Teachers' Implicit Theories of Professional Abilities in the Domain of School Improvement

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Numerous studies show positive effects of students' malleable implicit theories of their abilities on their self-regulated learning and learning achievements (Yeager and Dweck, 2012; Burnette et al., 2013), especially when domain-specific implicit theories are assessed (Costa and Faria, 2018). Thinking of school improvement as a collective learning process for the teaching staff, it is reasonable to assume that this relationship also exists on the teacher level. Hence, this study aims to provide answers to the following overarching question: What role do teachers' implicit theories of professional abilities play for school improvement? In a first step, a measurement instrument was developed to assess teachers' implicit theories of professional abilities in the domain of school improvement. In a second step, we explored the link between these implicit theories and collective teacher learning in the area of further developing the school's educational practices. In a sample of $N = 1,483$ Swiss primary school teachers at $N = 59$ schools, we analyzed how teachers' malleable (vs. fixed) implicit theories of professional abilities are related to collective metacognitive and emotional-motivational regulation activities and to the perception that the school is on the right track to improvement. Results show that teachers' implicit theories of professional abilities can be assessed reliably. Structural equation modeling analyses revealed that the more teachers view professional abilities as malleable and developable, the more positive their perceptions of the schools' improvement were. This relation was mediated by collective emotional-motivational regulation activities. However, no significant effect of a malleable implicit theory on collective metacognitive regulation was found. It can be concluded that teachers have varying beliefs about the malleability of teachers' professional abilities that are linked to their collective regulation. It therefore acknowledges the domain-specific effects of teachers' implicit theories in the area of school improvement.

Keywords: implicit theories of professional abilities, school improvement, teacher beliefs, self-regulated learning, motivation, metacognition, primary school

INTRODUCTION

Whether people implicitly believe that their abilities are innate and unchangeable (fixed theory) or changeable through time and training (malleable theory) is related to various motivational and cognitive effects (Dweck, 2017). Numerous studies have found a correspondence between holding to a more malleable theory and better emotional, motivational, and metacognitive self-regulation (Dweck and Leggett, 1988; Hong et al., 1999; Molden and Dweck, 2006). Further, implicit theories

influence how people interpret and respond to challenges (Burnette et al., 2013) and thus play a central role in the adaptive management of challenges (Yeager and Dweck, 2012).

Challenges in further developing educational practice in schools can be seen as collective learning processes. Therefore, from a school improvement perspective, a teacher's implicit theory that 'being a good teacher' is something that can be changed and learned seems crucial for professional development and improvement of the school organization. This is especially true, as schools and their actors are faced with constantly changing requirements and must be able to react competently to various challenges (within and outside the classroom). To do so, professional abilities need to be acquired in teacher training programs and further developed in an ongoing learning process. In this study, a teacher's professional abilities are conceptualized broadly as a set of social and intellectual skills (e.g., different kinds of content and pedagogical knowledge or adaptive self-regulation strategies) that all have an impact on the teacher's competencies in teaching and working cooperatively with other staff members (Kunter et al., 2013).

Over the last decades, school improvement has shifted from a rather prescriptive (top-down) best practice approach to a professionalization approach (balancing bottom-up initiatives and top-down reforms), where teachers are required to develop professional abilities as well as organizational structures to improve their teaching practice and student learning (Emmerich and Maag Merki, 2014; Hopkins et al., 2014). Thus, teachers are more and more seen as crucial actors not only for their personal development but also for collective and organizational improvement. In the last 15 years, a fast-growing body of literature on distributed leadership (Spillane, 2005), middle leadership (Harris et al., 2019), and teacher leadership (Robinson et al., 2008) has reflected this shift toward a school improvement perspective, where not only policymakers and principals but also the teaching staff are seen as drivers of change. To understand different aspects of teachers as agents of change, teachers' professional capacity has been operationalized as a combination of abilities, beliefs, dispositions, and work arrangements (Bryk et al., 2010). Consequently, successful professional development activities should not be exclusively about improving teaching abilities or about changing organizational structures, such as work arrangements, but also need to consider teachers' underlying belief systems, including their implicit theories of teachers' professional abilities. The rationale behind this is that the normative belief system of individuals or groups guides their actions and discourse patterns in everyday educational practices—and changes in these practices as well (Mitchell and Sackney, 2011; Sherer and Spillane, 2011; Shirrell et al., 2019). Failed reforms, for instance, are often seen as a product of professional development activities that were too limited in scope (e.g., with a narrow focus on new instructional materials or settings) and did not address teachers' belief systems or underlying assumptions concerning a specific innovation or reform (Ladwig, 2010; Heitink et al., 2016; Weddle et al., 2019). Therefore, not only subject-related content and pedagogical knowledge but also teachers' professional beliefs play a crucial role when it comes to developing teachers' professional competencies (Calderhead, 1996; Kunter et al., 2013). To successfully improve educational practices through professional learning activities, the role of teachers' beliefs needs to be taken into consideration. Up to now, this has not been done in a differentiated manner.

The analyses of implicit theories of abilities as either fixed or malleable have proven their value in different educational contexts, especially in terms of student learning (for an overview see Dweck, 2017). There is a growing body of research emphasizing the more significant effects of mindsets assessed for specific domains (Costa and Faria, 2018). However, so far, research on teachers' implicit theories has focused on how teachers' beliefs about intelligence may foster a growth classroom mindset or influence students' motivation and mindset (Leroy et al., 2007; Rattan et al., 2012; Dickhäuser et al., 2017) and has neglected perspectives on teachers as members of a professional learning community (Louis et al., 1996; Mitchell and Sackney, 2011). As a consequence, there is no measurement instrument available to analyze teachers' implicit theory of professional abilities. Further, questions arise as to whether findings from research on implicit theories in the educational context of student learning can be transferred to the context of teachers' professional development in the domain of school improvement.

In this study, we focus on possible associations between teachers' malleable theory of professional abilities and their perceptions of school improvement. Further, as literature about student learning has shown, the mediating role of regulation activities will be analyzed. Implicit theories of teachers' professional abilities will therefore be considered from two perspectives: first, from existing theoretical and empirical frameworks on implicit theories and teachers' beliefs in general, and second from a school improvement perspective. Both perspectives are combined with a theoretical framework on self-regulated learning to better understand processes and dynamics of teachers' implicit theories and their role in the domain of school improvement.

