International Electronic Journal of Mathematics Education
2022, 17(4), em0710
e-ISSN: 1306-3030
https://www.iejme.com

MODESTUM

Review Article

OPEN ACCESS

Whom do they become? A systematic review of research on the impact of practicum on student teachers' affect, beliefs, and identities

Lisa Österling [1*], Iben Christiansen [1]

[1] Stockholm University, Stockholm, SWEDEN
***Corresponding Author:** lisa.osterling@su.se

Citation: Österling, L., & Christiansen, I. (2022). Whom do they become? A systematic review of research on the impact of practicum on student teachers' affect, beliefs, and identities. *International Electronic Journal of Mathematics Education, 17*(4), em0710. https://doi.org/10.29333/iejme/12380

ARTICLE INFO

Received: 08 Mar. 2022

Accepted: 13 Aug. 2022

ABSTRACT

There is a widespread conviction in research on teacher education that practicum contributes to the development of student teachers' inner qualities. This article presents a systematic review of empirical research articles on teacher affect, identities, and conceptions of mathematics, based on 87 publications from 2001-2021. Becoming a teacher is described as a slow, uncertain, and individual process, with varied assumptions about what or whom the prospective teacher needs to become or feel. Generally, a synthesis was difficult, partly due to contextual as well as methodological differences among the included articles. Still, we could conclude how tensions between identities endorsed by school and university became influential for identity development. For affect, we saw contradictory results in how positive attitudes to mathematics can increase or decrease after practicum, and in how stable they are. Studies disagreed on the extent to which students' attitudes and beliefs determine their teaching approach. Despite this complexity, practicum-as-usual appears less successful than various interventions. This may have to do with the widespread implementation fidelity perspective, or with aspects focused on interventions being made more accessible for participants.

Keywords: affect, identity, mathematics teacher education, practicum, systematic literature review

INTRODUCTION

Teacher education does not only contribute knowledge to student teachers, but other key factors for their professional preparation are also their "attitudes, beliefs, goals, fears, hopes, and expectations" (Lerman et al., 2009, p. 73). Two major research areas are of relevance here: (1) affect and (2) identities.

From different theoretical positions, they provide explanatory power of understanding processes changing conceptions, beliefs, or affect towards mathematics and mathematics teaching, or of becoming a mathematics teacher. For this article, we focus on the practicum, the school-based part of mathematics teacher education, where expectations from university and the teaching profession are negotiated.

In mathematics education, affect has been divided into three broad categories: motivation, emotions, and beliefs (Hannula, 2016). The field touches theoretically on both cognitive and social perspectives and is researched by both quantitative and qualitative methods. Hence, affect has been described as individual and/or interpersonal (Touhilampi et al., 2016), where interpersonal affect interacts with culture. The cognitive dimension of individual affect includes beliefs about the self, such as self-efficacy, self-competence, and self-confidence (Hannula, 2011). The research on self-efficacy is substantial, commonly departing from the theorization of Bandura (1997), where self-efficacy is described as relatively stable, and where research contributes to an understanding of how teacher self-efficacy can be affected by feedback, enactment experiences, or affective states (Watson & Marschall, 2019). Beliefs related to the nature of mathematics are seen as partly psychological and partly social constructs assumed to be fostered through educational environments (Handal, 2003), which may influence instruction.

In identity research, a handful of review studies provides central insights and an overview of a complex research area within mathematics education. According to Darragh (2016), identity can be participative, narrative, discursive, psychoanalytic, or performative, depending on the theoretical perspective. Graven and Heyd-Metzuyanim (2019) followed up on Darragh's (2016)

This article is part of the TRACE project, funded by the Swedish National Research Foundation (Vetenskapsrådet), under project/grant number [017-03614].

Copyright © 2022 by Author/s and Licensed by Modestum. This is an open access article distributed under the Creative Commons Attribution License which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

review and added distinctions where identity is connected to either a sociopolitical claim, to teachers' experiences in various stages of their career, or to make claims about learning.

A closer connection between research on individual identities and research on affect and cognition is proposed by Lutovac and Kaasilia (2018), whereas Darragh (2016) pointed to theoretical inconsistencies in attempts to treat identities as a "catch-all term for affect" (p. 28). Apart from the theoretical differences, methodologies are debated. A critique of inconsistencies and circular methodologies for beliefs is raised by Lerman et al. (2009), concerning how teachers' beliefs are both inferred from observed actions, and at the same time treated as the cause of these actions. Similarly, Lutovac and Kaasila (2019) critique studies that claim to be data-driven but appear to use data to confirm rather than develop theory. This conceptual and methodological indeterminacy makes a synthesis and comparison of results challenging.

Not all agree on the importance of affect or identity. Smith (2001) claims that a focus on changing students' beliefs is unnecessary and inappropriate since beliefs are persistent and do not determine students' teaching styles. In addition, the ethics of inferring identities from actions is problematized: "Without intending to do so, some research on identity in mathematics education seems to re-entrench stereotypes about what sorts of identities excel at mathematics." (Jurdak et al., 2016, p. 15). The expectations on what student teachers learn from practicum are often implicit (Rusznyak & Bertram, 2021), and instead, different messages about what the teacher should be or become are transmitted in assessment instruments in teacher education (Christiansen et al., 2019).

The contribution of this literature review is to synthesize what empirical research on mathematics student teachers has inferred about the relationship between practicum and affect or identity, respectively. We ask, according to empirical research on mathematics teachers' affect and identities, who is the student teacher becoming from participating in practicum? And whom is the student teacher expected to become?

METHOD

After a systematic literature search, the included publications were categorized based on the focused development of the student teachers in terms of affect, identities, and conceptions of mathematics. Before we turn to the methods applied in the study, we clarify our terminology.

Terminology Used

We will use students to refer to student teachers, learners for pupils in schools, mentors for co-operating or supervising schoolteachers, lecturers for university staff who engage in teacher education or practicum, and researchers for the authors of the included publications.

In publications from both Anglophone and non-Anglophone countries, the way practicum is organized varies, as does the English terminology. In North American literature, a practicum is often referred to as field experiences and describes, for example, one-day-a-week placements in schools, while student teaching refers to longer periods of mentored teaching. An internship is a longer period where students generally have responsibility for teaching with minimal mentorship. Another way of organizing the practicum is mentored blocks of 4-20 weeks (e.g., in Singapore and Sweden). Besides practicum, field experience, student teaching, and internship, we see the terms teaching practice/practice teaching, school-based education, school experience, and clinical experience. In this article, we use practicum to describe the phenomena of teacher education taking place in a school context in all these forms.

Data Selection

In conducting this review, we followed an elaborated standard for systematic review studies, briefly described as:

1. applying a transparent and explicit search strategy,
2. formulating explicit in- and exclusion criteria,
3. coding the included papers as systematically as possible before, and
4. constructing a synthesis (see Onwuegbuzie & Frels, 2016; Torgerson et al., 2012).

Our first decision was to include only peer-reviewed journal articles in languages we could both read. We used our institution's search engine which links to ERIC, Scopus, and MathEdu, a direct search in ERIC, and search engines in relevant journals. We found that ERIC provided the most consistent and reliable results. We also searched What Works Clearinghouse, which led to papers on practicum but not specifically on mathematics education and did a database search for doctoral dissertations (using ProQuest, EEF, WWC, DART, NDLTD Global, SwePub, and Danish Research Database). In a preliminary selection of journals (June 2017), it became evident that only a few articles had been published before the new millennium. Hence, we limited our timespan to publications between 2001 and May 2021. We excluded journals listed as predatory, based on https://predatoryjournals.com/journals/.

From the initial search terms (mathematics and the terms practicum, field experience, student teaching, teaching practice, practice experience, and internship) in the first explorative search, we identified keywords, and in combination with ERIC's list of keywords, we developed a Boolean search string for our search in ERIC. We believe this ensured inclusion of main articles of possible relevance. The combined searches resulted in 442 potentially relevant articles and 93 potentially relevant dissertations.

Next, we checked that each article did indeed concern mathematics teacher education and practicum, that it reported on empirical research, and that it had to do with mathematics teaching; these were our inclusion criteria (**Table 1**). Some studies

reported on students working with one or a few learners. While we believe this approach is highly educationally relevant in teacher education, we decided to limit our inclusion criteria to practicum in full classes, and we set the limit to classrooms with at least 10 learners. To be included as an empirical study, we considered a broad range of data from research on practice, such as classroom observations, interviews, surveys, logbooks, reflections, and conversations on practicum teaching or lesson plans, but excluded earlier review studies and theoretical papers. We have included research on reflections on practicum, observations during practicum, interactions about teaching practice between mentors and students, and planning of actual practicum teaching but not planning or reflection on teaching when described as a task in a university course, micro-teaching, lectures given in schools, or teaching in afterschool clubs. Decisions on papers that concerned practicum only perimetrically were difficult, for example, we included Goos and Bennisson (2008) on communication amongst students and between students and novice teachers. For increased transferability, we decided to include only studies with at least two participating students. Validity concerns were noted, but since all papers were peer-reviewed, we did not apply validity or trustworthiness as exclusion criteria. This process resulted in a dataset of 163 articles and 49 doctoral dissertations. **Table 1** presents the inclusion and exclusion criteria for publications reviewed in this article.

Table 1. Inclusion and exclusion criteria

Criterion	In-/exclusion	Description
Population	Inclusion	Any participant in practicum experiences, students, mentors, learners, and lecturers.
Time span	Inclusion	2001-2020
Practicum	Inclusion	Studies concerning practicum, field experience, student teaching, internship, teaching practice, practice teaching, school-based education, school experience, or clinical experience with the teaching subject mathematics. Studies with a focus on reflections on practicum, observations during practicum, interactions about teaching practice, or planning of practicum teaching.
	Exclusion	Planning or reflection on teaching when described as a separate task in a university course, micro-teaching only, university lectures given in schools, or teaching in informal situations such as after-school clubs. Studies that did not concern mathematics teaching or mathematics teacher education. Studies in classrooms with less than 10 learners.
Outcomes	Inclusion	Studies report on at least one educational outcome, defined broadly as a change in affect, attitudes, beliefs, perceptions of mathematics or teaching, or identity.
Study design	Inclusion	Empirical studies.
	Exclusion	Studies with only one participant.
Journal	Exclusion	Articles in 'predatory' journals.

