Developments in Mathematics Teachers' Efficacy Beliefs

George N. Philippou and Marilena Pantziara

> *Promoting teachers' efficacy beliefs within teacher education programs may have the unintended effects of promoting problematic types of teachers' efficacy confidence, suppression of potentially beneficial teacher doubts, and fostering maladaptive motivation patterns.*
>
> (Wheatley 2005, p. 758)

Abstract Teacher efficacy beliefs refer to beliefs about one's capacity to organize and execute courses of action to accomplish a specific task. After almost 40 years of intensive research on teacher efficacy beliefs, and despite the impressive support of the claim that teacher efficacy beliefs constitute an important influence on teacher behaviour and student achievement, motivation and beliefs, the construct remains under serious criticism. It is not a surprise that after this huge effort of the international educational community, researchers expected more safe theoretical and practical outcomes.

Specifically, researchers contend that rather than being at the verge of maturity, research on teacher efficacy beliefs is still lacking clarity and demands radical reconceptualization. The weaknesses or objections raised recently include:

The definition of the construct. Despite Bandura's demand for specificity of the task of reference, in most studies the actual measure refers to global efficacy, which is ambiguous and hard to prove operationally.

Scale development. There are significant limitations to most of the established scales and a need for distinction between personal and collective teaching efficacy.

The sources of teacher efficacy beliefs. Apart from Bandura's four sources of efficacy beliefs, there are other contextual sources which deserve more attention and analysis.

G.N. Philippou (✉)
Department of Educational Studies, University of Nicosia, Nicosia, Cyprus
e-mail: edphilip@ucy.ac.cy

M. Pantziara
Department of Teachers' In-service Training, Cyprus Pedagogical Institute
University of Nicosia, Nicosia, Cyprus

B. Pepin, B. Roesken-Winter (eds.), *From beliefs to dynamic affect systems in mathematics education*, Advances in Mathematics Education,
DOI 10.1007/978-3-319-06808-4_5

Methodologies. The great majority of studies are quantitative with items mostly limited to global efficacy. Doubs are raised about the utility of numerical confidence levels and the related measures; the need for more qualitative and mixed research designs is underlined.

Complexity and multidimensionality of the construct. There is an urgent need for studies focusing on specific interpretive meaning of the concept and certain dimensions of efficacy in connection with the outcomes of practice.

In the present chapter we discuss and analyse these and other contentions with respect to current research; we draw on recent research, particularly but not only on review papers, in connection with studies that have examined efficacy beliefs with respect to teaching mathematics.

Keywords Teacher • Beliefs • Efficacy • Scales • Sources • Effects

Introduction

The construct "perceived efficacy beliefs" has been under study for almost 40 years. During this period an increasing volume of research has enriched our understanding of the construct and its role in human behavior. Since beliefs have been thought of as lenses through which one looks in interpreting the world (Philipp 2007, p. 258), it seems plausible to expect beliefs in one's efficacy to be a key personal resource in self-development, successful adaptation, and change. Bandura (2006a) asserted that perceived efficacy beliefs affect people's goals and aspirations, how well they motivate themselves, and their perseverance in the face of adversity. However, at the same time various research findings have been faced by other scholars with skepticism (see e.g. Wheatley 2005).

Bandura (1997, p. 3) defined perceived self-efficacy as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments". The construct *teacher efficacy beliefs (*TEBs*)* results from specifying "given attainments" as educational goals; it can be defined as "the teacher's beliefs in his/her capability to organize and execute courses of action required to successfully accomplish a specific teaching task in a particular context" (Tschannen-Moran et al. 1998, p. 233). As self-perception of competence, TEBs do not necessarily reflect an accurate assessment of capabilities (Goddard et al. 2004). The study of TEBs has captured the attention of many researchers, who have studied the meaning of the construct and its relevance to educational practice from a variety of standpoints and in many different contexts and cultures, particularly as a factor in improving teacher education and promoting educational reform (Chan 2008a). Research has demonstrated that TEBs beliefs, have been positively correlated with teaching practices and teacher classroom behaviors and a broad range of positive student outcomes (Betoret 2009; Brown 2005; Nie et al. 2013; Tschannen-Moran and Woolfolk Hoy 2001).