Teachers' Implicit Theory of Professional Abilities as Part of Teachers' Beliefs

Beliefs are domain-specific psychological understandings, premises, or propositions that are felt to be true (Braten, 2010; Valcke et al., 2010). They function as personal guides for individuals to define and understand the world and themselves (Pajares, 1992) and function as a filter through which new knowledge and experiences are screened for meaning (Kagan and Tippins, 1991). Teachers' beliefs have been defined as beliefs "about processes, variables, and actors that are central to learning and instruction settings, such as educational beliefs, epistemological beliefs, beliefs about inclusive education, etc." (Valcke et al., 2010). In terms of school improvement, some researchers argue that teachers should have a socio-constructivist view of learning when it comes to the implementation of educational reforms (Birenbaum et al., 2011; Sach, 2015; Heitink et al., 2016). From a socio-constructivist standpoint,

learning is understood as an interactive and intersubjective process, where individuals actively and collectively construct, deconstruct, and reconstruct their knowledge (Vygotsky, 1978; Mitchell and Sackney, 2011). Following this argumentation, beliefs can be seen as a product and predictor of cognitive processes, such as perceptions of the social context and how other people think and behave within this context (Valcke et al., 2010).

Implicit theory of the nature of abilities is a particular set of beliefs held by the individual (Dweck, 1999). Without necessarily being aware (therefore, *implicit*), people differ in how they think personal abilities can be changed through time and training. As a consequence, they turn to different approaches when confronted with a challenge (for instance, in the process of learning): Whereas some people enjoy trying new strategies and change routines quite flexibly, others stick to a set of routines with which they are already familiar (Dweck and Leggett, 1988). Research on implicit theories aims to solve the puzzle of why people follow different patterns in the regulation processes when facing new challenges, and whether one or the other way is more beneficial for learning (Burnette et al., 2013). Therefore, the concept of implicit theory is highly related to and centrally important in the discourse on self-regulated learning.

Self-regulated learning is best defined as individuals taking consciously control over their learning by setting goals, making choices on how to reach these goals, and if necessary adjusting motivational states, cognition, or metacognition in the process of learning (Winne and Hadwin, 2008). In the context of self-regulated learning, two motivational belief systems have been highlighted: a malleable and a fixed implicit theory of personal abilities (Dweck and Leggett, 1988). These implicit theories of personal abilities can be seen as a particular set of beliefs that influence how challenges are interpreted and that set different motivational patterns in motion (Yeager and Dweck, 2012). A fixed implicit theory (also termed entity theory or fixed mindset) entails the belief that abilities are something more innate and unchangeable (Dweck and Leggett, 1988). In contrast, people with a malleable implicit theory (also termed incremental theory or growth mindset) believe that their abilities are changeable through time and training. A malleable implicit theory can be associated with the concept of brain plasticity (Yeager and Dweck, 2012), where the brain is described as similar to other muscles, capable of growing when given repeated practice in the face of challenges. Dweck and colleagues focused mainly on implicit theories of intelligence, as implicit views on the nature of intelligence are the root of motivational patterns such as goal setting, goal operating, and goal monitoring (Burnette et al., 2013). There is ample empirical evidence that supports the impact of implicit theory on different aspects of self-regulated learning (Dweck, 2017). A malleable implicit theory (vs. a fixed implicit theory) is associated with better resilience and learning (Yeager and Dweck, 2012), a mastery orientation (Dweck and Leggett, 1988; Burnette et al., 2013; Compagnoni et al., 2019), better metacognition (Burnette et al., 2013; Karlen and Compagnoni, 2016), better emotional-motivational regulation strategies (Nussbaum and Dweck, 2008), and higher achievement during transitions (Blackwell et al., 2007).

But although implicit theories have been assessed mostly in a domain-general way for attributes, such as intelligence (Spinath, 1998; Hong et al., 1999) or willpower (Job et al., 2015), individuals can hold differing implicit theories for specific domains such as health (Schroder et al., 2016), writing (Karlen and Compagnoni, 2016), romantic relations (Knee, 1998), or programming aptitude (Scott and Ghinea, 2014). It is assumed that domain-specific implicit theories set up a frame of reference for evaluating performance, abilities, and traits in a specific domain (Costa and Faria, 2018). It therefore seems reasonable to argue that teachers may also hold implicit theories of the malleability of teachers' professional abilities that influence their self-regulation but also their evaluation of performance, abilities, and traits as teachers. Further, studies have shown that implicit theories not only influence individual self-regulation but also self-regulation on an interpersonal level (Knee and Canevello, 2006). Knee and colleagues have found that a malleable view of relationships is associated with better coping strategies, an optimistic evaluation of a relationship's potential, and a general intention to work on relationships (Knee, 1998; Knee et al., 2003; Knee and Canevello, 2006). A belief in the malleability view of relationships was generally associated with relationship-maintenance strategies, an emphasis on relationship development, and "the belief that relationships grow not despite obstacles but in part because of them" (Knee and Canevello, 2006). Although Knee and colleagues focused on romantic relations, they are among the few researchers that have conducted research in the interpersonal domain and found that implicit theories on the individual level influence self-regulation on the interpersonal level.

Based on Dweck's, and Costa and Faria's work we therefore assume that a domain-specific implicit theory of professional abilities sets up a frame of reference for evaluating not only an individual teacher's traits and abilities but also the traits and abilities of other teachers at a school. Additionally, based on Knee's work, we assume that a malleable implicit theory of teachers' professional abilities is associated with an optimistic evaluation of the collective professional potential, development, and general intention to work toward improvement. The concept of implicit theories of professional abilities might therefore not only explain differences in the personal self-regulation of a teacher but also influence the collective regulation of teachers as part of school communities. To this end, in this study we explore whether the concept of implicit theories can be transferred to research on collective professional development, such as school improvement.

School Improvement and a Teacher's Implicit Theory of Professional Abilities

School improvement can be pictured as a school's journey (Jackson, 2000; Hallinger and Heck, 2011), where different actors get on and off the means of transport at different stages, equipped with various sets of skills, dispositions, experiences, expectations, and beliefs. In this picture, the teaching staff is a traveling group where the destination, itinerary, and means of transport are constantly objects of negotiation–without the group members necessarily coming to

an agreement or joint solution. As a result of this, different patterns of school-level growth in student learning and in the professionalization of the school staff, as the two main goals of school improvement (Emmerich and Maag Merki, 2014), can be seen (Hallinger and Heck, 2011). To better understand these micro-political negotiations on means and ends of school improvement (Altrichter and Moosbrugger, 2015) and the different patterns of organizational growth (Hallinger and Heck, 2011), we base our argumentation on the theoretical framework of a school improvement capacity (Mitchell and Sackney, 2011; Maag Merki, 2017), where the complex interplay of individual and collective capacities to change educational practices is heuristically elaborated.

Since schools are complex conflict systems with different actors pursuing ambiguous goals with unclear technology on how to reach these goals (Cohen et al., 2012), it is neither a single factor nor the sum of various factors but rather a complex interplay of multiple features that explains success or failure when improving schools (Bryk et al., 2010; Emmerich and Maag Merki, 2014). The concept of a school improvement capacity gives expression to these complex nested structures in terms of three interrelated capacity dimensions: From a socio-constructivist point of view, Mitchell and Sackney argue that improving educational practices in a school is about: (1) (de-/re-) constructing personal knowledge and beliefs (personal capacity), (2) creating collective meaning and ideas that pass not only an individual's test but also a social test (interpersonal capacity), and (3) building lasting organizational structures in the form of discourse patterns that foster school improvement (organizational capacity) (Mitchell and Sackney, 2011).