The next step was to consider different possible reviews, and for this article, publications that addressed student teacher development concerning affect, attitudes, beliefs, conceptions of mathematics or mathematics teaching, or identity were selected. Another recently submitted article focuses on take-up in terms of knowledge and learning from practicum, based on the same literature search. To recognize studies about identities, beliefs, efficacy, or affect was straightforward when such theorizations were explicitly used in the publications. We also included publications that used perceptions, feelings, dispositions, or other descriptions of an outcome related to the self or the inner qualities of student teachers. Even though the line between identity/affect and knowledge is often blurred, we did not include publications focusing solely on knowledge development, for example, the development of pedagogic content knowledge.

Decisions on inclusion or exclusion of publications were made by each author for the first several papers and then compared. When a high degree of intercoder reliability had been reached, decisions on each successive paper were made by one author. In approximately 90% of the cases, this was straightforward. In the remaining cases, we discussed the inclusion criteria until an agreement had been reached (see **Appendix 1** for the full list of included publications). The result was 16 doctoral dissertations and 71 articles spread across an astonishing number of 47 journals. The result chapter begins with an overview of the included set of publications.

Data Extraction and Thematisation of Results

To represent reported findings accurately we tried wherever possible to use the exact formulations of each publication's research questions, aims, and results, and summarized each finding using quotes from the paper. In the extraction phase, we aimed to keep the language as close to the original as possible. For example, although 'understanding of mathematics teaching' can be similar to 'beliefs', we kept the language from the original publication in our summary. Once data extraction and summaries had been completed, we clustered similar codes within themes.

Based on earlier strands, as described in the introduction, we could make a divide between affective perspectives and identity perspectives. However, several publications did not explicitly state a theoretical position, and in addition, the broad use of beliefs was quite divergent. We, therefore, used the affective theme explicitly for affect or beliefs about the teacher him/herself, for example, self-efficacy beliefs or confidence. The second theme included studies explicitly using identity, including a few studies using positioning theory as well. The third theme gathered all publications on beliefs about mathematics, mathematics learners, or mathematics teaching. In addition, several publications discussed conceptions of mathematics without using the conceptualization of beliefs and were included in this third theme. Thus, the three resulting themes were, as follows:

1. affective issues: Developing attitudes, emotions or self-efficacy, or conceptions about the teacher him/herself;
2. identity and positioning; and
3. conceptions or beliefs about mathematics, mathematics learners, and/or of teaching.

Seventeen publications spanned two different themes and were included in both. We also extracted background information (publication year, location of study, intervention or usual practice, nature and length of practicum, level of education the students

were preparing for, and whether data were from the authors' institution) and the methodological approach (participants, sample size or scope, methods of data generation) from each included study. Unfortunately, far from all articles and dissertations specified the nature of the practicum studied. The lack of specificity in the articles meant that it was not possible to distinguish developments or changes due to the length or nature of the practicum.

RESULTS

The result section begins with an overview of the background information of the included studies. The distribution of publications based on country, participants, and data collection methods renders an overview of the generalizability of results. Thereafter, the results are grouped into three themes. The first theme concerns the affective issues, including attitudes, emotions, values, and beliefs student teachers hold towards themselves (42 publications). The second concerns positioning and identity formation (14 publications). The third theme summarizes conceptions related to mathematics, mathematics teaching, and/or mathematics learning (50 publications). Since several publications explored relations between different constructs, there were overlaps: 17 publications included two or three perspectives, most commonly both affect and conceptions about mathematics teaching. We highlight what teachers were expected to become in the headings below, and each section presents emerging and diverging patterns related to the contribution of practicum, together with relations between constructs.

Location of Studies

It was possible to extract the location of the study from all texts, and **Table 2** provides an overview of the included 87 publications.

Table 2. Number of publications from different countries

Number	**56**	**7**	**6**	**3**	**2**	**1**
Countries	USA	Turkey	Australia	Canada	New Zealand, Norway	Cyprus, Denmark, Finland, Germany, Ireland, Malta, Portugal, Sweden, Taiwan, UK, Zimbabwe

Two-thirds of the publications come from the USA (56). The dominance of publications from the USA risks skewing the field towards problems particular for that particular context. Apart from Turkey, the Anglophone world, such as Australia, Canada, and New Zeeland dominates. One reason for this is an unequal distribution of research resources to start with. Also, the decision to only include English language publications, due to unfortunate language restrictions of the authors of this publication, skews the distribution. only being able to read English language publications. This means that the whole continent of Latin America is not represented at all, and the representation of Asia, Africa, or Eastern Europe is indeed limited. Again, there is a gap in terms of what contexts are not represented, and at a same time dominance of perspectives from the global north.

A substantial number of the studies looked at researchers' practice, their institution, or mentors associated with the institution. Not all texts were not always explicit about this, but it could sometimes be inferred from the text.

Participants and Scope

All publications used student teachers as participants, fourteen publications included mentor teachers, six included lecturers, one included other school staff, and one included learner. Roughly half the studies were on elementary/middle-school students, a third on secondary, eight were mixed, and in a few cases, it was unclear. Thus, student teachers are the focus for the included publications. The representation of student teachers for different school levels was relatively well proportional to their respective number in teacher education.

Figure 1 shows how few large-scale studies were reported; only nine studies had more than 100 participants. One article did not report the scope. From **Figure 1**, we conclude that small-scale studies dominate the data set. In combination with the number of studies looking at the own institution, the transferability of results must be problematized, and the present article is an attempt to contribute with cumulative knowledge building across contexts.

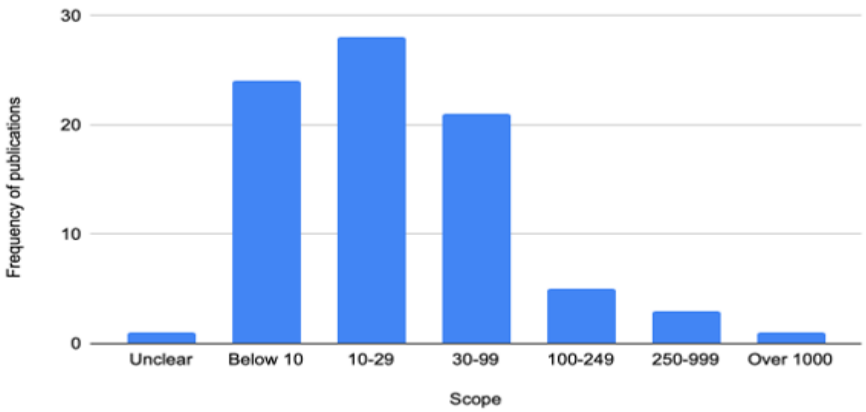

Figure 1. The distribution of the scope of participants

Research Designs or Methods in the Reviewed Studies

The dominance of small-scale studies is reflected in the dominance of qualitative methods for data-collection. Most common were interviewing (44 studies), but also surveys, questionnaires, or tests (40) using a quantitative method of analysis. Other methods of data collection were reflections and/or journals (29), written assignments or lesson plans (24), lesson observations (25), and focus groups or recorded conversations between various participants (20). Just over one-third of the studies (34) used a single data collection method, thus, a combination of methods was common.

In studies using lesson observations, all but one combined observation with other methods, and self-reported data (interviews, surveys, reflections) dominate the data. Since beliefs, conceptions or identities are not directly identifiable from observations of teaching, this seems a becoming choice.

Teachers' Affect, Confidence, and Efficacy

In this category, student teachers' affective aspects of teachers themselves, such as their confidence, efficacy, or attitudes were included. We found studies claiming that affect explains other dimensions of teaching, and/or that affect is possible to change or develop. Nonetheless, particular affective states appear to be valued in research for mathematics student teachers.

Becoming confident

In this theme, a range of affective changes related to confidence, perceptions of the self, or believes was included. Changed confidence was influenced by a supportive environment in practicum, and confidence in turn facilitated developments in mathematics teaching. Practicum was in some cases causing decreased confidence.

A supporting environment in practicum increased confidence. Such supportive environment was such as Taiwanese mentors' constructive feedback (Lin & Acosta-Tello, 2017), working in teams with lead teachers (Shelton et al., 2020), or classroom experiences scaffolded by portfolio work (Gujarati, 2019). Ebbelind (2020) instead found how previous mathematical experiences were important for student teachers' sense of security and proficiency.

Increased confidence facilitated developments in mathematics teaching, as when student teachers "realized that cherishing and respecting students' mathematical thinking was an effective way of encouraging students to ask questions and to communicate their thinking" (Lin & Acosta-Tello, 2017, p. 232). Two studies found decreased confidence as a result of practicum– after the first practicum, students were less confident that they had the necessary specialized content knowledge (Hine & Thai, 2019); and Boz (2008) found that while self-related concerns were reduced over years, concerns related to teaching tasks were not.

A change in what was perceived as important knowledge for teachers was found to be related to practicum, where Turkish students had changed their beliefs after practicum, from considering content knowledge most important to emphasizing the inclusion of pedagogical aspects (Ozgun-Koca & Sen, 2006), while German students came to value their content knowledge more (Gawlitza & Perels, 2014). Thus, these were contrasting findings on the contribution of practicum concerning what was valued as important knowledge for mathematics teachers.

These publications expressed a wish for student teachers to become increasingly confident and linked confidence to developments in mathematics teaching. Still, we saw contrasting results concerning the relevance of practicum for the development of confidence.

Becoming efficacious

Efficacy has been defined by Bandura (1997) as the ability or capacity of someone or something to produce the desired outcome. Some publications adhere to this meaning and talk about student teachers' efficacy as being different from their efficacy beliefs. However, it was not uncommon to find 'teacher efficacy' or 'self-efficacy' used to describe efficacy beliefs, for instance: "Teacher efficacy is the extent to which teachers believe they can control, or at least strongly influence, student achievement and motivation" (Utley et al., 2005, p. 82). The term efficacy (beliefs) was predominantly used in studies from the USA.

