SCHOOL LEADERSHIP & MANAGEMENT
2024, VOL. 44, NO. 1, 57–75
ISSN: 1363-2434 | E-SSN: 1364-2626

Effects of pre-pandemic school improvement and digital learning on schools during the COVID-19 pandemic

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ABSTRACT

After the outbreak of the COVID-19 pandemic, schools had to continuously adapt to new pandemic-related regulations and challenges, including the ad hoc transition to remote learning. According to theories on school improvement and professionalisation, sharing knowledge and experiences with digital learning is helpful when dealing with related issues. However, no existing empirical studies analyse longitudinally how pre-pandemic experiences with sharing knowledge and digital learning impacted perceived professionalisation during the pandemic and how this relationship is mediated both by schools' strategies to improve learning and by schools' collective efficacy. For this study $N = 280$ school principals from Germany, Austria, and German-speaking Swiss cantons participated in two online questionnaires in 2020 and 2021. Results from the structural equation model reveal that schools' pre-pandemic experiences with knowledge sharing and digital learning are positively indirectly related to the schools' perceived professionalisation in the first and second year of the pandemic. The relationship is mediated by the schools' collective efficacy in dealing with the pandemic and the schools' use of strategies to improve teaching. The results highlight the importance of building school improvement capacity and supporting schools in digital learning to navigate through unexpected emergencies like a pandemic.

KEYWORDS

COVID-19; school improvement; teaching improvement; collective efficacy; professionalisation

1. Introduction

The COVID-19 pandemic challenged education systems across the world. Due to lockdowns and social distancing measures, schools had to switch to emergency

remote education overnight (Bozkurt et al. 2020). After this abrupt start, schools had to continue adapting to new pandemic-related regulations and challenges in conditions of high uncertainty over a long period of time (Viner et al. 2020; UNESCO 2020). What worked before did not necessarily work as well amid this new situation. Hence, schools had to apply regulation strategies to adapt old or build new routines (Authors), particularly for supporting students, promoting digital learning (UNESCO et al. 2021), and collaborating remotely with colleagues.

From a theoretical perspective, challenging situations bear risks of failure but can also be the starting point of individual and collective learning (Argyris and Schön 1996; Maag Merki, Wullschleger, and Rechsteiner 2022). To handle such situations effectively, schools require a high capacity for improvement (Bryk et al. 2010; Hallinger and Heck 2011; Mitchell and Sackney 2011). One important element of sustainable improvement is for school staff to continuously share knowledge and ideas and to collaborate with each other, which allows them to develop strategies that improve teaching and student learning (Vangrieken et al. 2017). Additionally, previous experiences in digital learning (e.g. Dexter and Richardson 2020; Philipsen et al. 2019) guide educators in dealing with the challenges of remote learning, since teachers' improvement in competences for online and blended learning depends on feedback and support from experts.

However, there are no existing empirical studies that analyse longitudinally how schools' pre-pandemic knowledge sharing practices and digital learning influenced the improvement of school processes during the pandemic. Most of the existing studies are cross-sectional in nature, which means research is required that considers this relationship longitudinally and with mediators. In this study the researchers analysed two mediators: schools' collective self-efficacy (Bandura 1997) in handling the COVID-19 pandemic as an important motivational dimension (Vanlommel et al. 2023) and the schools' implemented strategies to improve teaching as an important requirement for effective school improvement (James et al. 2007). Furthermore, as a dependent variable, the researchers focused on the schools' perceived teacher professionalisation, which is one of the most critical dimensions of school improvement due to its impact on student learning (Desimone 2009; Mitchell and Sackney 2011). The aim of this study was thus to investigate longitudinally how pre-pandemic experiences in knowledge sharing and digital learning are related to schools' perceived professionalisation throughout the pandemic and how these relationships are mediated both by schools' collective efficacy in dealing with the pandemic and by schools' strategies to improve teaching.

2. Theoretical background/State of research

2.1. Knowledge sharing and digital learning as essential pre-pandemic school requisites

Sharing knowledge is considered one of the most important activities educators can engage in during their daily work because it allows them to create new

knowledge and skills not only on a personal or interpersonal level, but also on an organisational level. Therefore, it facilitates organisational learning (Beverborg et al. 2020; Garvin, Edmondson, and Gino 2008; Stoll et al. 2006; Mitchell and Sackney 2011; Leithwood and Louis 1998). Shared knowledge might be about a variety of pedagogical issues, like personal experiences, subject-specific experiences, subject-transcending experiences, and methods (James et al. 2007), particularly in digital learning (Philipsen et al. 2019). It can be offered in different ways, for example, using digital tools.