Several researchers argue that to develop a school's capacity to change there is a need to focus on how individual beliefs and collective sense-making processes are intertwined (Coburn, 2001; Sleegers et al., 2014). White's (1988) model of contextual rationality describes the organization as an important environment where meaning and order can be provided even when tasks and aims are ill-defined and sometimes contradicting—which is often the case in educational institutions (Cohen et al., 2012; Emmerich and Maag Merki, 2014). Therefore, in a process of collective sense-making, common ground is created within a specific context where questions and their answers are often vague and always a product of negotiation (Weick, 1995).

Following this argumentation, a teacher's implicit theory of professional abilities can be seen as an integral part of a teacher's personal capacity to change. Further, we assume that implicit theories of professional abilities influence how collaborative activities are performed and evaluated. However, the theoretical concept of school improvement capacity has been criticized as being still too vague to explain processes and dynamics between individuals' orientations and beliefs and their behavior as individuals or in a group (Maag Merki, 2017). Therefore, to better understand how individual beliefs and collective sense-making processes are actually intertwined, we argue that theoretical assumptions about self-regulated learning are helpful. To this end, the next section highlights

collaborative regulation activities for further developing educational practices.

Collective Metacognitive and Emotional-Motivational Regulation in School Improvement

With the concept of self-regulated learning a second theoretical layer has been added to conceptualize the dynamics of individual and collaborative activities aiming to further develop educational practices. The literature on self-regulated learning focuses mostly on student learning and has neglected teachers, who can be seen as active and lifelong learners–in particular when it comes to professional development and school improvement. By framing teachers as learners aiming to further develop educational practices individually and collectively, it becomes possible to transfer theoretical and empirical assumptions in the field of self-regulated learning to the domain of school improvement.

Implicit theories of abilities are related to various aspects of self-regulated learning, especially the regulation of motivation and metacognition through goal setting and monitoring (Nussbaum and Dweck, 2008; Burnette et al., 2013). Thus, expert learners should display a more powerful repertoire of self-regulated learning strategies when facing challenges in further developing educational practices (Zimmerman, 2015; Panadero, 2017). Two sets of regulation strategies have been shown to be important in the context of learning: activities to regulate emotional and motivational states, and metacognitive strategies. Whereas emotional-motivational regulation activities aim to solve motivational and emotional problems by enhancing perseverance and self-reinforcement (Zimmerman, 2015), metacognitive regulation activities are defined as strategies for monitoring, analyzing, and adjusting the learning process (Winne and Hadwin, 2008).

Winne and Hadwin's recursive model of self-regulated learning (Winne and Hadwin, 2008; Panadero, 2017) illustrates a bridge between personal beliefs and self-regulation processes. According to the recursive model, a learner COPES with a task by relying on task and cognitive *conditions*, *operating* with different (more or less suitable) strategies at hand, which in turns ends up in a *product* (result) more or less satisfactory depending on the *evaluation* according to personal *standards* (Winne and Hadwin, 2008). Whenever the learner has to stop their routine and adjust certain aspects of the learning process, self-regulated learning is at work. These adjustments can be made either by changing conditions (task or cognitive), starting new operations, or by lowering or raising standards (Winne and Hadwin, 2008). According to this theoretical framework, emotional-motivational and metacognitive regulation activities are the means to successfully change conditions, operations, or standards.

Theories of self-regulated learning have been criticized as focusing too strongly on individual learning processes and consequently neglecting social aspects of learning (Hadwin et al., 2011). To expand Winne and Hadwin's theoretical framework from an exclusively individual perspective to collective regulation processes, the concept of socially shared

regulation of learning was introduced (Hadwin et al., 2011; Panadero and Järvelä, 2015). Socially shared regulation of learning is defined as "the interdependent or collectively shared regulatory processes, beliefs, and knowledge orchestrated in the service of a co-constructed or shared outcome" (Hadwin et al., 2011). According to that, successful collaboration in groups, which is conceptualized as a sense of higher self-efficacy for group work, emerges when individuals share the regulation of learning (Hadwin et al., 2011). This is done by co-constructing shared tasks representations, articulating shared goals, and through shared metacognitive monitoring and control of motivation. Several researchers have found evidence of shared regulation of emotions, motivations, and metacognition on a student level (i.e., Järvenoja and Järvelä, 2009).

When migrating these conceptual ideas to the research on school improvement, regulation activities in schools can be conceptualized as individual and collective processes of identification, analysis, and adaptation of conditions, operations, and standards by applying cognitive, metacognitive, and motivational and emotional strategies (Maag Merki et al., in press).

Following the argumentation of the recursive model of self-regulated learning (Winne and Hadwin, 2008), a teacher's implicit theory of professional abilities can therefore be understood as an integral part of the cognitive conditions. Hence, teachers' beliefs have an impact on operations such as emotional-motivational and metacognitive regulation strategies and therefore indirectly also on the product of these operations (e.g., perceiving the school's improvement) (Muis, 2007). This is in line with the argumentation in Weddle et al. (2019) study on teacher cooperation. Weddle et al. pointed out a need to further examine emotional and motivational aspects of how teachers perceive collaboration as a possible key to better understanding how capacity-building efforts work and how effective strategies can be fostered.

To sum up, we base our argumentation on three different theoretical anchors: first, the socio-cognitive framework by Dweck and Leggett (1988) to analyze the influence of self-theories (such as implicit theories about professional abilities) on regulation processes; second, the recursive model of self-regulated learning by Winne and Hadwin (2008) to obtain a more in-depth picture of these regulation processes (in this case emotional-motivational and metacognitive regulation activities involved in further developing educational practice); third, the socio-constructivist approach of Mitchell and Sackney (2011) to conceptualize the intertwined dimensions of individual and collective regulation activities to further develop educational practice.

Research Questions and Hypotheses

This study aims to provide answers to the following overarching question: What role do teachers' implicit theories of professional abilities play for school improvement? The following research questions are central for this article:

1. Do teachers have varying implicit theories of professional abilities, and can these theories be measured reliably?
2. What role do the implicit theories of professional abilities play for teachers' collective metacognitive and emotional-motivational regulation activities at their school?
3. How are implicit theories of professional abilities related to teachers' perceptions of their school's improvement?

