teachers' perspectives on the dilemmas and challenges of classroom leadership. Journal of Early Childhood Teacher Education, 25(2), 123–129. https://doi.org/10.1080/1090102050250205

Nassauer, A., & Legewie, N. M. (2021). Video data analysis: A methodological frame for a novel research trend. Sociological methods & research, 50(1), 135–174. https://doi.org/10.1177/0049124118769093

OECD. (2019). Teaching, assessing and learning creative and critical thinking skills in primary and secondary education. Retrieved May 3rd from https://www.oecd.org/education/ceri/assessingprogressionincreativeandcriticalthinkingskillsineducation.htm

Oswald, K., & Zhao, X. (2021, 2021/04/01). Collaborative Learning in Makerspaces: A Grounded Theory of the Role of Collaborative Learning in Makerspaces. SAGE Open, 11(2), 21582440211020732. https://doi.org/10.1177/21582440211020732

Papert, S. (1991). Situating constructionism. In S. Papert & I. Harel (Eds.), constructionism (pp. 1–11). Ablex Publishing.

Peppler, K., Halverson, E., & Kafai, Y. B. (2016a). Makeology: Makerspaces as learning environments (Volume 1) (Vol. 1). Routledge.

Peppler, K., Halverson, E. R., & Kafai, Y. (2016b). Introduction to This Volume. In K. Peppler, E. R. Halverson, & Y. Kafai (Eds.), Makeology (Vol. 2, pp. 1–9). Routledge.

Pescosolido, A. T. (2001). Informal leaders and the development of group efficacy. Small Group Research, 32(1), 74–93. https://doi.org/10.1177/104649640103200104

Pescosolido, A. T. (2002). Emergent leaders as managers of group emotion. The Leadership Quarterly, 13(5), 583–599. https://doi.org/https://doi.org/10.1016/S1048-9843(02)00145-5

Rajala, A., & Kumpulainen, K. (2017). Researching teachers' agentic orientations to educational change in Finnish schools. In Agency at Work (pp. 311–329). Springer.

Ramey, K. E. (2017). FUSE Studios: Bringing interest-driven, integrated-STEAM learning into schools via makerspaces Northwestern University].

Ramey, K. E., & Stevens, R. (2019, 2019/12/01/). Interest development and learning in choice-based, in-school, making activities: The case of a 3D printer. Learning, Culture and Social Interaction, 23, 100262. https://doi.org/https://doi.org/10.1016/j.lcsi.2018.11.009

Regalla, L. (2016). Developing a maker mindset. In K. Peppler, E. R. Halverson, & Y. Kafai (Eds.), Makeology (Vol. 1, pp. 257–272). Routledge.

Richardson, L. (1990). Writing strategies: Reaching diverse audiences (Vol. 21). Sage Publications.

Rieken, F., Boehm, T., Heinzen, M., & Meboldt, M. (2019). Corporate makerspaces as innovation driver in companies: a literature review-based framework. Journal of Manufacturing Technology Management, 31(1), 91–123. https://doi.org/10.1108/JMTM-03-2019-0098

Riikonen, S. M., Kangas, K., Kokko, S., Korhonen, T., Hakkarainen, K., & Seitamaa-Hakkarainen, P. (2020). The development of pedagogical infrastructures in three cycles of maker-centered learning projects. Design and Technology Education: an international journal, 25(2), 29–49.

Rojas-Drummond, S. M., Albarrán, C., & Littleton, K. S. (2008). Collaboration, creativity and the co-construction of oral and written texts. Thinking skills and creativity, 3(3), 177–191. https://doi.org/10.1016/j.tsc.2008.09.008

Rojas-Drummond, S., Mazón, N., Littleton, K., & Vélez, M. (2014). Developing reading comprehension through collaborative learning. Journal of Research in Reading, 37(2), 138–158. https://doi.org/10.1111/j.1467-9817.2011.01526.x

Rouse, R., & Rouse, A. G. (2022). Taking the maker movement to school: A systematic review of preK-12 school-based makerspace research. Educational Research Review, 35, 100413. https://doi.org/10.1016/j.edurev.2021.100413

Sarooghi, H., Libaers, D., & Burkemper, A. (2015, 2015/09/01/). Examining the relationship between creativity and innovation: A meta-analysis of organizational, cultural, and environmental factors. Journal of Business Venturing, 30(5), 714–731. https://doi.org/https://doi.org/10.1016/j.jbusvent.2014.12.003

Schatzki, T. R. (2019). Social change in a material world. Routledge.