'Knowledge sharing' refers to exchanging ideas and opinions, helping others with less expertise, and using the knowledge of different team members to achieve a shared goal. Previous research indicates that knowledge sharing is positively related to team performance and organisational learning in economic and educational contexts (Louis 2006; Staples and Webster 2008; Thoonen et al. 2012). More precisely, it leads to innovation (Al-Husseini, El Beltagi, and Moizer 2021), high-quality decisions (van Knippenberg, de Dreu, and Homan 2004), increased teacher creativity (Da'as 2022), and improved instructional practice and student performance (Moolenaar, Sleegers, and Daly 2012). Montani and Staglianò (2021) revealed in the non-educational context that during the pandemic, knowledge sharing promoted innovative behaviour. Thus, similarly to non-pandemic times, knowledge sharing might have been pivotal for educators to effectively address pandemic-related challenges, to develop effective teaching strategies for distance learning, and to increase teachers' and schools' professional competences.

Pre-pandemic experiences in digital learning may have also positively contributed (Dexter and Richardson 2020; Philipsen et al. 2019). Previous studies indicate that the use of digital tools was common in handling remote learning and social distancing during the pandemic (Su et al. 2022; UNESCO et al. 2021). A study from König, Jäger-Biela, and Glutsch (2020) revealed that teachers' mastery of core challenges such as maintaining social contact with students, providing online lessons, introducing new learning content, and providing task differentiation and feedback were positively related to their ICT competences and to the digital teaching instruments available at their schools. Dincher and Wagner (2021) found that teachers were more likely to use web-based teaching technologies during the pandemic when they had higher levels of technical affinity. Furthermore, the more a teacher knew about online teaching, the higher their self-efficacy was for online teaching during the pandemic (Huang et al. 2022).

2.2. Schools' strategies for improving teaching practices as a mediator

The main goal of school improvement is to maintain or enhance the quality of teaching and student learning (Hopkins 2005). Accordingly, knowledge sharing should be focused on these primary tasks (James et al. 2007). During the pandemic maintaining instructional quality was among the greatest challenges

(cf. Feldhoff et al. 2022), as regular face-to-face classroom instruction could not fully take place. Furthermore, social distancing restricted teacher collaboration and sharing of knowledge about which strategies might be most promising for supporting the students. Teachers and schools tried to address these challenges using digital tools. A push towards online teaching and learning was observed (Dhawan 2020; Pokhrel and Chhetri 2021).

However, some researchers (Fuchs 2022; Hodges et al. 2020) say the switch to digital tools cannot truly be labelled 'digital learning' or 'remote learning' because it occurred under special circumstances. Schools had to switch to an emergency mode where they used creative problem-solving strategies to maintain instructional quality. Teaching under such emergency conditions requires 'a way of thinking about delivery modes, methods, and media, specifically as they map to rapidly changing needs and limitations in resources, such as faculty support and training' (Hodges et al. 2020).

Accordingly, teachers needed to experiment with teaching methods that seemed promising for their students' learning. At the same time, they had to continuously and critically reflect on current practices (Sleegers et al. 2014), routines, and strategy regulation (Maag Merki, Wullschleger, and Rechsteiner 2022). They thus created new knowledge and modified practices. All of this depended on previous experiences with knowledge sharing and digital learning, as did any teacher competences that increased during the pandemic. In other words, pre-pandemic experiences had to be transferred into strategies that improved teaching practices during the pandemic for there to be effective school professionalisation.

2.3. Perceived collective efficacy as a mediator

'Collective efficacy' describes a 'group's shared belief in its conjoint capabilities to organise and execute courses of action required to produce given levels of attainments' (Bandura 1997, 477). Collective efficacy is context-specific and is fed by mastery experience, physiological arousal, vicarious experience, and verbal persuasion (Bandura 1997; Loughland and Ryan 2022). Thus, collective efficacy to handle the COVID-19 pandemic was likely to be judged as high when organisational capacities related to a specific task (e.g. schooling under pandemic conditions) were also estimated as high. Results from an Australian study indicate that COVID-19 changed task conditions and that teacher efficacy in the task 'engagement of students' declined compared to before the pandemic (Fray et al. 2022).