First, we hypothesize that teachers have varying implicit theories of teachers' professional abilities, which can be measured reliably (H1) (Dweck, 1999). Second, since individual beliefs have been shown to affect not only perceptions of personal but also interpersonal strategies (Knee and Canevello, 2006), we hypothesize that a more malleable implicit theory of professional abilities is positively related to teachers' perception of collective regulation activities (metacognitive [H2a] and emotional-motivational regulation activities [H2b]) (Nussbaum and Dweck, 2008; Burnette et al., 2013). Although in reality a change in ability can be in a positive or negative direction, several researchers have indicated that the concept of a malleable implicit theory focuses on the phenomena of increasing abilities (Dweck, 1999; Dresel and Schloz, 2011). Therefore, third, we assume that a malleable implicit theory of teachers' professional abilities is associated with an optimistic evaluation of a general intention to work toward improvement (H3) (Knee and Canevello, 2006). Finally, we assume that this effect is mediated through collective emotional-motivational and metacognitive regulation activities (H4; Muis, 2007; Dweck, 2017).

MATERIALS AND METHODS

Study Design and Sample

To answer these research questions, we collected data from 1,625 teachers and principals at 59 primary schools in the German-speaking part of Switzerland. All of the participants took part in the study on a voluntary basis and actively gave informed consent to participate by completing an online questionnaire. Although the sample was not obtained through random sampling, it can be considered representative both on a school and teacher level for all primary schools in the German-speaking part of Switzerland, as outlined below.

First, a short overview of the primary schools in the German-speaking part of Switzerland: Almost 95% of Swiss pupils attend eight years of primary level schooling from pre-school to Grade 6 at a public school (FSO, 2019). There is no national curriculum, and traditionally, the primary responsibility for regulation and enforcement in these schools lies with the cantons and communes (Eurydice, 2020a). However, in 2006 the Federal Constitution and the Intercantonal Agreement on Harmonization of Compulsory Education (HarmoS Agreement) (EDK, 2011) obliged the cantons to coordinate and harmonize their educational systems with regard to structure and objectives (Eurydice, 2020b). This led to profound changes not only for the cantons and communes but also their schools. For instance, all schools had to undergo large-scale curriculum reform in the subsequent

TABLE 1 | Descriptive statistics of the sampled primary schools (*N* = 59).

	Mean (SD)	Median	Min	Max
Response rate (in %)	83.8 (10.7)	85.7	46.9	100
Size				
N_{staff}	28.9 (17.7)	23	6	74
$N_{student}$	226.7 (143.7)	184	34	593
SES[a]				
Taxable income	33,489 (10,390)	31,030	16,183	64,735
Social welfare	2.36 (1.66)	1.65	0.5	6.3
Regional context[b]	–	4	1	9

[a]*Socioeconomic background of the school's community (SES) was measured in terms of average taxable income (in Swiss francs, CHF) and social welfare ratio (in %)*
[b]*Regional context of a school is rated on an ordinal scale from 1 (rural) to 9 (urban).*

10 years (D-EDK, 2016). Further, through increased autonomy for every school, low-stake accountability structures in the form of school inspections were introduced to monitor and assess the quality of primary schools (Eurydice, 2020c). In addition, schools in the German-speaking part of Switzerland all face similar organizational challenges, at least to a certain degree, in terms of high turnover in teaching staff (Denzler, 2010; Sandmeier et al., 2018) and an increase in the heterogeneity of the students (FSO, 2018). Therefore, we assumed that these schools and their staff were most likely to have experienced similar school improvement issues, such as changing educational structures, articulating shared development goals for the school organization, experimenting with new teaching techniques, or developing enhanced collaborative work in teams.

Second, despite these similarities, we acknowledge that primary schools face different challenges depending on their context and organizational structures, such as the size of the primary schools, the regional context (e.g., urbanization), and the socioeconomic background of the community (Muijs et al., 2004; Bryk et al., 2010). Thus, the sampled schools, as well as all primary schools in the German-speaking part of Switzerland, varied greatly in size: Whereas some smalls schools had fewer than 10 teaching staff and only a few more than 30 students, other schools could be considered as large schools, with more than 70 teaching staff and almost 600 students. Further, the 59 schools in our sample were located in different regional contexts. The regional context was measured on a scale from 1 (*rural*) to 9 (*urban*). Most schools in German-speaking Switzerland and in our sample are located in small- to medium-sized agglomerations (from 3 to 6 on the scale). In terms of the social context, the schools' local communities differed not only in their social welfare ratio (from very low 0.5% to relatively high 6.3% of the population) but also in the average taxable income. In the sample there were richer and poorer communities, where a rich community had an average income about four times the average income of a poor community. In sum, the schools in our sample were confronted with very different situations and challenges in terms of context and organizational structures (see **Table 1**).

Third, as the school sample was quite heterogeneous in terms of context and organizational structures, the effects of teachers' implicit theories of professional development on collaborative activities and the school's improvement might be influenced by these differences on a school level. To take this into account, in

the analyses described below we controlled for the nested structure in our data.

Fourth, all teachers and principals in the study filled out an online questionnaire at the beginning of the school year 2019/20. To investigate teachers' implicit theories of professional abilities, we relied on a subsample of teachers (*N* = 1,483; 88% women; aged 21–67 years [*M* = 43.31, SD = 11.37]), who had at least 1 year of experience teaching at their school. We therefore excluded all principals having no teaching duties (*N* = 40) and teachers with less than a year of work experience at their school (*N* = 105) from the sample. The survey response rate on an individual level was 83.1% (*N* = 1,232). On a school-level the response rate was slightly higher (*N* = 59; *M* = 83.8, SD = 10.7; Min = 46.9, Max = 100). The average years of total teaching experience was close to 18 (*M* = 17.64, SD = 10.92), and the average years of teaching experience at the current school was around 10 (*M* = 10.39, SD = 8.83). More than half of the teachers reported working part-time, with a worktime <75%.

Last, our data was diverse not only in terms of school characteristics but also in terms of teacher demographics. A possible sampling bias was analyzed by comparing teacher demographics (gender, age, seniority) and school characteristics (size, regional context, and socioeconomic background) with data on all Swiss primary schools provided by the Swiss Federal Statistical Office (FSO, 2020). Since no significant differences were found, a sampling bias could be excluded. Therefore, the database of the SIC study was a solid basis for examining our research questions.

Measures
Implicit Theories of Professional Abilities
Whether teachers believe that the ability to be a good teacher is predominantly given or something that can be cultivated was assessed by adapting an instrument that was developed to assess students' self-theories (Schöne et al., 2003). In a pilot study with 90 secondary school teachers, we adapted the original scale items to fit the context of staff members at schools in order to capture teachers' self-theories of the malleability of professional abilities. This resulted in a reliable measurement instrument based on 4 items (*N* = 90; *M* = 4.26, SD = 0.96; Cronbach's *α* = 0.81). The items covered different facets of teachers' implicit theories of professional abilities (see **Table 2**). For example, teachers were asked whether they thought that the ability to be a good teacher is predominantly given (= 1) or is something that can be changed (= 6) and whether teacher training programs or professional development activities cannot (= 1) or can improve (= 6) teaching abilities. With our main data from more than 1,000 primary teachers, the instrument to measure teachers' implicit theories of professional abilities showed an acceptable Cronbach's alpha value close to 0.70 (DeVellis, 2012) (*N* = 1,175; *M* = 4.45, SD = 0.81; Cronbach's *α* = 0.69). Factor structure and validity of the instrument are discussed in detail in the sections below.