In this chapter we review progress of research on TEBs in two parts. First, we discuss research reported before the end of the past century and the questions

that gradually arose, and next we focus on recent developments, with emphasis in teachers' mathematics efficacy research. In conclusion we propose some ideas for future research.

Early Progress and (Un) Expected Problems

Clarifying the Concept

The construct TEBs is conceptualized as both context and content specific; it differs from the general perception of *confidence* which refers to more generalized conceptions of competence (Bandura et al. 1996). TEBs concern beliefs that vary across contents and teaching tasks, as well as according to the group of students and the environment. Setting the borders of the construct, Bandura (2006b, p. 309) distinguished perceived *self-efficacy* from *self-esteem*, *locus of control*, and *outcome expectancy*. Self-efficacy is a judgment of capability; self-esteem is a judgment of self-worth, and locus of control concerns beliefs about factors influencing an outcome, whether determined by one's actions rather than by forces outside one's control. Outcome expectancies are judgments about the results that are likely to occur from the execution of the task. Bandura conceptualized TEBs as an operative capability, while outcome expectancy refers to the effect of the execution of this teaching. In other words, *efficacy expectancies* refer to perceived ability to execute specific teaching actions, while *outcome expectancies* refer to teachers' beliefs about the effects that specific teaching actions will have on students. A teacher may highly perceive his/her ability to execute a teaching task, but may have doubts about the final outcome. High outcome expectancy reflects the degree to which a teacher or a group of teachers believe that the family background and the wider environment could be controlled.

Three types of TEBs have been identified: *Personal teacher efficacy* refers to an individual trait; *general teacher efficacy* refers to beliefs in the ability of teachers in general to bring about the required learning outcomes (Tschannen-Moran et al. 1998); c*ollective teacher efficacy beliefs* (CTEBs) refer to judgments of teachers in a school that the faculty as a whole is capable to effectively organize and execute teaching actions (Goddard et al. 2004). CTEBs – the resultant of personal efficacies of a group of teachers – reflects the extent to which the group believes in their skills to promote students' learning, via interactive, coordinative, and synergistic dynamics of their transactions (Bandura 2006b). Although the first two types of TEBs were consistently extracted through factor analysis using the scale by Gibson and Dembo (1984), general teaching efficacy was criticized as similar to locus of control and its frequent failure in terms of validity and reliability (Henson 2002; Tschannen-Moran and Woolfolk Hoy 2001). Some researchers have recently suggested that this concept should be abandoned (Tuchman and Isaacs 2011).

A point of agreement among the scholars (Tschannen-Moran et al. 1998; Wheatley 2005; Wyatt 2014) concerns the specificity of TEBs and the consequent

differing levels of TEBs, according to tasks. One's capability to apply instructional methods may differ from one's beliefs about one's ability to keep discipline in the class, or to create a positive climate. Since TEBs are content and task specific, global measures of the concept can hardly help educational practice. Yet, the use of global measures by researchers who claim specificity continues to be one of the biggest anomalies in the field (Wyatt 2014). Specificity, however, comes at the expense of generalizability, so the target is an optimal level of specificity (Tschannen-Moran and Woolfolk Hoy 2001). For instance, scale items asking for "efficacy for teaching" are too global, the same could be argued for items asking for "efficacy for teaching mathematics", but efficacy to teach a certain addition of fractions or to solve a specific quadratic equation may result in diminishing the practical relevance of the findings. Apart from the optimal specificity, a complementary solution would be more use of qualitative or mixed research designs that have the potential to produce insightful findings that can make the study of TEBs of greater use to teacher educators.