Social-cognitive theory assumes that the higher the perceived collective efficacy, the higher the level of schools' effort, persistence, and resilience when facing challenges (Goddard, Hoy, and Hoy 2004). Several studies have confirmed a positive relationship between teachers' self- and collective efficacy, their engagement in professional learning activities (Durksen, Klassen, and Daniels 2017; Geijsel et al. 2009; Moolenaar, Sleegers, and Daly 2012), and student achievement (Goddard, Hoy, and Hoy Woolfolk 2000; Hoy, Sweetland, and Smith 2002).

Furthermore, a study in the Netherlands points to the importance of collective efficacy for increasing perceived professional learning and human capital among teachers during periods of change (Vanlommel et al. 2023). Accordingly, perceived collective efficacy can be considered a mediator between pre-pandemic experiences with knowledge sharing and digital learning and schools' strategies for handling the pandemic, which in turn influenced professionalisation.

3. Research questions and hypotheses

This thesis describes one of the first longitudinal studies of how schools' pre-pandemic experiences in knowledge sharing and digital learning impacted their professionalisation throughout the pandemic, considering schools' collective efficacy and strategies for teaching improvement as possible mediators. The following research questions were addressed:

> R1) How are schools' pre-pandemic experiences in knowledge sharing and digital learning related to those schools' perceived professionalisation in the first and second years of the COVID-19 pandemic?
>
> R2) How is this relationship mediated by the schools' collective self-efficacy in dealing with the pandemic and the schools' strategies for improving teaching?

Based on previous theoretical and empirical results, the researchers hypothesised the following:

- Schools' pre-pandemic experiences in knowledge sharing and digital learning are positively related to those schools' perceived professionalisation in the first (H1a) and second years (H1b) of the COVID-19 pandemic with a full single mediation by the schools' collective efficacy.
- Schools' pre-pandemic experiences in knowledge sharing and digital learning are positively related to those schools' perceived professionalisation in the first (H2a) and second years (H2b) of the COVID-19 pandemic with a full single mediation by the schools' strategies for improving teaching.
- The relationship between the schools' pre-pandemic experiences and perceived professionalisation in the first (H3a) and second years (H3b) of the pandemic is doubly and serially mediated by the schools' collective efficacy and strategies for improving teaching at the time of the first survey, through a chain whereby pre-pandemic experiences first positively affect collective efficacy, which in turn affects the strategies used to improve teaching.

4. Method

4.1. Study design and methods

The data originates from the tri-national longitudinal study in Germany, Austria and Switzerland. In the original dataset from which this study took its data,

school principals of general education schools in fourteen German states, in all Austrian states, and in five German-speaking Swiss cantons were surveyed at three time points (t1: fall 2020, t2: spring 2021, t3: summer 2021) using an online questionnaire. The longitudinal data from t1 and t3 were included in this study's analyses.

4.2. Sample

The sample was a controlled convenience sample that sufficiently measures the basic population within central parameters (federal states and cantons and general school types in the participating countries) at single measurement points (cf. Feldhoff et al. 2022). This article examines the longitudinal data of principals ($N = 280$) who participated in the surveys at t1 and t3. The distribution of these principals among the three countries is as follows: 44% were from Germany, 34% from German-speaking Switzerland, and 22% from Austria. Fifty-three percent worked at primary schools, 8% at special schools, 9% at grammar schools (K5-13), and 29% at secondary schools (K5-10). Due to panel mortality, the examined dataset includes some deviation from the population regarding the structure of federal states. In Germany there are data from only 12 of 14 participating federal states, and the proportion between these federal states differs from the full population. However, the panel is robust enough to examine the research questions within the three participating countries overall. See appendix for more information on the sample.

4.3. Variables in the model

To test the hypotheses, this study's researchers used different variables from the surveys at t1 and t3. At t1 principals were asked about their school before the pandemic. Pre-pandemic experience in knowledge sharing within the school team was measured with the scale 'knowledge sharing' (KNLS) by Epstein and Salinas (1993, 3 items; e.g. 'We are all willing to share knowledge and ideas with others' with a scale ranging from 1 = 'does not apply at all' to 6 = 'applies completely'). Pre-pandemic experience in digital learning was measured by three self-developed scales represented by the second order factor PEDL. The PESDL scale, 'experience of school stakeholders with digital learning', had 3 items (e.g. 'Which experiences had different groups of individuals [pupils, parents, teachers, principal] with digital learning before the school closures?' with a scale ranging from 1 = 'little experience' to 4 = 'a lot of experience'). The EUDMT scale, 'expectation of digital media use for teaching', had 2 items (e.g. 'To what extent did you expect teachers to use digital media for the following [teaching] tasks?' with a scale ranging from 1 = 'not at all expected' to 4 = 'strongly expected'). The EUDMC scale, 'expectation of digital media use for collaboration', had 3 items (e.g. 'To what extent did you expect teachers to use digital media for the following tasks? The use of digital

media for. .. [communication with students]', 4-points scale ranging from 1 = 'not at all expected' to 4 = 'strongly expected').