Collective Regulation Activities
Two subscales were used to examine collective regulation activities (see **Table 3**). A first subscale to assess emotional and motivational regulation activities on a collective level was

TABLE 2 | Measurement instrument to assess teachers' implicit theories of professional abilities.

Item		N	M	SD	r^{it}	α-drop	α
1	The ability to be a good teacher is predominantly given (= 1) or is something that can be changed (= 6)	1,177	3.50	1.25	0.46	0.64	–
2	Through training, classroom teaching and teaching related skills cannot (= 1) or can be improved (= 6)	1,177	5.10	0.98	0.46	0.62	-
3	Teachers vary in their repertoire for facing challenges in classroom teaching and teaching related tasks. This repertoire cannot (= 1) or can be changed (= 6)	1,175	4.90	0.95	0.46	0.63	-
4	Teacher training programs or professional development activities cannot (= 1) or can improve (= 6) teaching abilities	1,177	4.40	1.31	0.51	0.59	–
Latent construct	Teachers' implicit theory of professional abilities (fixed = 1; growth = 6)	1,175	4.45	0.81	–	–	0.69

M = mean and SD = standard deviation. r^{it} indicates item-total correlation coefficients. α-drop indicates Cronbach's alpha of latent construct if item is dropped. α indicates Cronbach's alpha of the latent construct.

TABLE 3 | Measurement instruments to assess collective regulation activities and feeling of the school being on the right track, with example item and scale characteristics.

Latent construct	Example item	N	M (SD)	Items	Range	α	ICC$_1$(ICC$_2$)
1. Collective metacognitive regulation activities	We, as a school, often think about what works and what does not work in our teaching	1,157	4.60 (0.64)	6	1-6	0.87	0.040 (0.449)
2. Collective emotional-motivational regulation activities	We, as a school, find ways to deal with negative emotions in order to continue our work	1,161	4.69 (0.66)	6	1-6	0.88	0.056 (0.537)
3. Being on the right track to improving	We, as a school, think that our pedagogic repertoire is continuously improving	1,159	4.48 (0.66)	4	1.75-6	0.93	0.040 (0.449)

M = mean and SD = standard deviation. α indicates Cronbach's alpha of the latent construct. ICC$_1$ and ICC$_2$ are the intraclass correlation coefficients.

developed based on a valid measurement instrument to assess students' emotional and motivational regulation (Schwinger et al., 2007). For example, the teachers were asked whether they as a school found ways to deal with negative emotions in order to continue their work. Teachers responded to this and other five statements on a 6-point Likert scale from 1 (*strongly disagree*) to 6 (*strongly agree*). The items were first tested in our pilot study ($N = 90$; $M = 4.46$, SD = 0.58; Cronbach's $\alpha = 0.88$) and then applied to the main data ($N = 1,157$; $M = 4.60$, SD = 0.64; Cronbach's $\alpha = 0.87$; ICC1[2] = 0.040 [0.449]). Both results indicated a high reliability of the test instrument in terms of Cronbach's alpha values. As an additional reliability measure, we calculated intraclass correlation coefficients (ICCs). An ICC(1) describes the ratio of between-school to within-school variance and thus indicates the extent to which there is variance between or within schools (Lüdtke and Trautwein, 2007). Since in research ICCs on between-school differences are typically rather low (Kyriakides and Creemers, 2009; Brunner et al., 2018), values lower than 0.10 can still reveal substantial explanation. With an ICC(1) coefficient of 0.04, almost 5% of the variance in collective emotional-motivational regulation activities could be explained by differences between schools. The ICC(2) considered the number of teachers at a school completing the questionnaire. ICC(2) coefficients higher than 0.40 indicated fair reliability for the class mean ratings (LeBreton and Senter, 2008).

To capture teachers' perceptions of collective metacognitive regulation activities, teachers responded to six statements on a 6-point Likert scale (e.g., "In our school, we often think about what works and what does not work in our teaching," or "In our school, from time to time we check whether we need additional information or materials"). Results from both our pilot study ($N = 90$; $M = 4.83$, SD = 0.60; Cronbach's $\alpha = 0.89$) and our main sample ($N = 1,161$;

$M = 4.69$, SD = 0.66; Cronbach's $\alpha = 0.88$; ICC1[2] = 0.056 [0.537]) showed a high reliability of the test instrument. Moderate ICCs indicated that the sampled schools differed in terms of their collective metacognitive regulation activities.

School on the Right Track to Improving
As a school improvement outcome variable, we assessed teachers' perceptions of their *school being on the right track to improving educational practices*. Research on the effects of an individual's perception of collective regulation activities and structures has been reported to provide insights concerning the basis upon which professional development activities may flourish (Moolenaar et al., 2014). Since individuals perceive and evaluate their organization based on what happens in their close social neighborhood (Meredith et al., 2017), analyzing how individuals apply regulation activities and see others applying such activities provides an opportunity to make sense-making processes visible and work out how individual beliefs are intertwined with collective interaction patterns (Sherer and Spillane, 2011). Returning to the analogy of school improvement as a journey, perceptions about being on track (whether right at the start of a journey or after having traveled quite far) is one way to take into consideration different school contexts and stages when it comes to school-level growth in student learning (Hallinger and Heck, 2011; Sleegers et al., 2014). Therefore, we created a measurement instrument to assess a collective sense of heading in the right direction when further developing the school (e.g., "In our school we think that our pedagogical repertoire is continuously improving"). Teachers responded to four statements on a 6-point Likert scale from 1 (*totally disagree*) to 6 (*totally agree*). The reliability scores were high both in the pilot study ($N = 90$; $M = 4.57$, SD = 0.57; Cronbach's $\alpha = 0.92$) and with the main data ($N = 1,159$; $M = 4.48$, SD = 0.66; Cronbach's $\alpha = 0.93$; ICC$_{1[2]}$ = 0.040 [0.449]).

Moderate ICCs revealed that there was some between-school variance. This meant that to some degree, teachers at a specific school had similar perceptions of their school's improvement, but within-school variance was still remarkable (see **Table 3**).