Recognized Importance of Teacher Efficacy Beliefs and Unresolved Problems

Bandura (2006a, p. 10) refers to "three main pathways" through which efficacy beliefs play a key role in cognitive development, namely: students' beliefs in their competence to learn, teachers' beliefs in their personal efficacy to promote students' learning, and faculties' collective sense of efficacy. High efficacy teachers are expected to better influence their students' learning, view difficulties as surmountable, and persist in the face of obstacles, while low efficacy teachers are easily convinced of the futility of their effort, tend to be disappointed in the face of difficulties and may give up trying (Bandura 2006a). Indeed, TEBs have been consistently associated with teacher behavior, student attitudes, and student achievement (Tschannen-Moran and Woolfolk Hoy 2007, p. 954) and with factors of interest to teacher educators and reformers, such as teacher retention, commitment and willingness to experiment (Wheatley 2002). Mathematics self-efficacy beliefs were found to be a better predictor of students' performance than students' mathematics anxiety and their conceptions about the usefulness of mathematics (Pajares and Miller 1994). Furthermore, TEBs were found to be linked to pre-service teachers' ability to construct mathematical problems, their mathematical background and their ability to teach problem posing (Philippou et al. 2001).

Inquiry into CTEBs emphasizes that teachers have not only self-referent efficacy perceptions but also beliefs about the conjoint capability of a school faculty (Goddard et al. 2004, p. 4). CTEBs were empirically found to be linked to differences in students' achievement among schools and to differences among schools with regard to teachers' TEBs; the effect of CTEBs was found to be a significant predictor of between schools differences in students' mathematics achievement (Goddard 2002). CTEBs were also found to have stronger effects on student achievement than

student race or socio-economic status, even after controlling for students' prior achievement, race/ethnicity, and gender (Goddard et al. 2004).

The enthusiasm for efficacy research, however, could not hide complaints and uncertainties about the field. Tschannen-Moran et al. (1998) wondered whether research on efficacy beliefs was close to maturity highlighting questions that continued to perplex researchers in the field, such as: Do TEBs constitute a trait that can be captured by a self-report instrument, or they are specific to given contexts? Does the concept need to be refined or expanded to capture more aspects of teachers' self-efficacy? What contributes to the development of positive TEBs, how malleable is a sense of efficacy once it is established, and in what ways do TEBs influence teaching behavior?

Although similar issues have frequently been raised, the end of the confusion continues to be out of sight. Researchers urge for a clearer meaning of the construct, deeper examination of its genesis and development, reconsideration of the measures and methodologies, and more relevance to educational practice (see e.g. Labone 2004). Critics question the assumption of causality from findings of correlational nature, the conclusions drawn on the basis of global measures (Wheatley 2002), and the assumption that high efficacy leads to greater effort and better teaching outcomes. Wheatley (2002) identified several types of TEBs that can obstruct educational reform and analyzed potential benefits of efficacy doubts. A list of these benefits includes *teacher learning and change*, *fostering reflection and productive collaboration, and supporting motivation to learn*. Overconfident teachers are satisfied from current practices and have no reason for critical reflection and change, running the danger of falling into stagnation. On the contrary, a dose of uncertainty may motivate reexamination of old practices and lead to a state of disequilibrium that constitutes the basis for new knowledge, in an era of reformed curricula moving towards meaning-centered education.

To bring research on efficacy to maturity, Labone (2004) asked for diverse research methodologies and more focus on the interpretivists and the critical theorists, which had been somewhat neglected as well as for a theoretical grounding for the study of the development of TEBs, and for broadening the construct to explore dimensions that facilitate educational reform. On the theoretical side, the multiple meanings of teacher efficacy make it problematic for teacher educators to interpret and use research findings; on the practical level, Wheatley (2005, p. 747) could not "identify any tools from teacher efficacy research that can be consistently useful to teacher education". In addition, Wheatley (2005) warned that efforts to increase TEBs can back fire, because teachers' confidence in their capability may produce more bad outcomes than positive, especially in the context of teacher education.

Progress in the field during the present century has so far failed to silence complaints about global measures, rare use of qualitative and mixed research designs. These designs, including the use of interviews and classroom observations may produce insightful findings useful to teacher educators. For instance, Klassen et al. (2011) refer to unfulfilled promises despite some signs of progress; they found that only 8.7 % of the reviewed studies were qualitative. Wyatt (2014) highlighted

the continuing problematic situation in efficacy research right in his title; his objective was *"re-conceptualization" of* TEBs*, "tackling enduring problems with the quantitative research and moving on"*.