All studies in this category conveyed efficacy as a desirable trait for teachers, but rarely focused on whether it indeed impacts teaching. One exception was a study that found high-level teacher efficacy to correlate with teaching lessons characterized by higher cognitive demand, extended learner explanations, learner-to-learner discourse, and explicit connections between representations, whereas students with lower efficacy levels taught whole-class instruction lessons (Lee et al., 2017).

The interrelatedness of efficacy and practicum experience has been researched, at times with contradictory results. In some studies, practicum was found to develop efficacy (Hunt-Ruiz & Watson, 2015; Rethlefsen & Park, 2011; Swars et al., 2007, 2009), and one explanation for this is that students may not feel sufficiently prepared to teach after their coursework (Colwell & Enderson, 2016). Other studies found decreased efficacy after practicum: "Data revealed that, as science and mathematics teacher education in a methods course progressed, science and mathematics teaching efficacy significantly increased. This effect appeared to decrease slightly by the end of student teaching." (Utley et al., 2005, abstract). Hine (2015) found that practicum confirmed students' initial perceptions of teaching readiness, while other authors found low teaching efficacy from the onset to be a strong predictor of non-development (Ashun & Reinink, 2009; Eddy, 2006).

The contradictory and complex picture makes a synthesis of results difficult to present. The development of efficacy beliefs depends on the design and length of the program, the content and design of the practicum, the individual students, and the quality of collaborations and mentoring support. Brinkmann (2019) found the strongest effect size on efficacy was to implement different teaching strategies, and to help or motivate learners. The collaborative part of lesson study, including collaborative lesson planning, observations, and teaching peers in the methods classroom (Mostofo, 2013, 2014; Mostofo & Zambo, 2016) had a positive impact on self-efficacy. The quality of mentoring (Kang, 2012) or even professional development for lecturers (Livers, 2012) were

found to impact efficacy. A negative effect on teaching efficacy was found among students who experienced external locus of control regarding their teaching (Brown et al., 2012). According to two studies from the USA, the organization of teacher education affected efficacy, where integrated programmes resulted in students having higher perceptions of their preparedness for teaching, compared to one-year post-bachelor programs (van Es et al., 2014) or to an internship program in a school context (Clark, 2004; Clark et al., 2015). Among the above-mentioned studies, some claimed a causal relation between efficacy and other constructs, but the causality had opposing directions in different studies. We, therefore, suggest that efficacy and other variables are interdependent constructs, and question a simplistic causal relation between constructs.

Across the different studies, individual variations between student teachers' self-efficacy were found to be substantial. Still, they all claim that efficacy or efficacy beliefs were important either to have or to develop.

Having a positive attitude

Compared to confidence and efficacy, the attitude or emotions of student teachers were attributed less attention. Elementary pre-service teachers who experienced teaching as "different" from their previous experiences developed "more positive attitudes and beliefs about STEM teaching" (Adams et al., 2014, p. 14), and students came to value an inquiry-based approach to learning as important for their professional development after doing an investigation based on their practicum (da Ponte et al., 2017). However, another study found that practicum reduced students' motivation and willingness to use so-called learner-centered activities (Yazgan-Sag et al., 2016), while views towards teaching urban secondary mathematics depended strongly on the personal relationship with the mentor (Williams, 2007).

Again, studies focus on different aspects in a practicum concerning the development of attitudes, and it is difficult to combine results into a synthesis. Still, regardless of the objective of attitudes and emotions, students were expected to demonstrate a positive attitude.

Summary of affects

Most of the studies in this theme engaged how practicum could provide the means for development of efficacy, beliefs, attitudes, or confidence. Only a few studies instead took beliefs or confidence as a means for developing teaching, such as when students with stronger efficacy beliefs were found to teach lessons with higher cognitive demands (Lee et al., 2017), or when increased confidence enabled students to increase their respect for learners' mathematical thinking (Lin & Acosta-Tello, 2017). Attention to affective developments during practicum seems crucial to the researchers in these studies, and this review indicates that this is better achieved through a knowledgeable, supportive, and collegial practicum environment. We saw attempts to look for causal relations, where some studies proclaimed affective states to be the root of students' success in practicum, while others looked for how practicum changed student teachers' affect. Given these contradictory results, we choose to align with those authors who describe the relationship between knowledge, teaching, and affect as co-development, with several contextual and individual variations during practicum.

Identity and Positioning

In the included studies, the theorization of identities or positionings was often accorded substantial attention, and only a few publications used identity without a theoretical conceptualization (e.g., Moyer & Husman, 2006). Student teachers' identity was treated as either developing or continuously transforming, in line with findings from earlier reviews on mathematics education (Darragh, 2016). In addition, identities were commonly described as involving multiple sub-identities. For example, personal identities were distinguished from normative identities and used to explain why two student teachers from the same teacher education programresponded differently to the external demands placed on them by the university and school contexts (Hodges & Hodge, 2017). Identities were seen as emerging or being negotiated between the student teachers' prior experiences and the available identities in the different contexts.

Two studies engage both identity and positioning. Mosvold and Bjuland (2016) describe how they are connected, where identity is defined as narrative positionings. Walshaw's (2004) instead uses a foucauldian conceptualization of positioning as a process of normalisation in relation to available discourses.

Available identities, according to the included studies, were negotiated in the practicum situations. The formation of identities that reflected a mathematics reform promoted by the university was enabled by coherence between school and university (Bahr et al., 2014). In contrast, Akkoc and Yesildere-Imre (2017) saw how changes in identities occurred when school and university promoted different perceptions of a good mathematics teacher, though Hodges and Hodge (2017) found that the level of change varied between students. In these studies, the identity promoted in university was seen as the desired identity development.

Mathematics teaching identities were continuously transformed, but Walshaw (2004) saw positionings related more strongly to available discourses at the beginning of practicum and described the participation in practicum as a political/ideological transformation:

> "Teaching experience then becomes much more than an issue of content knowledge and technical skills; it is, above all, a source of (micro)political engagement. Developing a sense of the pedagogical grows out of a history of response to local discursive classroom codes and wider educational discourse and practices, all of which interrupt, derail, and elide the best intentions of the pre-service teacher" (Walshaw, 2004, p. 80).

Hence, when students cannot live up to their 'best intentions', not only the local classroom discourses but also historical discourses about mathematics teaching influence their positionings.

Several publications researched the influence of particular aspects in practicum on identity change. Mentor relationships were critical for shaping students' identities as mathematics teachers, where prior experience as learners of mathematics influenced their identities as teachers (Kang, 2012; Williams, 2007), and collaborative work between peers and monitoring teachers during practicum had an impact on identity (Kaasila & Lauriala, 2010). The context and framing of practicum were influential for identity development. One intervention moved mathematics education courses into elementary schools (Moyer & Husman, 2006), and digital tools, such as integration of technology (Goos, 2005) or an online community (Goos & Bennisson, 2008) also influenced student teachers' identity. Williams (2007) concluded that participation in practicum enabled decisions on what identities students wanted to take in the classroom.

Summary of identity and positioning

To sum up, the studies on identity describe a constant identity development and negotiation going on in practicum. The contradictory message is that despite the focus on developments from practicum, the desired identity formation should be in line with the identities promoted in university-based teacher education, rather than identities promoted in schools.

Conceptions about Mathematics, Mathematics Learners, and Mathematics Teaching

We use conceptions to include a broad range of views, beliefs, attitudes, or perceptions related specifically to mathematics. As a result, this is a broad theme with 50 publications. Bahr et al. (2013) worked with beliefs items grouped into three categories: beliefs about mathematics, conceptions about learning or knowing mathematics, and beliefs about learners' learning and doing mathematics, and we follow a similar grouping, where we begin by addressing the studies about conceptions of mathematics, followed by conceptions of mathematics learners, and finally conceptions of teaching mathematics.

Conceptions of mathematics: Becoming a mathematics lover

We found nine publications that engaged students' conceptions of mathematics, and these were only able to trace a small influence from practicum.

Intervention studies reported positive but limited developments. Problem-solving was perceived to be a more central component of mathematics teaching after student teachers had done practicum (Pratt & Woods, 2007), and Dunn (2004) found that longer field experience as part of a methods course resulted in more conceptually focused mathematics for at-risk learners. Positive conceptions of mathematics developed from experiencing how mathematics can be realistically used outside the classroom (Adams et al., 2014), conceiving of mathematics as an interrelated web (Bahr et al., 2013), and about reasoning, but with limited changes in teaching (Grueber & Ozgun-Koca, 2013).

Among studies on existing practices, only one reported that the duration of early practicum was negatively related to a math-as-inquiry conception (Jacobson, 2017). Most studies found that practicum experiences accounted for a minor part of the variation in attitudes towardmathematics (e.g., Fusco, 2011, Jong, 2009; Jong & Hodges, 2015). Fusco (2011) even found that the number of high school- and mathematics courses attended were the most potent influence on students' mathematics beliefs. Grootenboer (2006) identified a 'wash-out' effect of practicum on students' attitudes to mathematics, where the attitudes of New Zeeland students who had done their practicum in primary school did not change much, while the students who did their practicum in intermediate schools developed more negative attitudes. This difference was attributed to the students' experience in the intermediate mathematics classes:

> "… the mathematics was described as content focused, routine, worksheet or textbook-based, individualistic, and lacking in variety. Most of the reports were of streamed classes (ability grouped) which followed a "pre-test, teaching, post-test" unit pattern, and an: explanation, examples, worksheet or textbook" routine for the lessons …" (Grootenboer, 2006, p. 25).

Thus, students who described the mathematics teaching they encountered as routine work did either not change or developed a more negative conception of mathematics. Fusco (2011) found that earlier completed college courses in mathematics, not practicum, was most influential.

Summing up, practicum had a limited impact on conceptions of mathematics. However, the desired change was for more positive conceptions of mathematics as problem-solving, inquiry, and reasoning, in line with what is often referred to as reform mathematics.