Data Analysis

To assess all the measurement instruments used in this study and to test our first hypothesis (H1) about the reliability of our latent construct to assess teachers' implicit theories of professional development, confirmatory factor analyses (CFA) were computed using the *lavaan* package Version 0.6-6 (Rosseel, 2012) in R (RStudio-Team, 2020). Fit indices of the CFA models were estimated by applying a robust maximum likelihood estimator (MLR) for the correction of data that is not normally distributed (Satorra and Bentler, 1994). Additionally, missing data was estimated with the full-information maximum likelihood method (Arbuckle et al., 1996). Further, as the assumption of non-independence of the observations was violated, due to a complex nested data structure, we applied a survey design approach (Muthen and Satorra, 1995). In this way, unbiased estimators were calculated by introducing the cluster variable 'school.'

The other hypotheses (H2, H3, and H4) about the direct and indirect relations of teachers' implicit theories of professional development were tested by applying a structural equation modeling technique using Mplus Version 8.3 (Muthén and Muthen, 2017). Again, due to the nested structure of our data, we estimated the standard errors in consideration of the violation of the assumption of non-independence of observations. Applying the COMPLEX function with the cluster variable 'school' delivered unbiased parameter estimates (Muthen and Satorra, 1995). Missing values were estimated with the full information maximum likelihood method. To test significance of direct and indirect effects, confidence intervals were calculated by the bootstrap function in Mplus (using 1,000 bootstrap samples), as bootstrapping does not rely on the assumption of normality (Bollen and Stine, 1992).

RESULTS

Teachers' Implicit Theories of Professional Abilities

CFA including all the latent constructs used in the statistical model revealed a good model fit and decent factoring structure (χ^2 (164) = 515.04, $p < 0.001$, Scaling correction factor Yuan-Bentler correction (Mplus variant) = 1.306, robust CFI =.96, robust TLI = 0.95; robust RMSEA [90% CI] = 0.049 [0.045–0.054], SRMR = 0.033). Standardized factor loadings for the latent construct of teachers' implicit theories of professional abilities ranged from 0.57 to 0.64, indicating that the factor substantially influenced the variables. Communalities higher than 0.30 but lower 0.45 indicated a modest but acceptable explanation of the items' total variance by the latent factor (36% of the total variance was explained by the factor). A composite measure based on the four items had a modest but acceptable internal consistency. Hence, a reliable test instrument based on four items to assess teachers' implicit theory of professional abilities was developed (see **Table 2**).
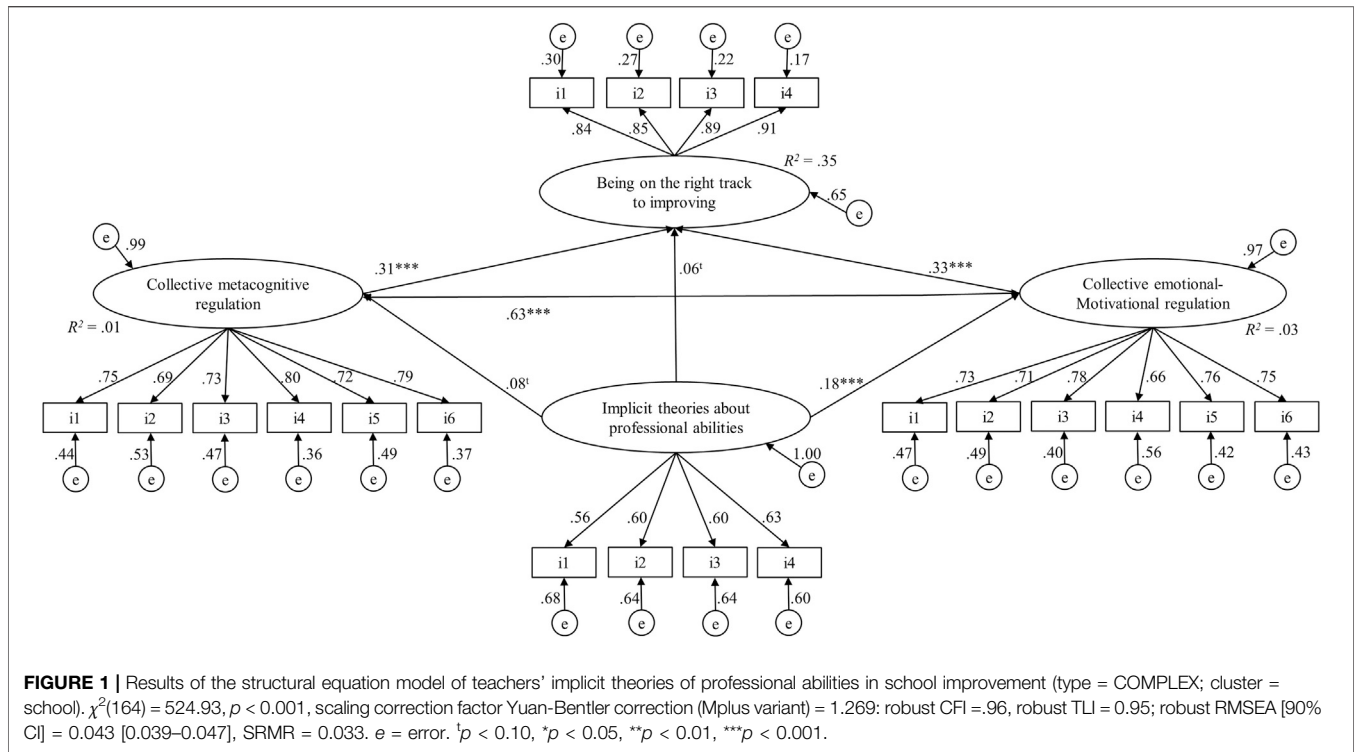
Implicit Theories and Collective Regulation Activities

As a second research question, we investigated the role of implicit theories of professional abilities when it comes to collective metacognitive and emotional-motivational regulation activities at the school. We hypothesized that teachers' implicit theories are directly related to their perceptions of collective regulation activities (metacognitive [H2a] and emotional-motivational regulation activities [H2b]) to improve educational practices. The results of the multilevel structural equation modeling in **Figure 1** showed how teachers' implicit theories of professional abilities are related to collective regulation activities (see **Table 4**). A standardized coefficient of 0.177 (SE = 0.047, $p < 0.05$, CI = [0.085–0.270]) revealed that a malleable theory is moderately positive associated with collective emotional-motivational regulation activities (H2a). Positive upper and lower boundary of the confidence interval indicated that this relation was significant. Implicit theories and collective metacognitive regulation activities were not significantly associated with each other (beta = 0.080, SE = 0.047, $p > 0.05$, CI = [−0.012–0.172]) (H2b).