Recent Developments

The Concept and Its Measurement

Operationalizing TEBs relies on consistent measurement of the construct; a process traditionally performed using self-report scales comprised of items that address a range of teaching tasks and situations. Most scales, however, were widely recognized as global measures, nonaligned with demands for specificity. As Bandura (2006b, p. 307) argued any *"one measure fits all"* approach has limited explanatory and predictive value due to tenuous relevance to the domain of functioning. Substantiating this argument, Klassen et al. (2011) found that almost one half of the 218 studies reviewed used measures incongruent with efficacy theory; they did not assess teachers' capabilities to carry out a course of action. On the same line Goddard et al. (2004) asserted that the broadening of the scope of the construct by adding new areas of teacher functioning at work has led to a need for developing specific scales for tasks in terms of content and domains, e.g. specific teaching skills, relations with peers, and ability to influence the organization.

In recent studies many researchers have used the Teacher Sense of Efficacy Scale (TSES) by Tschannen-Moran and Woolfolk Hoy (2001) – a long and a short version (with 24 and 12 items, respectively). TSES comprise three factors: efficacy for *instructional strategies*, *classroom management*, and *student engagement*. Most TSES items have the stem "To what extent can you…?" and "How much can you do to…?" TSES has been characterized as "superior to previous measures" because it has a unified and stable factor structure and is closely aligned with self-efficacy theory (Klassen et al. 2009). Klassen et al. (2009) have validated the TSES using theory-testing techniques in Canada, Cyprus, Korea, Singapore, and the United States. To this end, six groups of teachers were chosen to enable tests of validity across levels (elementary, middle and secondary schools) and cultural/geographical settings. The study established the importance of the construct across diverse teaching conditions examining measurement invariance of the scale and the relationship between TEBs and job satisfaction. Internal consistency and the three factor model of the TSES were confirmed as well as its reliability and measurement invariance across the five countries. In addition, the study provided evidence that TEBs is a valid construct across culturally diverse settings and also that, TEBs showed a similar relationship with teachers' job satisfaction in five contrasting settings.

Recognizing the predominance of the TSES over other scales, Duffin et al. (2012) examined its factor structure in an attempt to resolve "discrepancies in the interpretation of Bandura's theory in the process of creating TEBs measures, which led to

questioning of the psychometric properties of different measures used" (p. 828). They analyzed the scores of pre-service teachers at their early stage of development to gather evidence of internal structure validity. Two plausible rival models derived from prior research (a single factor and three-factor model) were tested using confirmatory factor analyses. Results showed good fit for both models, while high interfactor correlations indicated strong support for the uni-dimensional model. The findings suggested that pre-service teachers who lack pedagogical knowledge and teaching experience do not differentiate between the different aspects of teaching measured by the TSES.

Extending the three dimensions of the TSES, Chan (2008a) developed a scale focusing on teaching functions in secondary schools in times of education reform. The scale (TSES-18) was designed to assess TEBs in six domains: *teaching high ability learners, classroom management, guidance and counseling, student engagement, teaching to accommodate diversity, and teaching for enriched learning*. The scale and its subscales were found to be valid, internally consistent, and also related positively with an equivalent and convergent measure of TEBs and with a measure of personal accomplishment, while they related negatively- slightly or moderately – with two components of burnout -emotional exhaustion and depersonalization (Chan 2008a, p. 191).

Several approaches to measuring CTEBs have been proposed (Goddard et al. 2004); by taking the average of the measures of individual members in the school about their own personal efficacy; by considering the average on items measuring individual member beliefs about the group's capability, and by asking the members of the group to discuss and collectively respond on the items. Goddard (2002) developed and validated a scale for measuring CTEBs in line with the cyclical model by Tschannen-Moran et al. (1998). This model examines the development of TEBs as the outcome of processing efficacy sources, analyzing the task and assessing personal competence, followed by examining the consequences of actual performance and finally reconsidering the sources in a new cycle. Goddard provided evidence that using the short version (12-item of TSES) could be equally effective as using the long version of the scale (24-item). In an effort to advance awareness about CTEBs Goddard et al. (2004) developed a conceptual model to explain the formation and influence of these beliefs. They argued that the connections between CTEBs and student outcomes partially depend on the reciprocal relationships among teachers' collective efficacy, personal efficacy and their professional practices.