Conceptions of mathematics teaching: Becoming a reform-based teacher

Studies on conceptions of mathematics teaching mainly concerned student teachers developing conceptions of teaching in line with so-called reform mathematics or connecting theory and practice. The difficulty in changing students' conceptions of mathematics teaching was found repeatedly, but apart from Fusco (2011), who saw a negative impact from practicum, all publications reported that practicum, coursework, or particular interventions provided opportunities for students to change at least aspects of their conceptions of mathematics teaching in the direction desired by researchers.

In the included studies, learner-centered, explorative, problem-solving, and/or conceptual mathematics teaching was desired. Bahr (2013) found that practicum had a substantive impact, and 12 weeks of full-time student teaching led to four Zimbabwean students showing "many changes in conceptions on teaching mathematics … from subject-centred to student-centered approaches" (Nyaumwe, 2004, p. 23). In contrast, several publications claimed that university coursework was more important (Borgen, 2006; Jong, 2009; Lloyd, 2009; Stein, 2008). All studies emphasised that changing conceptions of teaching required time and effort.

We found a multitude of aspects that explained changes in conceptions of teaching. The first aspect concerns paying attention to learners, which requires time and attention in practicum, and we present a few examples. The relevance of teaching conceptual knowledge and connecting with learners' existing knowledge was improved by a three-step process of seeing teaching modeled, rehearsing with peers, and then practicum (Lai et al., 2015). An observed move from focusing on mathematics and individual learners to focusing on the whole class and institutional goals took place during a one-semester practicum (Bieda et al., 2015). And a particular assignment asking learners to reflect on their 'Aha-moments' led students to a greater awareness of the importance of knowing their learners and anticipating their "misconceptions" (Caniglia et al., 2017). Turkish students' belief that student-centered teaching is more challenging than teacher-centered teaching remained after practicum, even though their conceptions of effective teaching became more complex (Ozgun-Koca & Sen, 2006).

A second aspect was problem-solving teaching and related approaches such as questioning or word problems. These aspects increased from different interventions, for example participating in a community of practice (Pratt & Woods, 2007), the professional development of mentors (Livers, 2012), or teaching via videoconference (Plonczak, 2010).

A third aspect was the conceptions of technology in teaching, mainly as a way to foster conceptual understanding or use representations to support learners' sense-making. For instance, students learned that "the accuracy of the figures and graphs generated with technology facilitated pupils' conjecturing, analyzing, and deducing." (Juersivich et al., 2009, p. 18). Workshops and coursework together with practicum changed beliefs about using technology in mathematics teaching (Kartal & Cinar, 2018), and practicum strengthened a positive attitude towards technologies in teaching (Meagher et al., 2011).

Across these aspects, integrating theory and practice in practicum was assumed to foster coherence, for example between courses and mentors (Bahr et al., 2014; Hodges & Hodge, 2017). However, several studies reported difficulties achieving this coherence. A Turkish study found that students' perceptions of a good teacher were unstable and sensitive to incompatible messages from the school and university contexts (Akkoc & Yesildere-Imre, 2017; Akkoc et al., 2016), and Nolan (2012) reported on how hard it was for students to challenge the school orthodoxy during practicum. Still, several studies proposed initiatives to strengthen links between theory and practice. An ePortfolio was found to support the linking of theory to practicum experiences (Hartmann & Calandra, 2007). Five publications described students' participation in collegial learning communities or lesson study with mentors and lecturers (Campbell, 2012; Cavanagh & Garvey, 2012; Gurl, 2011; Rasmussen, 2016; Savard et al., 2017). Combining lesson study and a learning community, and using additional materials resulted in "an equity-oriented practice that provided more [learners] opportunities to participate and learning mathematics" and changed students' conceptions of "learning mathematics as something cannot be given to [learners] from the teacher" (Campbell, 2012, p. 245-246). Apart from Savard et al. (2017), who found student teachers struggling to transform their teaching, the lesson-study initiatives proved fruitful for integrating theory and practice, and for developing informed teaching practice.

Looking across these studies, interventions such as mentor professional development, or connecting practice to courses or lesson studies, were generally successful, as was better coherence between the university and school messaging. Success was attributed to the development of a reform-oriented conception of mathematics teaching, including learner-centered approaches, problem-solving, inquiry, or paying attention to learners' mathematical thinking. However, all publications acknowledged the vast individual differences and the challenges both in changing conceptions of teaching and in observing the change take place.

Conceptions of mathematics learners: Becoming aware of diversity

The encounter with mathematics learners is obviously what sets the school context apart from the university experience, and an important part of the practicum is learning from interactions with learners. Particular attention was given in the research to students engaging with learner diversity, whether it concerned the "gifted" (Chamberlin & Chamberlin, 2010), or whether it involved avoiding deficit thinking about a diverse student population (Garza & Harter, 2016). Spending practicum in special needs classrooms changed students' attitudes and efficacy toward teaching learners with disability (Burton & Pace, 2009). One study homed in on the experience of dissonance as important in changing students' beliefs (Caniglia et al., 2017). For instance, students were surprised that some learners dislike mathematics, and they only realised the importance of knowing their learners as individuals when they experienced this dissonance with their own beliefs. In addition, attention to learner thinking (Baker, 2017), or awareness about attending to learners' conceptions and choosing task situations with an appropriate cognitive demand (Suh & Fulginti, 2012), increased during practicum. The encounter with mathematics learners during practicum broadens the awareness of diversity among mathematics learners.

Summary of conceptions

Practicum had limited impact on conceptions of mathematics, but interventions did successfully change conceptions of mathematics teaching, although individual differences are found. Also, practicum did influence a broader conception of the diversity among mathematics learners. Student teachers are expected to embrace a positive conception of mathematics. They are expected to both be able to enact and appreciate reform-based teaching and become aware of diversity among learners.

DISCUSSION

Synthesising and generalising results from international research presents several challenges. The first challenge is the contextually different ways of organizing practicum and teacher education. The contexts of the different studies were not always well described, as the length of practicum or the school level, which also put-up obstacles for comparing results across different studies. Also, the methodological approaches in the included studies varied greatly, as did the different definitions and framings of central constructs such as affect and identity.

Nevertheless, certain contours of shared patterns of who the student teacher becomes, and what they are expected to become, can be summarized across the studies. The first pattern of who the student teacher becomes concerns the intricate relation between enacted teaching and the individual affect, identity, and conceptions of mathematics. Some studies found how changes in conceptions or affects lead to no visible changes in teaching practices, others found a range of observed changes in teaching. Changes in teaching were both found to influence affect, or to be influenced by affect, or even as an inter-related development between teaching experiences and affect, identities, and conceptions about mathematics.

A second pattern is perhaps better referred to as a non-result; most publications agreed that the development of affect, identities or conceptions is a slow, uncertain, and individually diverse process. Research on practicum-as-usual shows minor development of self-efficacy and conceptualizations of mathematics, and sometimes even a negative development of conceptions of reform-oriented mathematics teaching. Many studies concluded the individual differences were substantial, and with students' pre-conceptions sometimes more influential than practicum itself on self-efficacy.

From this systematic review, we must conclude that the empiric results are weak or contradictory and does not support any strong claims of causality between identity or affect and learning to teach. Methodologically, we saw how the problematic conceptualizations raised in the introduction, where beliefs or identities were both inferred from observation of their activities as well as explained as the basis of these same activities (Darragh, 2016; Lerman et al., 2009) were also found in the included publications. We remind of the risk of a confirmation-bias raised by Lutovac and Kaasilia (2019), where the identity (or affect or conception) promoted by the researcher constitutes both the means and the goal for change. However, this is not only a conceptual or methodological problem but most likely also reflects how these constructs and learning to teach are co-determinant. We argue that a simplistic cause-effect-relation provides insufficient explanatory power. Instead, an interdependency between several factors can better explain the contradictory results we saw, as many of the included studies did.

For practicum in teacher education, some interesting conclusions can be drawn from this review. Particularly the well-designed intervention studies serve as an inspiration for designing practicum. Still, we must conclude that empiric results do not provide strong evidence for a general emphasis on self-development as an objective for practicum, an issue that has been problematized in earlier research (Juersivich et al., 2009; Rusznyak & Bertram, 2021; Smith, 2001). To problematize the present emphasis on student teachers' self-development during practicum we return to the question of who the teacher needs to be or become, and about this, what expectations teacher education can pose on the inner self of the students.

The norms or expectations for what the teachers need to become were prevalent in many studies, where some took a fidelity implementation approach. The message conveyed by the different articles, across contexts, is that a student teacher is expected to align with reform mathematics and be increasingly aware of how to attend to the diversity among learners, but also be or become positive, efficient, confident, and constantly developing his/her identity. We call for teacher education research and practice reflect on the purposefulness of the strong focus on self-development.

Author contributions: All authors have sufficiently contributed to the study and agreed with the results and conclusions.

Funding: This article is part of the TRACE project, founded by the Swedish National Research Foundation (Vetenskapsrådet), under project/grant number [017-03614].

Ethics approval statement: The authors state that no ethics approval was needed for this article since the data collection consisted of already published articles and dissertations. They were treated in accordance with the general ethical principles for quality in research.

Declaration of interest: No conflict of interest is declared by authors.

Data sharing statement: Data supporting the findings and conclusions are available in **Appendix 1**.

REFERENCES

Adams, A. E., Miller, B. G., Saul, M., & Pegg, J. (2014). Supporting elementary pre-service teachers to teach STEM through place-based teaching and learning experiences. *Electronic Journal of Science Education, 18*(5), 1-22.

Akkoc, H., & Yesildere-Imre, S. (2017). Becoming a mathematics teacher: The role of professional identity. *International Journal of Progressive Education*, *13*(2), 48-59.

Akkoc, H., Balkanlioglu, M. A., & Yesildere-Imre, S. (2016). Exploring preservice mathematics teachers' perception of the mathematics teacher through communities of practice. *Mathematics Teacher Education and Development, 18*(1), 7-51.

Ashun, M. A., & Reinink, J. (2009). Trickle down mathematics: Adult pre-service elementary teachers gain confidence in mathematics-Enough to pass it along? *Adults Learning Mathematics, 4*(1), 32-40.