Teachers' Implicit Theories and the School Being on the Right Track to Improvement

Our third research question concerned the role of implicit theories of professional abilities on teachers' perception about their schools being on the right track to improvement. We hypothesized that teachers with a malleable theory (vs. fixed theory) have a more positive perception of the school's improvement (H3). Implicit theories of professional abilities were positively correlated to the perception of the school's improvement (Pearson's $r = 0.13$, $p < 0.01$). However, there was no significant direct association of holding a more malleable theory and teachers' perceptions of their own school being on the right track to improving (see **Figure 1**) when we controlled for collective regulation (H4). But with a standardized coefficient of 0.058 (SE = 0.035, $p < 0.10$) and a lower boundary of the confidence interval only marginally negative (CI = [−0.001–0.117]) there was a tendency toward a positive association between a malleable theory and perception that their own school was on the right track to school improvement (see **Table 4**). A malleable theory was significantly related to a more positive perception of the school's improvement through collective regulation strategies: for one, mediated through emotional–motivational regulation activities ($\beta = 0.059$, SE = 0.017, $p < 0.05$, CI = [0.026–0.093]) and for another, through emotional-motivational regulation activities via metacognitive regulation activities (beta = 0.035, SE = 0.010, $p < 0.05$, CI = [0.014–0.055]). Teachers' implicit theories were not significantly associated with the feeling of being on the right track through metacognitive regulation activities (beta = 0.025, SE = 0.015, $p < 0.10$, CI = [−0.004–0.054]) or through metacognitive regulation activities via emotional–motivational regulation activities (beta = 0.017, SE = 0.010, $p < 0.10$, CI = [−0.003–0.037]). For both indirect effects, there was a tendency toward a positive relation. The total effect of the model was significant (beta = 0.149, SE = 0.056, $p < 0.05$, CI = [0.084–0.303]).

FIGURE 1 | Results of the structural equation model of teachers' implicit theories of professional abilities in school improvement (type = COMPLEX; cluster = school). $\chi^2(164)$ = 524.93, $p < 0.001$, scaling correction factor Yuan-Bentler correction (Mplus variant) = 1.269: robust CFI =.96, robust TLI = 0.95; robust RMSEA [90% CI] = 0.043 [0.039–0.047], SRMR = 0.033. e = error. $^t p < 0.10$, $^* p < 0.05$, $^{**} p < 0.01$, $^{***} p < 0.001$.

TABLE 4 | Standardized coefficients, standard errors, and confidence intervals for direct, indirect, and total effects for structural equation model.

Effects	β (SE)	CI$_{95}$	
		LL	UL
Direct effects			
IT → MR	0.080(0.047)	−0.012	0.172
IT → EMR	0.177(0.047)	0.085	0.270
IT → BoT	0.058(0.030)	−0.001	0.117
MR → BoT	0.311(0.032)	0.247	0.374
EMR → BoT	0.334(0.037)	0.262	0.405
Indirect effects			
IT → MR → BoT	0.025(0.015)	−0.004	0.054
IT → EMR → BoT	0.059(0.017)	0.026	0.093
IT → EMR → MR → BoT	0.035(0.010)	0.014	0.055
IT → MR → EMR → BoT	0.017(0.010)	−0.003	0.037
Total effect	0.149(0.056)	0.084	0.303

IT = Teachers' implicit theories of teachers' professional abilities, MR = collective metacognitive regulation activities, EMR = collective emotional-motivational regulation activities, BoT = being on the right track to improving. β = beta (standardized coefficient), SE = standard error, CI$_{95}$ = 95% confidence interval, LL = lower level, UL = upper level. Confidence intervals were calculated using 1,000 bootstraps.

DISCUSSION

This study aimed to analyze the role that teachers' implicit theories of professional abilities play for school improvement. With the development of a reliable test instrument to assess teachers' implicit theories of professional abilities an important first step to understand teacher beliefs about professional development and school improvement has been undertaken. Applying the test instrument revealed that primary teachers do vary in their implicit theories of the malleability of teacher abilities. Low ICC coefficients do not reveal any patterns indicating that malleable or fixed implicit theories can be explained by school affiliation. With a mean higher than 4 [on a 6-point Likert scale from 1 (*not changeable*) to 6 (*changeable*)] the majority of primary teachers in our sample tend to believe that professional abilities are changeable and developable. Nevertheless, with a minimum score of 1.5 to a maximum of 6 there is a range from rather fixed to malleable implicit theories of professional abilities. About 15% of the teachers reported to have a moderate to strong fixed implicit theory, answering the items on average between 1 and 3.5. More than every fourth teacher (27.6%) had an average score between 3 and 4, indicating that a substantial percentage of primary teachers are quite undecided concerning whether teaching abilities can actually be learned or not. These initial results reveal that our first hypothesis—that teachers vary in their implicit theories of professional abilities (H1)—can be accepted.

Based on our results, implicit theories of the malleability of teachers' abilities do indeed have an impact on perceptions of collective regulation activities and assessment of the school's recent development: First, teachers believing in the malleability of professional abilities evaluate the use of collective emotional-motivational regulation strategies more positively than teachers with more fixed theories (H2a) do. Whether this is because teachers with a malleable perspective on professional abilities embrace rather than avoid challenging situations (Dweck and Leggett, 1988) and therefore have more experience in applying emotional-motivational regulation strategies still needs to be assessed. Since there is no such effect in terms of

metacognitive regulation activities (H2b), previous research on students' implicit theories and the use of regulation strategies can only be transferred to some extent (Nussbaum and Dweck, 2008). Our second hypothesis—that there is a direct impact of different implicit theories of professional abilities on collective regulation activities (H2)—was therefore only partially fulfilled.

A possible interpretation of why collective metacognitive regulation activities were not found to be related to implicit theories of professional abilities is that the measurement instrument applied in this study might not have been suited to making differences in the metacognitive regulation of teachers in a group visible. This might be due to the fact that teachers are possibly used to reflecting upon and monitoring their work on a collective level informally rather than systematically (Mandinach and Schildkamp, 2020). Teachers might generally agree to collectively reflect on their educational work; however, this reflection might be largely superficial and based on informal exchange, without teachers necessarily analyzing in depth and sustainably adjusting their educational practices (Ehlert et al., 2009; Drossel et al., 2019). Therefore, these reflective activities might have limited impact on substantially further developing educational practices as a team. In this study, metacognitive regulation activities were assessed with a measurement instrument focused solely on teachers' collective monitoring and evaluating their work without explicitly mentioning the more complex facets of metacognitive activities, such as analyzing and adjusting cognitive or task conditions, operations, or standards (Winne and Hadwin, 2008). Whereas reflection in the tradition of Dewey has been conceptualized as a distinct form of thinking, where thoughts and actions are attentively and critically explored and framed by an individual's underlying belief system and the social context, it has been argued that practitioners often use *reflecting* synonymously with all kinds of *thinking processes* (Nguyen et al., 2014). This might relate to our finding that teachers, no matter what their implicit theory of professional abilities, report that they apply metacognitive regulation activities to collectively improve educational practices.