Enochs et al. (2000) developed the Mathematics Teaching Efficacy Belief Instrument (MTEBI). It comprised 21 items in two subscales, measuring Personal Mathematics Teaching Efficacy and Mathematics Teaching Outcome Expectancy, respectively. The scale was subjected to testing for factorial validity and also to confirmatory factor analysis, utilizing the structural equation modeling software EQS. Two indicative items: *Even if I try very hard, I will not teach mathematics as well as I will most subjects (teaching efficacy); the mathematics achievement of some students cannot generally be blamed on their teachers (outcome expectancy).* MTEBI has been widely used in studies focusing on mathematics TEBs (Bates et al. 2011; Evans 2011; Gresham 2008; Tran et al. 2012).

The Genesis and Development of Teacher Efficacy Beliefs

Sources of Efficacy Beliefs

Identifying potential sources which contribute to the genesis and development of TEBs is of major interest for teacher educators in their effort to facilitate teachers' acquisition of positive efficacy beliefs. Bandura (1997) postulated four cognitive sources: *mastery experience, vicarious experience, social persuasion, and physiological and emotional arousal*. Mastery experience refers to one's sense of competence and is empowered by success. However, not all successful experiences reinforce efficacy. Success in trivial tasks does not influence efficacy beliefs. Vicarious experience i.e., observing other's actions, may enhance one's confidence, particularly if the observed person is perceived as having similar qualities to the observer. Social persuasion refers to feedback provided by significant others, i.e., faith in one's capabilities by teachers, parents and superiors. Finally, relaxation and positive emotions relate to self-assurance and the anticipation of future success, leading to higher self-efficacy.

Bandura's sources of TEBs have been studied through different approaches, with respect to their influence on teachers' efficacy, and in connection to other educational parameters, such as the role of TEBs as coping resources against job stressors (Betoret 2009; Brand and Wilkins 2007; Chang 2009). Much of the relevant research (Charalambous et al. 2008; Tschannen-Moran and Woolfolk Hoy 2007) has focused on the weight of each source in the formation of TEBs and also on their effect on TEBs of teachers being at different career stages. All four Bandura's sources were found to contribute to high teacher efficacy, while teacher efficacy was negatively connected to job stressors (Betoret 2009). Usher and Pajares (2006) examined the influence of Bandura's sources on academic self efficacy and efficacy for self regulation. They found that all four sources predicted academic self efficacy with the effect of mastery experience being stronger that the effect of the other three sources.

Brand and Wilkins (2007) examined elementary pre-service teachers' development as effective teachers of science and mathematics, through a relevant methods course. They used naturalistic inquiry to examine TEBs, drawing on participants' experiences of participation in course activities. Analyzing written reflections, at the end of the semester, with regard to factors that influenced teaching capability, the authors reported that all Bandura's sources influenced TEBs, with mastery experiences being the most influential. A relationship was also found between mastery experiences and the other sources, indicating that this source is a function of the other three sources. The conclusion was that vicarious experiences, social persuasion, and stress reduction influence mastery experiences and thus indirectly influence efficacy beliefs.

Additional sources of TEBs have also been investigated. Tschannen-Moran and Woolfolk Hoy (2007) referred to external and internal efficacy sources. External sources relate to the teaching task, including the resources available, students' factors (e.g. ability, motivation), and contextual factors (school principal, colleagues' support, teaching resources). Internal sources concern teachers' judgments about personal

capabilities. Tschannen-Moran and Woolfolk Hoy (2007) examined TEBs sources of 255 novice and experienced elementary, middle and high school teachers. Different contextual variables were found to be related to teachers' TEBs. Teaching resources made a significant independent contribution to explaining variance in novice teachers' TEBs beliefs, whereas the School Level Taught made a significant contribution to explaining the variance in experienced teachers' TEBs, with higher TEBs found among teachers who taught younger students. Verbal persuasion and specifically the support of colleagues and the community made a significant contribution to explaining only novice teachers' TEBs. Mastery experience measured as satisfaction with past professional performance was moderately related to both novice and experienced teachers' efficacy beliefs. Mastery experiences of experienced teachers were related to the support they received in the form of verbal persuasion from administrators, colleagues, parents and the community. Mastery experiences of novice teachers were related to support from parents and the community. Contextual factors and mastery experience explained 49 % of the variance for novice teachers' TEBs compared with 19 % for experienced teachers' TEBs. Mastery experiences were found to make the strongest contribution to TEBs for both samples.