To study the main relationship in both years of the pandemic, the 3-item scale 'perceived professionalisation' from (Maag Merki, Wullschleger, and Rechsteiner 2022) was used as the dependent variable at t1 and t3 (PPROFI, PPROF3; e.g. ' … that our competences to support the students have been increasingly strengthened' with a scale ranging from 1 = 'does not apply at all' to 6 = 'applies completely').

At t1 the schools' collective efficacy (CEFF) was surveyed as a mediator variable. This was based on a 4-item scale by Schwarzer and Jerusalem (1999), adapted to the successful mastery of the pandemic (e.g. 'We as a school can make pedagogical progress despite the current extra-ordinary situation' with a scale ranging from 1 = 'does not apply at all' to 6 = 'applies completely'). The mediator variable of the school's strategy for dealing with the pandemic was measured using a four item 'improving teaching' scale based on the theory of Leithwood, Harris, and Hopkins (2020) at both t1 and t3 (IMPT1, IMPT3; e.g. 'We reflect on our current pedagogical methods critically' with a scale ranging from 1 = 'does not apply at all' to 6 = 'applies completely').

The reliabilities of all these scales range between Cronbach's alpha .67 and .85. A detailed overview of the items can be found in the supplemental data.

4.4. Analyses

The aim of the analyses was to examine how prior experience with knowledge sharing and digital learning affected schools' professionalisation during the pandemic, considering the mediations of collective efficacy and strategies for improving teaching. Direct and mediated effects were considered. To analyse these effects longitudinally, the researchers computed a structural equation model (SEM) (Byrne 2010) in MPLUS 7.3 with the MLR estimator (Muthén and Muthén, 1998-2017). Since there are often problems with the normal distribution when estimating the significance of indirect effects through an SEM, the more robust bias-corrected bootstrap method was used to estimate the significance of the indirect effects (Williams and MacKinnon 2008).

The scales 'improving teaching' and 'perceived professionalisation' were measured at two points in time (t1 and t3). This makes it possible to analyse the variables' inter-individual change or stability between the two points using autoregressive paths. The temporal difference also allows causal effects to be analysed (Feldhoff, and Radisch, 2021). A prerequisite for this is the stability of the latent variables' factor structure between the two time points (Widaman, Ferrer, and Conger 2010). The researchers checked this using factorial measurement invariance analyses (Brown 2015). Both scales had scalar measurement invariance (same construct meanings, same factor loadings, and same intercepts) and were thus suitable for the planned analyses.

The goodness of fit of the model was tested with the five common fit indices (Hu and Bentler 1999; Marsh, Wen, and Hau 2004): chi^2 test, comparative fit index (CFI), Tucker-Lewis index (TLI), root mean square error of approximation (RMSEA), and standardised root mean square residual (SRMR). A good model fit requires the cut-off values of CFI and TLI to be greater than .90 and the values of RMSEA and SRMR to be less than .80. The chi^2 value in relation to the degrees of freedom (*df*) should be less than 3 (ibid.).

5. Results

5.1. Descriptive statistics and bivariate analyses

Table 1 displays the descriptive statistics.[1] Knowledge sharing was relatively high in schools before the pandemic ($M = 5.08$), while the prior experience with digital learning ($M = 2.36$) was rather low. Before the pandemic-related school closures, principals' expectations for digital media use in instruction ($M = 2.93$) was slightly higher than principals' expectations for digital media use in collaboration ($M = 2.69$), but both were at a rather low level.

The collective efficacy in dealing with the COVID-19 pandemic at t1 ($M = 4.65$) was relatively high. According to the principals, most schools used the strategy of improving teaching to address challenges (Mt1 = 4.16, Mt3 = 4.28). However, there was also a significant variance in how schools used this strategy and a significant increase ($p = 0.029$) in strategies to improve teaching in the second year of the pandemic.