Sedláček, M., & Šeďova, K. (2020). Are student engagement and peer relationships connected to student participation in classroom talk? Learning, Culture and Social Interaction, 26, 100411. https://doi.org/https://doi.org/10.1016/j.lcsi.2020.100411

Seitamaa-Hakkarainen, P., Sormunen, K., Davies, S., Matilainen, J., & Hakkarainen, K. (2022). Collaboration and Co-regulation in Invention Projects. In T. Korhonen, K. Kangas & L.Salo (eds.) Invention Pedagogy–The Finnish Approach to Maker Education. (pp. 40–55). Routledge.

Sheridan, K., Halverson, E. R., Litts, B., Brahms, L., Jacobs-Priebe, L., & Owens, T. (2014). Learning in the Making: A Comparative Case Study of Three Makerspaces. Harvard educational review, 84(4), 505–531. https://doi.org/10.17763/haer.84.4.brr34733723j648u

Sheridan, K. M., Clark, K., & Williams, A. (2013, 2013/09/01). Designing Games, Designing Roles: A Study of Youth Agency in an Urban Informal Education Program. Urban Education, 48(5), 734-758. https://doi.org/10.1177/0042085913491220

Shin, M. S., Recchia, S. L., Lee, S. Y., Lee, Y. J., & Mullarkey, L. S. (2004). Understanding early childhood leadership: Emerging competencies in the context of relationships. Journal of Early Childhood Research, 2(3), 301–316. https://doi.org/10.1177/1476718X04046649

Siewiorek, A., Saarinen, E., Lainema, T., & Lehtinen, E. (2012). Learning leadership skills in a simulated business environment. Computers & Education, 58(1), 121–135. https://doi.org/10.1016/j.compedu.2011.08.016

Skåland, G. (2022). I hate little bits: The collaborative construction of children's creative making in a public library makerspace. In K. Kumpulainen, A. Kajamaa, O. Erstad, Å. Mäkitalo, K. Drotner, & S. Jakobsdóttir (Eds.), Nordic Childhoods in the Digital Age (pp. 154-167). Routledge. https://doi.org/https://doi.org/10.4324/9781003145257

Spillane, J. P., & Orlina, E. C. (2005). Investigating leadership practice: Exploring the entailments of taking a distributed perspective. Leadership and policy in schools, 4(3), 157–176. https://doi.org/10.1080/15700760500244728

Srivastava, P., & Hopwood, N. (2009). A practical iterative framework for qualitative data analysis. International journal of qualitative methods, 8(1), 76–84. https://doi.org/10.1177/160940690900800107

Stake, R. (2005). Qualitative case studies. In N. K. Denzin & Y. S. Lincoln (Eds.), The Sage handbook of qualitative research (3rd ed.) (pp. 443–466). Sage.

Stevens, R., Ramey, K. E., Meyerhoff, P., Hilppö, J., Kumpulainen, K., Kajamaa, A., Rajala, A., & Halverson, R. (2018). Exploring the adoption, spread, and sustainability of an informal steam learning innovation in schools. In. International Society of the Learning Sciences, Inc.[ISLS].

Sun, J., Anderson, R. C., Perry, M., & Lin, T.-J. (2017, 2017/07/03). Emergent Leadership in Children's Cooperative Problem Solving Groups. Cognition and Instruction, 35(3), 212–235. https://doi.org/10.1080/07370008.2017.1313615

Timmermans, S., & Tavory, I. (2012). Theory construction in qualitative research: From grounded theory to abductive analysis. Sociological theory, 30(3), 167–186. https://doi.org/10.1177/0735275112457914

Tissenbaum, M., Berland, M., & Lyons, L. (2017, 2017/03/01). DCLM framework: understanding collaboration in open-ended tabletop learning environments. International Journal of Computer-Supported Collaborative Learning, 12(1), 35-64. https://doi.org/10.1007/s11412-017-9249-7

VanWynsberghe, R., & Khan, S. (2007). Redefining case study. International journal of qualitative methods, 6(2), 80–94. https://doi.org/10.1177/160940690700600208

Varantola, K., Launis, V., Helin, M., Spoof, S., & Jäppinen, S. (2012). Guidelines of the Finnish Advisory Board on Research Integrity. Responsible conduct of research and procedures for handling allegations of misconduct in Finland.