Phelps (2010) examined the sources that pre-service elementary teachers use when they construct TEBs and their learning goals. She used narrative interviews (stories about participants' past experiences and their development as learners of mathematics) with 22 participants with regard to mathematics and its importance, to examine retrospectively factors that they reported as affecting the development of their motivational profiles. Phelps considered self-efficacy as one construct of expectancy theory, and learning goals as one construct of reasons for engagement, jointly providing a "picture of pre-service elementary teachers' motivation to learn mathematics" (p. 294). Results revealed that participants relied on multiple sources to construct their TEBs and goals, including past performance, vicarious experiences, verbal persuasions, career goals, and the fit between their views of mathematics and the nature of mathematics activities, as experienced in their classes.

The Development of Efficacy Beliefs During Teacher Education

Since Bandura (1997) stated that efficacy beliefs are most at play early in learning and, once constructed, become resistant to change, teacher education programs attracted the interest of researchers, as a means to develop efficacy beliefs in pre-service teachers. During teacher education programs pre-service teachers acquire familiarity with the basics of pedagogy and teaching skills, which may help mold TEBs at the time of genesis. Charalambous et al. (2009) examined the effect of a mathematics program on pre-service primary teachers' attitudes, epistemological beliefs, and TEBs. The program comprised two content courses taught successively during the first and the second year of studies. The TSES scale was administered to 91 students before and after each of the courses and semi structured interviews were conducted. The analyses showed mixed changes in students' attitudes and beliefs depending on their background. A positive change in TEBs was observed for the

group with high mathematics ability (as determined by their option to take mathematics in the university entrance exams).

Evans (2011) studied the effect of a mathematics method course on Teaching Fellows in an alternative teacher – recruitment program, with regard to mathematical content knowledge, attitudes toward mathematics and TEBs. He analyzed data collected at the beginning and at the end of the semester, using a mathematics content test, an attitude scale and the MTEBI, as well as participants' reflective journals on their teaching and learning reported during the semester. Findings indicated significant improvements in both mathematical knowledge and attitudes toward mathematics, but no significant increase was found in TEBs (neither for teaching efficacy, nor for expectancy efficacy). Both measures, however, correlated with attitudes and were above the neutral point on a five-point scale.

Field-work provides pre-service teachers with precisely the type of enactive mastery experiences that Bandura suggests as a source of TEBs. Charalambous et al. (2008) investigated pre-service teachers' mathematics PTE beliefs during fieldwork. Exploratory factor analysis of longitudinal data (using TSES at the beginning, middle and end of the field work) resulted in a two-factor model (emerged in all three scale administrations), reflecting TEBs in relation to mathematics instruction and in classroom management. The results indicated that during fieldwork, pre-service teachers' TEBs in mathematics improved but not in uniform ways. The analysis of semi-structured interviews with eight participants, suggested that pre-service teachers' TEBs were mainly informed by enactive mastery experiences, vicarious experiences, and social persuasion (experimentation with teaching, and interaction with mentors, tutors, peers, and pupils).

Chang (2009) used a multi-case study to explore the developmental process in beginning elementary mathematics teachers' efficacy with and without mathematics and science backgrounds. Participants were six teachers, three with and three without mathematics and science background, in both cases one with low, one with medium, and one with high efficacy. Data analyzed included initial and follow up interviews, recordings, observations, and reflection notes. Chang found a cyclical developmental model with five gradations continuous over time. The characteristics of each gradation were identified after being subjected to at least 1 month of continuous observations and also verified through the interview process and participants' reflection notes. Posttest scores revealed that all six participants' efficacy ratings rose during the first year of teaching, while the five-gradation model, showed that beginning mathematics teachers with different levels of efficacy exhibited different characteristics of efficacy development. The qualitative findings showed that during the first year of teaching the two low efficacy teachers reached the first and the second gradations, the two medium-efficacy teachers reached the third gradation, one of the high-efficacy teachers exhibited the characteristics of the fourth gradation and the other one, who possessed a mathematics and science background, even entered the fifth gradation. In conclusion, beginning mathematics teachers who had the same level of TEBs tended to exhibit substantial similarities in their developmental processes, though there were slight differences between two teachers with the same efficacy level and different backgrounds.