Finally, most of the school leaders confirmed that during the pandemic, the teacher competences increased (Mt1 = 4.44, Mt3 = 4.53). Again, there was a substantial variance across the schools. Perceived professionalisation did not change significantly between the first and second years of the pandemic ($p = 0.147$).

5.2. Structural equation model

Figure 1 presents the results of the SEM, the direct and indirect effects of prior experience with knowledge sharing and digital learning on the schools'

Table 1. Descriptive statistics.

	Variable	Mean	SD	Min	Max	*N*
1.	KNLS Knowledge sharing	5.08	0.70	2	6	279
2.	PESDL Prior experience of school stakeholders with digital learning	2.36	0.67	1	4	280
3.	EUDMT Expectation of digital media use for teaching	2.93	0.71	1	4	278
4.	EUDMC Expectation of digital media use for collaboration	2.69	0.73	1	4	279
5.	CEFF Collective efficacy COVID-19	4.65	0.65	3	6	280
6.	PPROF1 Schools' perceived professionalisation t1	4.44	0.84	2	6	279
7.	PPROF3 Schools' perceived professionalisation t3	4.53	0.81	2	6	270
8.	IMPT1 Improving teaching t1	4.16	0.81	2	6	279
9.	IMPT3 Improving teaching t3	4.28	0.74	2	6	273

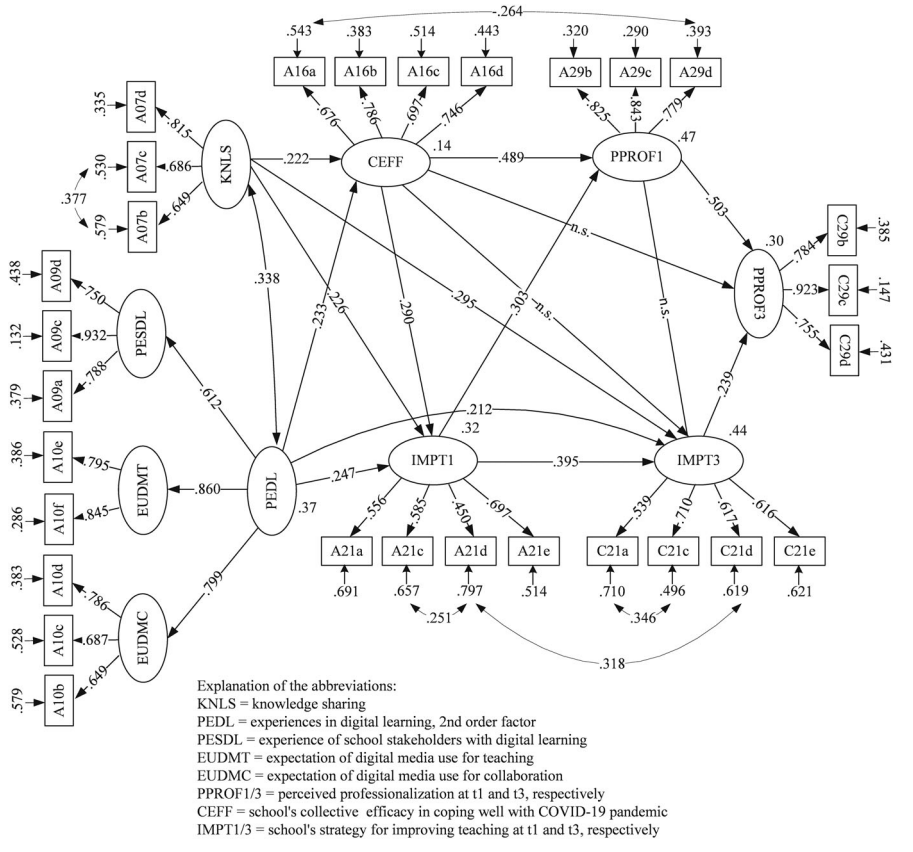

Figure 1. Structural equation model standardised effects.

perceived professionalisation, and the mediating effects of the schools' collective efficacy in dealing with the pandemic and the schools' strategies for improving teaching. The model indicates a good fit between the theoretically postulated model according to the hypotheses and the empirical data (CFI = .958, TLI = .951, RMSEA = .035, SRMR = .048, $Chi^2/df = 1.33$, $N = 267$).