Vincent-Lancrin, S., González-Sancho, C., Bouckaert, M., de Luca, F., Fernández-Barrerra, M., Jacotin, G., Urgel, J., & Vidal, Q. (2019). Fostering Students' Creativity and Critical Thinking: What It Means in School. Educational Research and Innovation. ERIC.

Vinodrai, T., Nader, B., & Zavarella, C. (2021). Manufacturing space for inclusive innovation? A study of makerspaces in southern Ontario. Local Economy, 36(3), 205–223. https://doi.org/10.1177/02690942211013532

Volet, S., Vauras, M., Salo, A.-E., & Khosa, D. (2017). Individual contributions in student-led collaborative learning: Insights from two analytical approaches to explain the quality of group outcome. Learning and Individual Differences, 53, 79–92. https://doi.org/10.1016/j.lindif.2016.11.006

Vossoughi, S., & Bevan, B. (2014). Making and tinkering: A review of the literature. National Research Council Committee on Out of School Time STEM, 67, 1–55.

Vygotsky, L. S., & Cole, M. (1978). Mind in society: Development of higher psychological processes. Harvard university press.

Wenger, E. (2010). Communities of practice and social learning systems: the career of a concept. In Social learning systems and communities of practice (pp. 179–198). Springer.

Wertsch, J. V. (1994). The primacy of mediated action in sociocultural studies. Mind, Culture, and Activity, 1(4), 202–208.

Wertsch, J. V. (2007). Mediation. In H. Daniels, J. V. Wertsch, & M. Cole (Eds.), The Cambridge Companion to Vygotsky (pp. 178–192). Cambridge University Press. https://doi.org/DOI: 10.1017/CCOL0521831040.008

West, R. E. (2009). What is shared? A framework for understanding shared innovation within communities. Educational Technology Research and Development, 57(3), 315–332. https://doi.org/10.1007/s11423-008-9107-4

West, R. E., & Hannafin, M. J. (2011). Learning to design collaboratively: Participation of student designers in a community of innovation. Instructional Science, 39(6), 821–841. https://doi.org/10.1007/s11251-010-9156-z

Wiles, J. L., Rosenberg, M. W., & Kearns, R. A. (2005). Narrative analysis as a strategy for understanding interview talk in geographic research. Area, 37(1), 89–99. https://doi.org/10.1111/j.1475-4762.2005.00608.x

Wilkinson, K., Anzivino, L., & Petrich, M. (2016). The big idea is their idea. In K. Peppler, E. R. Halverson, & Y. Kafai (Eds.), Makeology (Vol. 2, pp. 161–179). Routledge.

Willis, J., Jost, M., & Nilakanta, R. (2007). Foundations of qualitative research interpretive and critical approaches. SAGE.

Wright, T., Oliveira, L., Espino, D. P., Lee, S. B., & Hamilton, E. (2021). Getting There Together: Examining Patterns of a Long-Term Collaboration in a Virtual STEM Makerspace. Advances in Quantitative Ethnography: Third International Conference, ICQE 2021, Virtual Event, November 6–11, 2021, Proceedings 3 (pp. 334–345). Springer International Publishing.

Yamaguchi, R. (2001). Children's learning groups: A study of emergent leadership, dominance, and group effectiveness. Small Group Research, 32(6), 671–697. https://doi.org/10.1177/104649640103200601

Yamaguchi, R., & Maehr, M. L. (2004). Children's emergent leadership: the relationships with group characteristics and outcomes. Small Group Research, 35(4), 388–406. https://doi.org/10.1177/1046496404263272