Intervention Studies Aimed at Enhancing Teacher Efficacy Beliefs

Tuchman and Isaacs (2011) asserted that "efforts to increase teacher self-efficacy through in-service and other similar interventions have met with mixed success, and no clear pattern can be concluded from prior studies" (p. 415). In this section we summarize two recent intervention studies; the first examined the impact of peer coaching on TEBs and the other the effect of new technologies on TEBs. The studies provide ideas for teacher training programs focusing in developing TEBs.

In the context of communities of practice, peers can influence each other's practices by jointly attempting specific strategies that help participants experience success (a joint mastery experience) (Bruce and Ross 2008). Peers can also influence each other's efficacy through social persuasion, as one observes a peer implementing successful strategies (vicarious experience), and also through enhancing feelings arising from effective teaching or reducing negative feelings arising from negative teaching experiences (physiological and emotional cues) (Bruce and Ross 2008). Peer coaching in relation to mathematics teaching practices and efficacy beliefs are expected to have an impact on student learning. In Bruce and Ross' study four pairs of Grade 3 teachers and two pairs of Grade 6 teachers participated in a professional development program over 6 months. The program focused on three dimensions of mathematics teaching: facilitating student teacher interaction, supporting student construction of mathematical meaning, and selecting effective mathematics tasks. Data included teacher classroom observation (at the beginning and at the end of the program), self assessment, interviews, and field notes that focused on the above three teaching dimensions. The analyses indicated that all pairs successfully implemented the main steps of peer coaching and key strategies for effective mathematics teaching, especially in facilitating student interaction and improving the quality of tasks assigned. As a result they moved toward a more constructivist approach (student directed, manipulative-based, and conceptually-focused learning) and toward facilitating student-student interaction, assigning open- ended student tasks that encourage multiple solutions. The data indicated that participants TEBs improved presumably as a result of a "nexus of sources of efficacy information" (p. 360). By the end of the program, teachers reported feeling more capable of teaching mathematics with an emphasis on conceptual understanding. They attributed this change to several facets of the program recognizing that some of their existing practices were similar to those modeled by presenters (vicarious experience); receiving positive feedback from their peer coaching partners (social and verbal persuasion, physiological, and emotional cues), and by acquiring and applying new instructional strategies in their own classrooms (mastery experiences).

Though the use of technology has long ago been recognized as essential for teaching and learning mathematics (NCTM 2000), we still know little about the use of technological innovations to facilitate mathematics instructions and the impact they have on teachers' efficacy and classroom practices. To explore these issues, Tran et al. (2012) reported the effects of a computer-based teaching tool known as Spatial Temporal Mathematics (ST Math) on teacher efficacy, outcome expectancy, and instructional practice. This program utilizes images to help students develop

spatial–temporal cognition that can improve understanding of mathematical concepts and operations. In an experimental design 339 Grade 2–5 teachers were randomly assigned to a control or treatment group, to examine the effects of ST Math approach on teacher beliefs about mathematics teaching. For the treatment group the program involved a minimum of two 45-min sessions of the ST Math program per week, while the control group experienced the regular mathematics instruction in the same content. Data sources included questionnaires with items asking teachers to describe experiences from the implementation of ST Math in their classrooms, measuring TEBs and teaching outcome expectancy using the scale MTEBI, and their instructional practices as related to mathematics (integration of scientific reasoning in the classroom). After a first year implementation the results indicated that ST Math had a positive impact on student achievement in mathematics. Hierarchical linear modeling showed that students' time on ST Math and the integration of ST Math into daily instruction were positively associated with TEBs, outcome expectance and instructional practices.

Effects of Teacher Efficacy Beliefs

In this section we focus on studies examining the relation of TEBs with and the impact on educational practice, including the provision of ideas for teacher educators to enhance teachers' capability to apply democratic education methods.