Pre-pandemic experiences with knowledge sharing and digital learning, which were positively correlated with each other on a medium level (β = .338), were indirectly related to the schools' perceived professionalisation at both t1 and t3. There was a total indirect effect on the schools' perceived professionalisation at t1 of β = . 198 for KNLS ($p = .001$) and of β = .212 for PEDL ($p = .003$). The indirect effect at t3 was β = .159 for KNLS ($p = .001$) and β = .174 for PEDL ($p = .000$). The following direct and indirect effects could be identified:

Direct effects

Almost all analysed direct effects were significant on a low to medium level, with β ranging from .239 to .503. However, at t3 the direct effects of schools' collective efficacy both on strategies for improving teaching and on perceived

professionalisation were not significant. Additionally, perceived professionalisation at t1 did not significantly influence strategies for improving teaching at t3.

There was a positive autoregressive path (β = .395, p = .004) in the school's strategy for improving teaching from t1 to t3, indicating a medium relative stability over the school year in terms of the implementation of strategies to improve teaching. Furthermore, there was a positive autoregressive path (β = .503, p = .000) in the schools' perceived professionalisation from t1 to t3, pointing to a relative stability in the perception that the pandemic impacted schools' professionalisation.

Indirect effects

An overview of all indirect effects related to the hypotheses can be found in Table 2. Here the authors explain only the most relevant effects in more detail.

Pre-pandemic experiences in knowledge sharing and digital learning each had an indirect effect on schools' perceived professionalisation at t1, mediated via collective efficacy (KNLS β = .110, p = .013; PEDL β = 0.116, p = .030). Pre-pandemic experiences in knowledge sharing and digital learning also had an indirect effect on schools' perceived professionalisation at t3, mediated via collective efficacy and via perceived professionalisation at t1 (KNLS β = .056, p = .032, PEDL β = .058, p = .054).

The schools' strategies for improving teaching at t1 functioned as a mediator between pre-pandemic experiences and perceived professionalisation both at t1 (β = .069, p = 0.053; β = .075, p = 0.057) and at t3 (β = .034, p = 0.061; β = 0.038, p = 0.053) though the effects again were slightly above the 5% alpha-error-level. The serial mediating effect of strategies for improving teaching at t1 followed by strategies for improving teaching at t3 was not significant. However, when considering the mediating effect at t3 of schools' strategy for improving teaching at t3 alone, there were indirect effects around the 10% alpha-error level (β = .070, p = .104; β = .051, p = .074).

The relationship between pre-pandemic experiences and perceived professionalisation at t1 did not experience a significant serial mediating effect through both collective efficacy and strategies for improving teaching.

6. Discussion

The COVID-19 pandemic was a significant challenge for schools (Feldhoff et al. 2022) because they had to switch suddenly to remote teaching and adapt to continuous new conditions amid high uncertainty. To maintain and enhance instructional quality and student learning under emergency conditions, schools needed to apply regulation strategies, adapt old routines, or build new ones (Maag Merki, K., Wullschleger, A., and Rechsteiner, B. 2022). School improvement capacity, particularly knowledge sharing within the school, can be an important prerequisite for this (e.g. Mitchell and Sackney 2011).

Table 2. Hypothesised indirect effects and total indirect effects.