Bahr, D. L. (2013). It takes a village: Investigating the critical role clinical faculty play in mathematics teacher education. *Teacher Development*, *17*(4), 518-537. https://doi.org/10.1080/13664530.2013.838601

Bahr, D. L., Monroe, E. E., & Eggett, D. (2014). Structural and conceptual interweaving of mathematics methods coursework and field practica. *Journal of Mathematics Teacher Education, 17*(3), 271-297. https://doi.org/10.1007/s10857-013-9258-z

Bahr, D. L., Monroe, E. E., & Shaha, S. H. (2013). Examining preservice teacher belief changes in the context of coordinated mathematics methods coursework and classroom experiences. *School Science and Mathematics, 113*(3), 144-155. https://doi.org/10.1111/ssm.12010

Baker, K. (2017). *Characterizing and facilitating prospective teachers' engagement with student thinking about fractions* [Doctoral dissertation, The University of North Carolina at Chapel Hill]. https://doi.org/10.17615/xvhk-1d13

Bandura, A. (1997). *Self-efficacy: The exercise of control.* W. H. Freeman and Company.

Bieda, K. N., Sela, H., & Chazan, D. (2015). "You are learning well my dear": Shifts in novice teachers' talk about teaching during their internship. *Journal of Teacher Education, 66*(2), 150-169. https://doi.org/10.1177/0022487114560645

Borgen, K. L. (2006). *From mathematics learner to mathematics teacher: Preservice teachers' growth of understanding of teaching and learning mathematics* [Doctoral dissertation, The University of British Columbia].

Boz, Y. (2008). Turkish student teachers' concerns about teaching. *European Journal of Teacher Education*, *31*(4), 367-377. https://doi.org/10.1080/02619760802420693

Brinkmann, J. L. (2019). Making a difference: Increasing elementary pre-service teachers' self-efficacy in mathematics. *Educational Planning, 26*(1), 7-21.

Brown, A., Westenskow, A., & Moyer-Packenham, P. (2012). Teaching anxieties revealed: Pre-service elementary teachers' reflections on their mathematics teaching experiences. *Teaching Education*, *23*(4), 365-385. https://doi.org/10.1080/10476210.2012.727794

Burton, D., & Pace, D. (2009). Preparing pre-service teachers to teach mathematics in inclusive classrooms: A three-year case study. *School Science and Mathematics, 109*(2), 108-115. https://doi.org/10.1111/j.1949-8594.2009.tb17943.x

Campbell, S. S. (2012). *Taking them into the field: Mathematics teacher candidate learning about equity-oriented teaching practices in a mediated field experience* [Doctoral dissertation, University of Washington].

Caniglia, J. C., Borgerding, L., & Courtney, S. (2017). AHA moments of science and mathematics pre-service teachers. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, *90*(2), 53-59. https://doi.org/10.1080/00098655.2016.1256745

Cavanagh, M. S., & Garvey, T. (2012). A professional experience learning community for pre-service secondary mathematics teachers. *Australian Journal of Teacher Education, 37*(12), 57-75. https://doi.org/10.14221/ajte.2012v37n12.4

Chamberlin, M. T., & Chamberlin, S. A. (2010). Enhancing preservice teacher development: Field experiences with gifted students. *Journal for the Education of the Gifted, 33*(3), 381-416. https://doi.org/10.1177/016235321003300305

Christiansen, I. M., Österling, L. & Skog, K. (2019). Images of the desired teacher in practicum observation protocols. *Research Papers in Education, 36*(4), 439-460. https://doi.org/10.1080/02671522.2019.1678064

Clark, J. A. (2004). *The impact of a mathematics performance-based assessment on elementary preservice teacher development* [Doctoral dissertation, University of Colorado at Denver].

Clark, S. K., Byrnes, D., & Sudweeks, R. R. (2015). A comparative examination of student teacher and intern perceptions of teaching ability at the preservice and inservice stages. *Journal of Teacher Education*, *66*(2), 170-183. https://doi.org/10.1177/0022487114561659

da Ponte, J. P., Santos, L., Oliveira, H., & Henriques, A. (2017). Research on teaching practice in a Portuguese initial secondary mathematics teacher education program. *ZDM*, *49*(2), 291-303. https://doi.org/10.1007/s11858-017-0847-7

Darragh, L. (2016). Identity research in mathematics education. *Educational Studies in Mathematics, 93*(1), 19-33. https://doi.org/10.1007/s10649-016-9696-5

Dunn, T. K. (2004). Enhancing mathematics teaching for at-risk students: Influences of a teaching experience in alternative high school. *Journal of Instructional Psychology*, *31*(1), 46-52.

Ebbelind, A. (2020). *Becoming recognised as mathematically proficient: The role of a primary school teacher education programme* [Doctoral dissertation, Linneus University].

Eddy, C. M. (2006). *The affects of a middle grades teacher education program on preservice teachers choice of teaching strategies and mathematical understanding* [Doctoral dissertation, Baylor University].

Fusco, L. K. (2011). *A mixed methods study of how the transition process impacts the autonomy of pre-service secondary mathematics teachers* [Doctoral dissertation, The University of Nebraska].

Garza, R., & Harter, R. A. (2016). Perspectives from pre-service mathematics and science teachers in an urban residency program: Characteristics of effective mentors. *Education and Urban Society, 48*(4), 403-420. https://doi.org/10.1177/0013124514533989

Gawlitza, G., & Perels, F. (2014). Changes in convictions and attitudes to the teaching profession and classroom management due to practical teaching experience. *Educational Research and Reviews*, *9*(16), 535-541. https://doi.org/10.5897/ERR2013.1697

Goos, M. (2005). A sociocultural analysis of the development of pre-service and beginning teachers' pedagogical identities as users of technology. *Journal of Mathematics Teacher Education*, *8*(1), 35-59. https://doi.org/10.1007/s10857-005-0457-0

Goos, M. E., & Bennison, A. (2008). Developing a communal identity as beginning teachers of mathematics: Emergence of an online community of practice. *Journal of Mathematics Teacher Education, 11*(1), 41-60. https://doi.org/10.1007/s10857-005-0457-0

Graven, M., & Heyd-Metzuyanim, E. (2019). Mathematics identity research: The state of the art and future directions. *ZDM, 51*(3), 361-377. https://doi.org/10.1007/s10857-005-0457-0

Grootenboer, P. (2006). The impact of the school-based practicum on pre-service teachers' affective development in mathematics. *Mathematics Teacher Education and Development*, *7*(1), 18-32.

Grueber, D., & Ozgun-Koca, S. A. (2013). Developing prospective teachers' knowledge to foster and inspire reasoning in STEM. *Teacher Education and Practice, 26*(2), 181-199.

Gujarati, J. (2019). Reflecting on action: Implications from the child mathematics inquiry portfolio. *Journal of Mathematics Education at Teachers College*, *10*(1), 1-10. https://doi.org/10.1007/978-3-030-00491-0_1

Gurl, T. (2011). A model for incorporating lesson study into the student teaching placement: What worked and what did not? *Educational Studies*, *37*(5), 523-528. https://doi.org/10.1080/03055698.2010.539777

Handal, B. (2003). Teachers' mathematical beliefs: A review. *The Mathematics Educator, 13*(2), 47-57.

Hannula, M. S. (2011). The structure and dynamics of affect in mathematical thinking and learning. In M. Pytlak, T. Rowland, & E. Swoboda (Eds*.), Proceedings of the 7th Congress of the European Society for Research in Mathematics Education* (pp. 34-60).

Hannula, M. S. (2016). Introduction. In G. A. Goldin, M. Hannula, E. Heyd-Metzuyanim, A. Jansen, R. Kaasila, S. Lutovac, P. Di Martino, F. Morselli, J. A. Middleton, M. Pantziara, & Q. Zhang (Eds.), *Attitudes, beliefs, motivation and identity in mathematics education: An overview of the field and future directions.* Springer. https://doi.org/10.1007/978-3-319-32811-9

Hartmann, C., & Calandra, B. (2007). Diffusion and reinvention of ePortfolio design practices as a catalyst for teacher learning. *Technology, Pedagogy and Education*, *16*(1), 77-93. https://doi.org/10.1080/14759390601168080

Hine, G. S. (2015). Self-perceptions of pre-service mathematics teachers completing a graduate diploma of secondary education. *Issues in Educational Research*, *25*(4), 480-500.

Hine, G. S., & Thai, T. (2019). Pre-service mathematics teachers' self-perceptions of readiness to teach secondary school mathematics. *Mathematics Teacher Education and Development, 21*(2), 64-86.

Hodges, T. E., & Hodge, L. L. (2017). Unpacking personal identities for teaching mathematics within the context of prospective teacher education. *Journal of Mathematics Teacher Education, 20*(2), 101-118. https://doi.org/10.1007/s10857-015-9339-2

Hunt-Ruiz, H., & Watson, S. B. (2015). The effect of early fieldwork on mathematics efficacy beliefs for pre-service teachers. *SRATE Journal, 24*(2), 59-66.

Jacobson, E. D. (2017). Field experience and prospective teachers' mathematical knowledge and beliefs. *Journal for Research in Mathematics Education*, *48*(2), 148-190. https://doi.org/10.5951/jresematheduc.48.2.0148

Jong, C. (2009). *Linking teacher learning to pupil learning: A longitudinal investigation of how experiences shape teaching practices in mathematics* [Doctoral dissertation, Boston College].

Jong, C., & Hodges, T. E. (2015). Assessing attitudes toward mathematics across teacher education contexts. *Journal of Mathematics Teacher Education*, *18*(5), 407-425. https://doi.org/10.1007/s10857-015-9319-6

Juersivich, N., Garofalo, J., & Fraser, V. (2009). Student teachers' use of technology-generated representations: Exemplars and rationales. *Journal of Technology and Teacher Education, 17*(2), 149-173.