We assumed, in line with research on relationships (Knee and Canevello, 2006), that teachers who believe in change have more positive perceptions of collective regulation activities. But since everyone seems to exchange information on and experiences in their teaching with peers at least to a certain extent, no such effect could have been shown. Therefore, future research might address the question as to what teachers think of when it comes to collective metacognitive activities to further develop educational practices and whether there are differences in the quality of these activities by referring to theoretical concepts about metacognition and reflection (Livingston, 2003; Nguyen et al., 2014).

Further, implicit theories of professional abilities indeed shape the way that teachers perceive the success of their school's improvement. However, our results indicate that this effect is fully mediated by collective regulation activities. Therefore, we must reject our third hypothesis—that teachers' beliefs about the malleability of professional abilities

is directly associated with their perceptions that the school is on the right track (H3).

Our fourth and last hypothesis about the mediating role of collective regulation activities can, again, only be accepted partially (H4). Whereas studies on students' implicit theories of personal abilities revealed indirect effects of a malleable theory on learning both through emotional–motivational regulation activities and metacognitive regulation activities (Muis, 2007; Dweck, 2017), on a teacher level there is no such relation straight from implicit theories through metacognitive regulation activities. However, there is an indirect path from implicit theories to school improvement through emotional–motivational regulation activities via collective metacognitive regulation activities. Thus, it seems that collective emotional–motivational regulation activities are of crucial importance and might function as door opener when it comes to associations between an individual's beliefs about the malleability of professional abilities and collective school improvement efforts.

Since teachers believing that professional abilities can be changed not only report experiencing better emotional-motivational regulation activities on the school level but also are more optimistic that their school is on the right track to improvement, one might wonder whether fostering a malleable implicit theory in the entire school staff might actually lead to a better pattern when it comes to school-level growth in terms of student learning (Hallinger and Heck, 2011). To this end, future studies need to address research questions on the impact of teachers' implicit theories of professional abilities with longitudinal designs and by measuring changes in teachers' and students' learning more objectively (i.e., learning achievements). Further, longitudinal data would allow analysis of a feedback loop from the evaluation of collective regulation activities back to the teachers' beliefs about the malleability of professional abilities. Another central limitation of this study is the self-report nature of the survey. Future research might need to assess collective regulation activities more directly through more fine-grained approaches (e.g., logfile, or group interview techniques).

Some additional limitations should be noted. In this study covariates such as age, gender, workload, and the teachers' formal roles were not included in the theoretical assumptions and the statistical modeling. To gain a more in-depth picture of implicit theories of professional abilities, some of these covariates might need to be addressed theoretically and empirically. In addition, studies on academic underachievers have revealed that the associations between implicit theories, self-regulated learning, and achievement are stronger for individuals with lower levels of performance (Paunesku et al., 2012; Job et al., 2015). It might be of interest to analyze such differentiated effects for teachers' implicit theories of professional abilities on a personal and school level. On a school level, the same argumentation might hold true when it comes to differences in the school's stage of the journey to school improvement. Fostering a malleable implicit theory of professional abilities might be particularly important for schools with challenging circumstances (i.e., high turnover rates or a problematic school climate). To this end, not only visible school

structures, such as school size or students' socioeconomic background, but also school differences in organizational deep structures, such as school climate (i.e., treatment of error, knowledge sharing (Staples and Webster, 2008)), openness to experimenting with new teaching ideas (Sleegers et al., 2014), or task cohesion (Brawley et al., 1987), and leadership issues might need to be addressed as well.

Further, although the internal consistency of the test instrument is acceptable, the instrument's reliability might be increased if one and the same items did not focus on both 'classroom teaching' and 'teaching related skills.' As teaching related skills is a wider concept subsuming various aspects of a teacher's professional competencies and can go beyond classroom teaching skills (aspects such as cooperating with colleagues, maintaining parental and community ties), a teacher might think of classroom teaching skills as fixed and at the same time teaching related skills as rather malleable or the other way around. Therefore, future research might further develop our test instrument to assess teachers' implicit theories of professional abilities by modifying the items such that they focus on the malleability of either classroom teaching or teaching related skills. In addition, as a next step in the development of a stable measurement instrument to assess teachers' implicit theories of professional abilities, test-retest reliability of the latent construct needs to be analyzed in other samples and educational contexts (Guttman, 1945).

Another limitation of this study is that the content validity of the measurement instrument used to assess collective metacognitive regulation activities is not entirely satisfactory. For future research the measurement instrument needs further development to adequately assess collective reflection as an in-depth inquiry process. In general, since most of the applied measurement instruments in this study are self-developed or have been migrated from research focused mainly on individual learning processes on a student level to research about collective learning processes on a teacher level, content validity of these instruments needs further verification. However, there is support for the validity of these instruments, as theoretical assumptions have been confirmed, for instance in terms of correlations between the applied measurement instruments.

Two interesting practical implications can be derived from our results that need to be interpreted within the cultural context of teachers in the German-speaking part of Switzerland: First, despite the fact that in recent years a large-scale curriculum reform has urged schools and their staff to change educational practice, by far not every teacher is fully convinced that professional abilities can actually be changed. This insight might be crucial for various stakeholders in the educational system, especially those in leading positions, such as policymakers, educational administrators, and principals, to better understand why implementing new policies, innovative teaching ideas, or working practices is sometimes a challenge equivalent to squaring a circle and does not always succeed in changing educational practice. Second, as the relatively low-stake accountability system of school inspections in Switzerland aims to further develop educational practice by giving teachers and schools as much autonomy as possible, teachers are requested to constantly further develop their professional abilities not only individually but also collectively. These high expectations of teachers to be self-directed learners in collaborative contexts (Slavit and Roth McDuffie, 2013) cannot be met if a substantial part of teachers do not fully belief in the malleability of professional abilities. Teacher educators might be of crucial importance in scaffolding and supporting teachers' learning processes and in addressing the impact of implicit theories on professional abilities in basic teacher education programs or in professional development programs.

To conclude, the promotion of malleable theories of professional abilities—the notion that 'good teachers' are not born but that good teaching is something that can be cultivated—may be used as a starting point not only for individual professional development but also for changing collective regulation strategies to foster personal, interpersonal, and organizational capacities for school improvement (Mitchell and Sackney, 2011; Maag Merki, 2017). Ultimately, changing educational practices may only work if teachers set their minds to it. Or in other words: Changing educational practices sometimes needs, for a start, some change in thinking.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors as soon as the research project is finished, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethikkommission der Philosophischen Fakultät (University of Zurich). The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

All authors contributed to conception and design of this study. KM, AW and BR organized the database. We acknowledge the work of further members of the research team in collecting the data. BR and MC wrote the first draft of the manuscript with input from all authors. BR, MC and KM developed the theoretical assumptions in the introduction. BR wrote the section about Materials and Methods, and performed the statistical analysis. MC and KM verified the analytical methods. All authors discussed the results and contributed to the final manuscript. KM and AW supervised the project.

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