Hypothesised indirect effects	Hypothesis	β	*P*
KNLS > CEFF > PPROF1	*H1a*	*0.110*	*0.013*
PEDL > CEFF > PPROF1	*H1a*	*0.116*	*0.030*
KNLS > CEFF > PPROF1 > PPROF3	*H1b*	*0.056*	*0.032*
PEDL > CEFF > PPROF1 > PPROF3	*H1b*	*0.058*	*0.054*
KNLS > CEFF > PPROF3	H1b	−0.031	0.218
PEDL > CEFF > PPROF3	H1b	−0.032	0.272
KNLS > IMPT1> PPROF1	*H2a*	*0.069*	*0.053*
PEDL > IMPT1 > PPROF1	*H2a*	*0.075*	*0.057*
KNLS > IMPT1 > PPROF1 > PPROF3	*H2b*	*0.034*	*0.061*
PEDL > IMPT1 > PPROF1 > PPROF3	*H2b*	*0.038*	*0.053*
KNLS > IMPT1 > IMPT3 > PPROF3	H2b	0.021	0.151
PEDL > IMPT1 > IMPT3 > PPROF3	H2b	0.023	0.162
KNLS > IMPT1 > PPROF1 > IMPT3 > PPROF3	H2b	0.001	0.773
PEDL > IMPT1 > PPROF1 > IMPT3 > PPROF3	H2b	0.001	0.783
KNLS > IMPT3 > PPROF3	H2b	0.070	0.104
PEDL > IMPT3 > PPROF3	*H2b*	*0.051*	*0.074*
KNLS > CEFF > IMPT1 > PPROF1	H3a	0.019	0.112
PEDL > CEFF > IMPT1 > PPROF1	H3a	0.020	0.105
KNLS > CEFF > IMPT1 > PPROF1 > PPROF3	H3b	0.010	0.119
PEDL > CEFF > IMPT1 > PPROF1 > PPROF3	H3b	0.010	0.110
KNLS > CEFF > IMPT1 > PPROF1 > IMPT3 > PPROF3	H3b	0.000	0.789
PEDL > CEFF > IMPT1 > PPROF1 > IMPT3 > PPROF3	H3b	0.000	0.797
KNLS > CEFF > IMPT3 > PPROF3	H3b	−0.009	0.306
PEDL > CEFF > IMPT3 > PPROF3	H3b	−0.009	0.330
KNLS > CEFF > IMPT1 > IMPT3 > PPROF2	H3b	0.006	0.284
PEDL > CEFF > IMPT1 > IMPT3 > PPROF3	H3b	0.006	0.293
Total indirect effects			
KNLS > PPROF1		*0.198*	*0.001*
PEDL > PPROF1		*0.212*	*0.003*
KNLS > PPROF3		*0.159*	*0.001*
PEDL > PPROF3		*0.174*	*0.000*

Note. Effects <10%-alpha-error-level in italics.

Additionally, experiences in digital learning might improve the chances of addressing social distancing rules successfully.

Up to now, with a lack of longitudinal studies, it was unclear how COVID-19 impacted school improvement strategies and professionalisation when also considering different pre-pandemic experiences and possible mediators between these variables. Hence, the aim of this study was to investigate how pre-pandemic experiences in knowledge sharing and digital learning were related to schools' perceived professionalisation during the pandemic and how this relationship was mediated by the schools' collective efficacy and strategies for improving teaching. The researchers used online questionnaire data collected in autumn 2020 and in summer 2021 from $N = 280$ school principals in Germany, the German-speaking part of Switzerland, and Austria. They conducted an SEM to analyse the data.

6.1. Hypothesis testing

Overall, the results demonstrate that the studied pre-pandemic experiences had significant total indirect effects on perceived professionalisation in autumn 2020 and in summer 2021. Hence, during the COVID-19 pandemic, schools benefitted

from their previous experiences with knowledge sharing and digital learning. However, the single indirect effects that the researchers hypothesised saw mixed results.

Consistent with H1a and by trend with H1b, the results indicate that collective efficacy mediated the main relationship at t1 and at t3, although the effect between pre-pandemic digital learning and perceived professionalisation at t3 just missed the 5% alpha-error-level. Accordingly, schools with intensive knowledge sharing practices and schools with more digital learning experiences before the outbreak of the pandemic also had a higher collective efficacy in facing the COVID-19 pandemic and in turn felt more professionalisation despite the pandemic in autumn 2020 and again in summer 2021. This confirms previous results in the context of the COVID-19-pandemic in the Netherlands which highlight the importance of collective efficacy when dealing with the pandemic (Vanlommel et al. 2023).

The schools' strategies to improve teaching also had a mediating effect on the main relationship at t1 and t3, which matches H2a and H2b. However, because the effects are smaller, these indirect effects are only significant by trend. The results suggest that compared with collective efficacy as a motivational mediator, the action-level mediator is less predictive for perceived professionalisation. Improving teaching through strategies like experimenting with different didactical tools in remote learning settings (Dexter and Richardson 2020; Philipsen et al. 2019) might be a challenging process with benefits that take more time to be realised. Moreover, it should be noted that a larger sample size might have led to significant results due to increased statistical power.

Interestingly, the direct effect of knowledge sharing on strategies for improving teaching was stronger at t3 than at t1. This could indicate that educational experience in knowledge sharing is even more important for longer-term implementation of such strategies. It is commonly agreed upon that school improvement and particularly teacher improvement is a long-term endeavour that includes reflection, development, and adaption of current practices as a continuous and cyclical process of professionalisation (Desimone 2009; Mitchell and Sackney 2011).