Jurdak, M., Vithal, R., de Freitas, E., Gates, P., & Kollosche, D. (2016). Survey on the State-of-the Art. In I. M. Jurdak, R. Vithal, E. de Freitas, P. Gates, & D. Kollosche (Eds.), *Social and political dimensions of mathematics education* (pp. 5-27). Springer International Publishing. https://doi.org/10.1007/978-3-319-29655-5_2

Kaasila, R., & Lauriala, A. (2010). Towards a collaborative, interactionist model of teacher change. *Teaching and Teacher Education, 26*(4), 854-862. https://doi.org/10.1016/j.tate.2009.10.023

Kang, H. J. (2012). *Identity development of preservice elementary teachers of mathematics from teacher education program to student teaching* [Doctoral dissertation, Arizona State University].

Kartal, B., & Cinar, C. (2018). Examining pre-service mathematics teachers' beliefs of tpack during a method course and field experience. *Malaysian Online Journal of Educational Technology*, *6*(3), 11-37. https://doi.org/10.17220/mojet.2018.03.001

Lai, M. Y., Auhl, G., & Hastings, W. (2015). Improving pre-service teachers' understanding of complexity of mathematics instructional practice through deliberate practice: A case study on "study of teaching". *International Journal for Mathematics Teaching and Learning*, 1-25. http://www.cimt.plymouth.ac.uk/journal/munyee.pdf

Lee, C. W., Walkowiak, T. A., & Nietfeld, J. L. (2017). Characterization of mathematics instructional practises for prospective elementary teachers with varying levels of self-efficacy in classroom management and mathematics teaching. *Mathematics Education Research Journal, 29*(1), 45-72. https://doi.org/10.1007/s13394-016-0185-z

Lerman, S., Amato, S. A., Bednarz, N., David, M. M. M. S., Durand-Guerrier, V., Gadanis, G., Huckstep, P., Moreira, P. C., Morselli, F., Movshovitz-Hadar, N., Namukasa, I., Proulx, J., Rowland, T., Thwaites, A., & Winsløw, C. (2009). Studying student teachers' voices and their beliefs and attitudes. In R. Even, & D. L. Ball (Eds.), *The professional education and development of teachers of mathematics* (pp. 73-82). Springer. https://doi.org/10.1007/978-0-387-09601-8_8

Lin, P. J., & Acosta-Tello, E. (2017). A practicum mentoring model for supporting prospective elementary teachers in learning to teach mathematics. *ZDM*, *49*(2), 223-236. https://doi.org/10.1007/s11858-016-0829-1

Livers, S. D. (2012). *Coaching the coaches: Supporting university supervisors in the supervision of elementary mathematics instruction* [Doctoral dissertation, University of Louisville].

Lloyd, M. E. R. (2009). *Transformation and transfer of novice mathematics teachers' practices and conceptions of teaching and learning: An examination of preservice and inservice classroom settings* [Doctoral dissertation, University of Virginia].

Lutovac, S., & Kaasila, R. (2018). Future directions in research on mathematics-related teacher identity. *International Journal of Science and Mathematics Education, 16*(4), 759-776. https://doi.org/10.1007/s10763-017-9796-4

Lutovac, S., & Kaasila, R. (2019). Methodological landscape in research on teacher identity in mathematics education: A review. *ZDM, 51*(3), 505-515. https://doi.org/10.1007/s11858-018-1009-2

Meagher, M., Ozgun-Koca, A., & Edwards, M. T. (2011). Pre-service teachers' experiences with advanced digital technologies: The interplay between technology in a pre-service classroom and in field placements. *Contemporary Issues in Technology and Teacher Education*, *11*(3), 243-270.

Mostofo, J. R. (2013). *Using lesson study with preservice secondary mathematics teachers* [Doctoral dissertation, Arizona State University].

Mostofo, J. R. (2014). The impact of using lesson study with pre-service mathematics teachers. *Journal of Instructional Research*, *3*, 55-63.

Mostofo, J., & Zambo, R. (2016). Improving instruction in the mathematics methods classroom through action research. *Educational Action Research*, *23*(4), 497-513. https://doi.org/10.1016/j.tate.2016.05.005

Mosvold, R., & Bjuland, R. (2016). Positioning in identifying narratives of/about pre-service mathematics teachers in field practice. *Teaching and Teacher Education*, *58*, 90-98. https://doi.org/10.1016/j.tate.2016.05.005

Moyer, P. S., & Husman, J. (2006). Integrating coursework and field placements: The impact on preservice elementary mathematics teachers' connections to teaching. *Teacher Education Quarterly*, *33*(1), 37-56. http://www.jstor.org/stable/23478733

Nolan, K. (2012). Dispositions in the field: Viewing mathematics teacher education through the lens of Bourdieu's social field theory. *Educational Studies in Mathematics*, *80*(1-2), 201-215. https://doi.org/10.1007/s10649-011-9355-9

Nyaumwe, L. (2004). The impact of full-time student teaching on preservice teachers' conceptions of mathematics teaching and learning. *Mathematics Teacher Education and Development*, *6*, 19-32.

Onwuegbuzie, A. J., & Frels, R. (2016). *Seven steps to a comprehensive literature review: A multimodal and cultural approach*. SAGE.

Ozgun-Koca, S. A., & Sen, A. I. (2006). The beliefs and perceptions of pre-service teachers enrolled in a subject-area dominant teacher education program about "effective education". *Teaching and Teacher Education, 22*(7), 946-960. https://doi.org/10.1016/j.tate.2006.04.036

Plonczak, I. (2010). Videoconferencing in math and science preservice elementary teachers' field placements. *Journal of Science Teacher Education*, *21*(2), 241-254. https://doi.org/10.1007/s10972-009-9166-3

Pratt, N., & Woods, P. (2007). Changing PGCE students' mathematical understanding through a community of inquiry into problem solving. *Research in Mathematics Education*, *9*(1), 79-94. https://doi.org/10.1080/14794800008520172

Rasmussen, K. (2016). Lesson study in prospective mathematics teacher education: Didactic and paradidactic technology in the post-lesson reflection. *Journal of Mathematics Teacher Education*, *19*(4), 301-324. https://doi.org/10.1007/s10857-015-9299-6

Rethlefsen, A. L., & Park, H. (2011). A mixed-method study: Assessing the BAR model's impact on preservice teachers' efficacy beliefs. *School Science and Mathematics*, *111*(3), 102-117. https://doi.org/10.1111/j.1949-8594.2010.00067.x

Rusznyak, L., & Bertram, C. (2021). Conceptualising work-integrated learning to support pre-service teachers' pedagogic reasoning. *Journal of Education (University of KwaZulu-Natal), 83*, 34-53. https://doi.org/10.17159/2520-9868/i83a02

Savard, A., Lin, T. W. J., & Lamb, N. (2017). Pre-Service elementary school teachers becoming mathematics teachers: Their participation in an online professional community. *Journal of Education and Learning, 6*(1), 41-53. https://doi.org/10.5539/jel.v6n1p41

Shelton, R., Kerschen, K., & Cooper, S. (2020). The impact of a varied field experience on preservice teachers' perceptions of their personal growth: A summer mathematics academy for early learners. *The Teacher Educator, 55*(1), 28-46. https://doi.org/10.1080/08878730.2019.1618424

Smith, J. D. (2001). Mathematics student teachers' responses to influences and beliefs. *Research in Mathematics Education*, *3*(1), 115-138. https://doi.org/10.1080/14794800008520088

Stein, C. C. (2008). *An exploration of elementary preservice teachers' performance and beliefs when negotiating reform-based mathematics education* [Doctoral dissertation, The University of North Carolina at Greensboro].

Suh, J. M., & Fulginiti, K. (2012). "Situating the learning" of teaching: Implementing lesson study at a professional development school. *School-University Partnerships*, *5*(2), 24-37.

Swars, S. L., Hart, L. C., Smith, S. Z., Smith, M. E., & Tolar, T. (2007). A longitudinal study of elementary pre-service teachers' mathematics beliefs and content knowledge. *School Science and Mathematics*, *107*(8), 325-335. https://doi.org/10.1111/j.1949-8594.2007.tb17797.x

Swars, S. L., Smith, S. Z., Smith, M. E., & Hart, L. C. (2009). A longitudinal study of effects of a developmental teacher preparation program on elementary prospective teachers' mathematics beliefs. *Journal of Mathematics Teacher Education*, *12*(1), 47-66. https://doi.org/10.1007/s10857-008-9092-x

Torgerson, C., Hall, J., & Light, K. (2012). Systematic reviews. In J. Arthur, M. Waring, R. Coe, & L. V. Hedges (Eds.), *Research methods and methodologies in education* (pp. 217-230). SAGE.

Tuohilampi, L., Laine, A., Hannula, M. S., & Varas, L. (2016). A comparative study of Finland and Chile: The culture-dependent significance of the individual and interindividual levels of the mathematics-related affect. *International Journal of Science and Mathematics Education*, *14*(6), 1093–1111. https://doi.org/10.1007/s10763-015-9639-0

Utley, J., Moseley, C., & Bryant, R. (2005). Relationship between science and mathematics teaching efficacy of preservice elementary teachers. *School Science and Mathematics*, *105*(2), 82-87. https://doi.org/10.1111/j.1949-8594.2005.tb18040.x

van Es, E. A., Sandholtz, J. H., & Shea, L. M. (2014). Exploring the influences of a partner-based teacher credential program on candidates' performance outcomes. *Peabody Journal of Education, 89*(4), 482-499. https://doi.org/10.1080/0161956X.2014.938996

Walshaw, M. (2004). Pre-service mathematics teaching in the context of schools: An exploration into the constitution of identity. *Journal of Mathematics Teacher Education, 7*(1), 63-86. https://doi.org/10.1023/B:JMTE.0000009972.30248.9c

Watson, S., & Marschall, G. (2019). How a trainee mathematics teacher develops teacher self-efficacy. *Teacher Development, 23*(4), 469-487. https://doi.org/10.1080/13664530.2019.1633392

Williams, D. L. (2007). *Student teaching in an urban context: Student teachers' views and construction of identities* [Doctoral dissertation, Georgia State University].

Yazgan-Sag, G., Emre-Akdogan, E., & Argun, Z. (2016). Prospective secondary mathematics teachers' reflections on teaching after their first teaching experience. *Acta Didactica Napocensia, 9*(3), 1-10.