Finally, the researchers expected in H3a and H3b that the relationship between pre-pandemic experiences and professionalisation would be mediated integrally in a chain that includes both mediators. The results reveal significant positive direct effects between the different factors, but the indirect serial effect was not significant. However, shorter sub-paths like the indirect effect of collective efficacy on perceived professionalisation at t3, with $\beta = 0.044$ and $p = .027$, confirm the assumption that motivational dimensions and implemented strategies both positively affect perceived professionalisation at t1 and at t3. The significant direct and partial indirect effects suggest that conducting this analysis with a larger sample is recommendable.

6.2. Limitations and further research perspectives

Although the results highlight the importance of mediators and pre-pandemic experiences for perceived professionalisation during the COVID-19 pandemic, some limitations and further research perspectives should be noted.

First, although this is a longitudinal study including two measurement points over the course of one year, the structural equation model can only be interpreted as correlational. The study aimed at understanding how schools handled the exceptional situation of the COVID-19 pandemic. Pre-pandemic experiences could only be assessed retrospectively at the first measurement point in autumn 2020.

Second, while the main study included three online surveys, we only included data from the first and the third survey for methodological reasons. Including all three measurement points would have come along with a sample reduction which in turn would have reduced statistical power. This risk is particularly evident in the non-significant indirect effects which the current model already reveals. Hence, we decided that the disadvantages outweighed the benefits of including an additional measurement point.

Third, knowledge sharing is only one of many important dimensions for school improvement capacity (Bryk et al. 2010; Hallinger and Heck 2011; Mitchell and Sackney 2011) and we only analysed the existence of knowledge sharing and not its quality (Decuyper, Dochy, and Van den Bossche 2010; Gräsel, Fussangel, and Pröbstel 2006; Havnes 2009; Schippers, Den Hartog, and Koopman 2007; Yang, Potts, and Shanks 2018).

Finally, as the main goal of school improvement is to enhance student learning (Hallinger and Heck 2011; Vangrieken et al. 2017), students' achievement data would be desirable as an additional outcome variable. However, because schools and individuals were burdened by the uncertainty of the pandemic, we did not want to place more workload on teachers, parents or students. Therefore, they decided to only assess school principals, who are considered important drivers for change (Leithwood, Harris, and Hopkins 2020).

6.3. Conclusions

Based on the results of the structural equation model, we conclude that schools did benefit from their pre-pandemic experiences in both, knowledge sharing and digital learning during the COVID-19 pandemic. Both increased collective efficacy, which mediated their effects on perceived professionality, particularly at an earlier stage of the pandemic. Additionally, pre-pandemic experiences in knowledge sharing and digital learning also supported the improvement of teaching strategies, which in turn led to a higher sense of professionalisation. However, our results also suggest that it takes more time for school members to actually perceive the positive effects from pre-pandemic experiences through improving teaching than through higher collective efficacy. High-quality teaching improvement is complex and challenging, particularly under changing conditions with a

lack of resources, such as in the pandemic. As schools with more experiences in digital learning and knowledge sharing also indicated a higher perception of their professionalization, the results highlight the importance of fostering schools' improvement capacity and supporting them in digital learning. In this effort, school principals take a central role (Leithwood, Harris, and Hopkins 2020), for example in role-modelling, trust-building, setting expectations, creating a knowledge-sharing-driven environment, and encouraging teachers to share their knowledge (Zeinabadi 2022). Another conclusion is that school improvement, particularly when it comes to improve teaching strategies, is not a short-term endeavour but needs time to flourish. Hence, school administrations and school leaders should be aware that improving school practices requires sustainable solutions and long-term support. For a better understanding of how the dimension of 'time' affects improvement efforts, more longitudinal research is needed.

Note

1. Complete documentation of the instruments used, including response formats, is available in the supplemental data.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the Jacobs Foundation under Grant 2020-1378-00 and the Robert Bosch Foundation under Grant 01000514-022.

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Appendix

Table A1. Description of the schools' pupils by means and standard deviations.

Characteristic of a schools' pupils	*M*	*SD*
From low-income families	29.47	22.126
With special needs	15.11	24.981
With other first language than German	25.51	21.663
Lacking learning support from family	27.41	24.394

Note. *M* = mean percentage of pupils with the according characteristic at that school.

Table A2. Description of the schools' school principal by frequencies.

Employment period of school principal at the school	Percentage
Less than one year	5%
1–4 years	35%
5–9 years	27%
10–14 years	24%
15 years or more	9%