APPENDIX 1

Publications Included in the Systematic Review

Adams, A. E., Miller, B. G., Saul, M., & Pegg, J. (2014). Supporting elementary pre-service teachers to teach STEM through place-based teaching and learning experiences. *Electronic Journal of Science Education, 18*(5), 1-22.

Akkoç, H., & Yesildere-Imre, S. (2017). Becoming a mathematics teacher: The role of professional identity. *International Journal of Progressive Education*, *13*(2), 48-59.

Akkoç, H., Balkanlioglu, M.A., & Yesildere-Imre, S. (2016). Exploring preservice mathematics teachers' perception of the mathematics teacher through communities of practice. *Mathematics Teacher Education and Development, 18*(1), 7-51.

Ashun, M. A., & Reinink, J. (2009). Trickle down mathematics: Adult pre-service elementary teachers gain confidence in mathematics-Enough to pass it along? *Adults Learning Mathematics, 4*(1), 32-40.

Bahr, D. L. (2013). It takes a village: Investigating the critical role clinical faculty play in mathematics teacher education. *Teacher Development*, *17*(4), 518-537. https://doi.org/10.1080/13664530.2013.838601

Bahr, D. L., Monroe, E. E., & Eggett, D. (2014). Structural and conceptual interweaving of mathematics methods coursework and field practica. *Journal of Mathematics Teacher Education, 17*(3), 271-297. https://doi.org/10.1007/s10857-013-9258-z

Bahr, D. L., Monroe, E. E., & Shaha, S. H. (2013). Examining preservice teacher belief changes in the context of coordinated mathematics methods coursework and classroom experiences. *School Science and Mathematics, 113*(3), 144-155. https://doi.org/10.1111/ssm.12010

Baker, K. (2017). *Characterizing and facilitating prospective teachers' engagement with student thinking about fractions*. (Publication No. 13420105) [Doctoral Dissertation, The University of North Carolina at Chapel Hill]. ProQuest. https://doi.org/10.17615/xvhk-1d13

Bieda, K. N., Sela, H., & Chazan, D. (2015). "You are learning well my dear": Shifts in novice teachers' talk about teaching during their internship. *Journal of Teacher Education, 66*(2), 150-169. https://doi.org/10.1177/0022487114560645

Bjerke, A. H., & Solomon, Y. (2020). Developing self-efficacy in teaching mathematics: Pre-service teachers' perceptions of the role of subject knowledge. *Scandinavian Journal of Educational Research*, *64*(5), 692-705. https://doi.org/10.1080/00313831.2019.1595720

Borgen, K. L. (2006). *From mathematics learner to mathematics teacher: Preservice teachers' growth of understanding of teaching and learning mathematics*. [Doctoral Dissertation. The University of British Columbia]. ProQuest.

Boz, Y. (2008). Turkish student teachers' concerns about teaching. *European Journal of Teacher Education*, *31*(4), 367-377. https://doi.org/10.1080/02619760802420693

Brinkmann, J. L. (2019). Making a Difference: Increasing elementary pre-service teachers' self-efficacy in mathematics. *Educational Planning, 26*(1), 7-21.

Brown, A., Westenskow, A., & Moyer-Packenham, P. (2012). Teaching anxieties revealed: Pre-service elementary teachers' reflections on their mathematics teaching experiences. *Teaching Education*, *23*(4), 365-385. https://doi.org/10.1080/10476210.2012.727794

Buhagiar, M. A. (2013). Mathematics student teachers' views on tutor feedback during teaching practice. *European Journal of Teacher Education*, *36*(1), 55-67. https://doi.org/10.1080/02619768.2012.678484

Burbank, M.D., Shooter, W., & Groth, C.A. (2014). Considerations for coursework and mentoring in an alternative-route-to-licensure program for STEM teachers. *Teacher Education and Practice, 27*, 248-265.

Burton, D., & Pace, D. (2009). Preparing pre-service teachers to teach mathematics in inclusive classrooms: A three-year case study. *School Science and Mathematics, 109*(2), 108-115. https://doi.org/10.1111/j.1949-8594.2009.tb17943.x

Campbell, S. S. (2012). *Taking them into the field: Mathematics teacher candidate learning about equity-oriented teaching practices in a mediated field experience*. [Doctoral Dissertation. University of Washington]. ProQuest. https://digital.lib.washington.edu/researchworks/handle/1773/20844

Caniglia, J. C., Borgerding, L., & Courtney, S. (2017). AHA moments of science and mathematics pre-service teachers. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, *90*(2), 53-59. https://doi.org/10.1080/00098655.2016.1256745

Cavanagh, M.S., & Garvey, T. (2012). A professional experience learning community for pre-service secondary mathematics teachers. *Australian Journal of Teacher Education, 37*(12), 57-75. https://search.informit.org/doi/10.3316/aeipt.195800

Chamberlin, M. T., & Chamberlin, S. A. (2010). Enhancing preservice teacher development: Field experiences with gifted students. *Journal for the Education of the Gifted, 33*(3), 381-416. https://doi.org/10.1177/016235321003300305

Charalambous, C. Y., Philippou, G. N., & Kyriakides, L. (2008). Tracing the development of preservice teachers' efficacy beliefs in teaching mathematics during fieldwork. *Educational Studies in Mathematics*, *67*(2), 125-142. https://doi.org/10.1007/s10649-007-9084-2

Clark, J. A. (2004). *The impact of a mathematics performance-based assessment on elementary preservice teacher development*. [Doctoral Dissertation, University of Colorado at Denver]. ProQuest. http://digital.auraria.edu/AA00003076/00001

Clark, S. K., Byrnes, D., & Sudweeks, R. R. (2015). A comparative examination of student teacher and intern perceptions of teaching ability at the preservice and inservice stages. *Journal of Teacher Education*, *66*(2), 170-183. https://doi.org/10.1177/0022487114561659

da Ponte, J. P., Santos, L., Oliveira, H., & Henriques, A. (2017). Research on teaching practice in a Portuguese initial secondary mathematics teacher education program. *ZDM*, *49*(2), 291-303. https://doi.org/10.1007/s11858-017-0847-7

Dunn, T. K. (2004). Enhancing mathematics teaching for at-risk students: Influences of a teaching experience in alternative high school. *Journal of Instructional Psychology*, *31*(1), 46-52.

Ebbelind, A. (2020). *Becoming recognised as mathematically proficient: The role of a primary school teacher education programme* [Doctoral dissertation, Linneus University], Linnaeus University Press. DiVA.

Eddy, C. M. (2006). *The affects of a middle grades teacher education program on preservice teachers choice of teaching strategies and mathematical understanding*. [Doctoral Dissertation, Baylor University]. ProQuest.

Elrod, M. J. (2017). *Exploring mathematics teacher education fieldwork experiences through storytelling*. [Doctoral Dissertation, University of South Florida].

Esterly, E. J. (2003). *A multi-method exploration of the mathematics teaching efficacy and epistemological beliefs of elementary preservice and novice teachers. [*Doctoral Dissertation, The Ohio State University] ProQuest.

Fusco, L. K. (2011). *A mixed methods study of how the transition process impacts the autonomy of pre-service secondary mathematics teachers*. [Doctoral Dissertation, The University of Nebraska]. ProQuest.

Garza, R., & Harter, R. A. (2016). Perspectives from pre-service mathematics and science teachers in an urban residency program: Characteristics of effective mentors. *Education and Urban Society, 48*(4), 403-420. https://doi.org/10.1177/0013124514533989

Gawlitza, G., & Perels, F. (2014). Changes in convictions and attitudes to the teaching profession and classroom management due to practical teaching experience. *Educational Research and Reviews*, *9*(16), 535-541. https://doi.org/10.5897/ERR2013.1697

Goos, M. (2005). A sociocultural analysis of the development of pre-service and beginning teachers' pedagogical identities as users of technology. *Journal of Mathematics Teacher Education*, *8*(1), 35-59.

Goos, M. E., & Bennison, A. (2008). Developing a communal identity as beginning teachers of mathematics: Emergence of an online community of practice. *Journal of Mathematics Teacher Education, 11*(1), 41-60. https://doi.org/10.1007/s10857-005-0457-0

Grootenboer, P. (2006). The impact of the school-based practicum on pre-service teachers' affective development in mathematics. *Mathematics Teacher Education and Development*, *7*(1), 18-32.

Grueber, D., & Ozgun-Koca, S. A. (2013). Developing prospective teachers' knowledge to foster and inspire reasoning in STEM. *Teacher Education and Practice, 26*(2), 181-199.

Gujarati, J. (2019). Reflecting on Action: Implications from the Child Mathematics Inquiry Portfolio. *Journal of Mathematics Education at Teachers College*, *10*(1), 1-10.

Gurl, T. (2011). A model for incorporating lesson study into the student teaching placement: What worked and what did not?. *Educational Studies*, *37*(5), 523-528. https://doi.org/10.1080/03055698.2010.539777

Harding, J., Hbaci, I., Loyd, S., & Hamilton, B. (2017). Integrating multicultural children's math books into Kindergarten through sixth-grade classrooms: Preservice teachers' reflections. *The Teacher Educator*, *52*(4), 386-407. https://doi.org/10.1080/08878730.2017.1358784

Hartmann, C., & Calandra, B. (2007). Diffusion and reinvention of ePortfolio design practices as a catalyst for teacher learning. *Technology, Pedagogy and Education*, *16*(1), 77-93. https://doi.org/10.1080/14759390601168080

Hine, G. S. (2015). Self-perceptions of pre-service mathematics teachers completing a Graduate Diploma of Secondary Education. *Issues in Educational Research*, *25*(4), 480-500.

Hine, G., & Thai, T. (2019). Pre-service mathematics teachers' self-perceptions of readiness to teach secondary school mathematics. *Mathematics Teacher Education and Development*, 21(2), 64-86.

Hinton, V., Flores, M., Burton, M., & Curtis, R. (2015). An investigation into pre-service special education teachers' mathematical skills, self-efficacy, and teaching methodology. *Issues in the Undergraduate Mathematics Preparation of School Teachers, 1,* http://www.k-12prep.math.ttu.edu/journal/1.contentknowledge/hinton02/article.pdf

Hodges, T.E., & Hodge, L.L. (2017). Unpacking personal identities for teaching mathematics within the context of prospective teacher education. *Journal of Mathematics Teacher Education. 20*(2), 101-118. https://doi.org/10.1007/s10857-015-9339-2

Hunt-Ruiz, H., & Watson, S.B. (2015). The effect of early fieldwork on mathematics efficacy beliefs for pre-service teachers. *SRATE Journal, 24*(2), 59-66.

Jacobson, E. D. (2017). Field experience and prospective teachers' mathematical knowledge and beliefs. *Journal for Research in Mathematics Education*, *48*(2), 148-190. https://doi.org/10.5951/jresematheduc.48.2.0148

Jong, C. (2009). *Linking teacher learning to pupil learning: A longitudinal investigation of how experiences shape teaching practices in mathematics*. [Doctoral Dissertation. Boston College]. https://dlib.bc.edu/islandora/object/bc-ir:101596/datastream/PDF/view

Jong, C., & Hodges, T. E. (2015). Assessing attitudes toward mathematics across teacher education contexts. *Journal of Mathematics Teacher Education*, *18*(5), 407-425. https://doi.org/10.1007/s10857-015-9319-6

Juersivich, N., Garofalo, J., & Fraser, V. (2009). Student teachers' use of technology-generated representations: Exemplars and rationales. *Journal of Technology and Teacher Education, 17*(2), 149-173.

Kaasila, R., & Lauriala, A. (2010). Towards a collaborative, interactionist model of teacher change. *Teaching and Teacher Education, 26*(4), 854-862. https://doi.org/10.1016/j.tate.2009.10.023

Kang, H.J. (2012). *Identity development of preservice elementary teachers of mathematics from teacher education program to student teaching*. [Doctoral dissertation, Arizona State University]. ProQuest. http://hdl.handle.net/2286/R.I.15147

Kartal, B., & Çinar, C. (2018). Examining pre-service mathematics teachers' beliefs of tpack during a method course and field experience. *Malaysian Online Journal of Educational Technology*, *6*(3), 11-37. https://doi.org/10.17220/mojet.2018.03.001

Lai, M. Y., Auhl, G., & Hastings, W. (2015). Improving pre-service teachers' understanding of complexity of mathematics instructional practice through deliberate practice: A case study on "Study of Teaching". *International Journal for Mathematics Teaching and Learning*. 1-25.

Lee, C. W., Walkowiak, T. A., & Nietfeld, J. L. (2017). Characterization of mathematics instructional practises for prospective elementary teachers with varying levels of self-efficacy in classroom management and mathematics teaching. *Mathematics Education Research Journal, 29*(1), 45-72. https://doi.org/10.1007/s13394-016-0185-z

Lin, P. J., & Acosta-Tello, E. (2017). A practicum mentoring model for supporting prospective elementary teachers in learning to teach mathematics. *ZDM*, *49*(2), 223-236. https://doi.org/10.1007/s11858-016-0829-1

Livers, S. D. (2012). *Coaching the coaches: Supporting university supervisors in the supervision of elementary mathematics instruction*. [Doctoral Dissertation, University of Louisville].

Lloyd, M. E. R. (2009). *Transformation and transfer of novice mathematics teachers' practices and conceptions of teaching and learning: An examination of preservice and inservice classroom settings*. [Doctoral Dissertation, University of Virginia].

Meagher, M., Ozgun-Koca, A., & Edwards, M. T. (2011). Pre-service teachers' experiences with advanced digital technologies: The interplay between technology in a pre-service classroom and in field placements. *Contemporary Issues in Technology and Teacher Education*, *11*(3), 243-270.

Mostofo, J. R. (2013). *Using lesson study with preservice secondary mathematics teachers*. [Doctoral Dissertation, Arizona State University]. ProQuest.

Mostofo, J. (2014). The Impact of using lesson study with pre-service mathematics teachers. *Journal of Instructional Research*, *3*, 55-63.

Mostofo, J., & Zambo, R. (2015). Improving instruction in the mathematics methods classroom through action research. *Educational Action Research*, *23*(4), 497-513. https://doi.org/10.1016/j.tate.2016.05.005

Mosvold, R., & Bjuland, R. (2016). Positioning in identifying narratives of/about pre-service mathematics teachers in field practice. *Teaching and Teacher Education*, *58*, 90-98. https://doi.org/10.1016/j.tate.2016.05.005

Moyer, P. S., & Husman, J. (2006). Integrating coursework and field placements: The impact on preservice elementary mathematics teachers' connections to teaching. *Teacher Education Quarterly*, *33*(1), 37-56. https://www.jstor.org/stable/23478733

Ní Fhloinn, E., Nolan, B. C., Hoehne Candido, G., & Guerrero, S. M. (2018). Pre-service versus in-service mathematics teachers' opinions of mathematics reform in post-primary schools in Ireland. *Irish Educational Studies*, 37(4), 431-452. https://doi.org/10.1080/03323315.2018.1512884

Nolan, K. (2012). Dispositions in the field: Viewing mathematics teacher education through the lens of Bourdieu's social field theory. *Educational Studies in Mathematics*, *80*(1-2), 201-215. https://doi.org/10.1007/s10649-011-9355-9

Nyaumwe, L. (2004). The impact of full-time student teaching on preservice teachers' conceptions of mathematics teaching and learning. *Mathematics Teacher Education and Development*, *6*, 19-32.

Özgün-Koca, S. A., & Şen, A. İ. (2006). The beliefs and perceptions of pre-service teachers enrolled in a subject-area dominant teacher education program about "effective education". *Teaching and Teacher Education, 22*(7), 946-960. https://doi.org/10.1016/j.tate.2006.04.036

Piccolo, D. L., Capraro, M. M., & Capraro, R. M. (2009). Mentoring urban interns: Amalgamation of experiences in the formation of mathematics teachers. *The Teacher Educator*, *45*(1), 37-53. https://doi.org/10.1080/08878730903386823

Piccolo, D. L., Capraro, M. M., & Capraro, R. M. (2010). Student teachers' general and content-specific pedagogical development within a mathematics milieu. *Middle Grades Research Journal*, *5*(4), 169-183.

Plonczak, I. (2010). Videoconferencing in math and science preservice elementary teachers' field placements. *Journal of Science Teacher Education*, *21*(2), 241-254. https://doi.org/10.1007/s10972-009-9166-3

Pratt, N., & Woods, P. (2007). Changing PGCE students' mathematical understanding through a community of inquiry into problem solving. *Research in Mathematics Education*, *9*(1), 79-94. https://doi.org/10.1080/14794800008520172

Rasmussen, K. (2016). Lesson study in prospective mathematics teacher education: Didactic and paradidactic technology in the post-lesson reflection. *Journal of Mathematics Teacher Education*, *19*(4), 301-324. https://doi.org/10.1007/s10857-015-9299-6

Rethlefsen, A. L., & Park, H. (2011). A mixed-method study: Assessing the BAR model's impact on preservice teachers' efficacy beliefs. *School Science and Mathematics*, *111*(3), 102-117.

Şahin, M., & White, A. L. (2015). Teachers' perceptions related to characteristics of a professional environment for teaching. EURASIA *Journal of Mathematics, Science & Technology Education*, *11*(3), 559-575.

Savard, A., Lin, T. W. J., & Lamb, N. (2017). Pre-Service elementary school teachers becoming mathematics teachers: Their participation in an online professional community. Journal of Education and Learning, 6(1), 41-53. http://dx.doi.org/10.5539/jel.v6n1p41

Shelton, R., Kerschen, K., & Cooper, S. (2020). The impact of a varied field experience on preservice teachers' perceptions of their personal growth: A summer mathematics academy for early learners. *The Teacher Educator*, 55(1), 28-46. https://doi.org/10.1080/08878730.2019.1618424

Stein, C.C. (2008). *An exploration of elementary preservice teachers' performance and beliefs when negotiating reform-based mathematics education.* [Doctoral Dissertation, The University of North Carolina at Greensboro].

Suh, J. M., & Fulginiti, K. (2012). "Situating the learning" of teaching: Implementing lesson study at a professional development school. *School-University Partnerships*, *5*(2), 24-37.

Swars, S., Hart, L. C., Smith, S. Z., Smith, M. E., & Tolar, T. (2007). A longitudinal study of elementary pre-service teachers' mathematics beliefs and content knowledge. *School Science and Mathematics*, *107*(8), 325-335.

Swars, S. L., Smith, S. Z., Smith, M. E., & Hart, L. C. (2009). A longitudinal study of effects of a developmental teacher preparation program on elementary prospective teachers' mathematics beliefs. *Journal of Mathematics Teacher Education*, *12*(1), 47-66. https://doi-org.ezp.sub.su.se/10.1007/s10857-008-9092-x

Temur, Ö. D., Dağ, S. A., & Turgut, S. (2017). Some reflections from pre-service elementary teachers' practice teaching on the area of understanding data in the math-teaching course. *International Electronic Journal of Elementary Education, 7*(3), 355-370.

Utley, J., Moseley, C., & Bryant, R. (2005). Relationship between science and mathematics teaching efficacy of preservice elementary teachers. *School Science and Mathematics*, *105*(2), 82-87.

van Es, E. A., Sandholtz, J. H., & Shea, L. M. (2014). Exploring the influences of a partner-based teacher credential program on candidates' performance outcomes. *Peabody Journal of Education, 89*(4), 482-499. https://doi.org/10.1080/0161956X.2014.938996

Walshaw, M. (2004). Pre-service mathematics teaching in the context of schools: An exploration into the constitution of identity. *Journal of Mathematics Teacher Education, 7*(1), 63-86.

Williams, D. L. (2007). *Student teaching in an urban context: Student teachers' views and construction of identities*. [Doctoral Dissertation, Georgia State University].

Yazgan-Sag, G., Emre-Akdogan, E., & Argün, Z. (2016). Prospective Secondary mathematics teachers' reflections on teaching after their first teaching experience. *Acta Didactica Napocensia, 9*(3), 1-10.