Correlation of Teacher Efficacy Beliefs with Other Parameters

Empirical studies have shown that TEBs relate to students' performance and to teachers' behaviors (Betoret 2009; Tschannen-Moran and Woolfolk Hoy 2001; Tran et al. 2012). Bagaka's (2011) examined whether teacher characteristics and practices can enhance secondary school students' mathematics efficacy beliefs. He analyzed self-report data from 3173 secondary school students and their mathematics teachers (193). Using the principal component factor analysis he identified two dimensions of TEBs and practices: *interest and enjoyment of mathematics*, and *ability and competence in teaching mathematics* (p. 823) and five dimensions of students' mathematics self-efficacy: (a) students' lack of interest in and fear of mathematics; (b) students' competence in mathematics; (c) students' mathematics self-confidence and competence; (d) students' interest in, effort in, and perception of the importance of mathematics; and (e) mathematics anxiety. Teachers' frequent use of mathematics homework, their level of interest and enjoyment of mathematics, and their ability and competence in teaching mathematics were found to play a key role in promoting students' mathematics self-efficacy and in narrowing the gender gap in students' confidence and competence in mathematics. The problem with this study concerns alienation with theory. "Interest and enjoyment of mathematics" is considered as a dimension of TEBs, and "lack of interest", and "mathematics anxiety"

as dimensions of students' mathematics efficacy. The concepts of interest and anxiety do not fall under the construct "efficacy".

Tella (2011) examined mathematics teachers' internet self-efficacy and its influence on mathematics instruction. She used self- report data from 90 math teachers and interviews with 15 heads of mathematics, seeking information from the respondents about their internet self-efficacy and on the ways the internet has influenced their teaching of mathematics. The analyses indicated that participants had high internet self-efficacy and that correlations existed between mathematics teachers' age, internet usage and internet self-efficacy. The author concludes that "internet self-efficacy and usage were revealed to improve the way teacher teach mathematics and conduct research" (p. 156). The findings justified increase of internet usage, on the part of mathematics teachers to enhance high internet self-efficacy.

Brown (2005) examined the relationship between early childhood teachers' efficacy beliefs, their beliefs about the importance of early childhood mathematics, and their mathematics instructional practices. She analyzed self- report data from 94 prekindergarten teachers using the TSES scale for TEBs, and the instrument by Kowalski et al. (2001) for beliefs about mathematics, and data from recorded observations of classroom practices of 20 of these teachers. Brown found that high efficacy participants rated the importance of mathematics higher on the belief scale than their lower efficacy colleagues; the findings also confirmed that in assessing their capabilities high efficacy participants rated themselves higher in instructional strategies, classroom management, and student engagement, though they did not rate their efficacy beliefs in doing mathematics as high as their TEBs, meaning that low efficacy in mathematics does not inhibit mathematics TEBs.

Bates et al. (2011) examined pre-service early-childhood teachers' mathematics self-efficacy and mathematics teaching efficacy in connection to their actual mathematical performance. They analyzed self-report data from 89 participants, using a scale measuring mathematics self-efficacy, the MTEBI for mathematics TEBs, and a test of basic mathematics skills. The results indicated that the participants' mathematics self-efficacy was positively correlated with their personal mathematics teaching efficacy, and that their mathematical performance was related to their mathematics self-efficacy and mathematics teaching efficacy. As it was expected, in regard to student outcomes, only those participants with high teaching efficacy were found to believe that they could have an effect on their students.

Teacher Efficacy Beliefs in Reform Efforts

Educational reforms typically impose new demands on the already complex work of teaching, thus aggravating teachers' concerns (Charalambous and Philippou 2010). Instructional innovation typically requires the adoption of newer evidence-based instruction to replace more traditional teaching**.** Student-centered and constructivist teaching has been proposed as a means to enhance students' potential to be active, creative, and reflective self-directed learners in a changing world. In this respect, Nie et al. (2013) examined the connection between TEBs and constructivist instruction analyzing data collected from 2,139 primary teachers, using the TSES and a

scale measuring constructivist instruction. Structural equation modeling showed that positive TEBs predicted constructivist instruction. Although TEBs also predicted didactic instruction, the strength of the prediction was different in terms of the effect size measures (variance explained 39 % for the constructivist against 4.6 % for the didactic instruction), indicating the connection of constructivist views and high TEBs.

In any attempt to introduce educational reforms teachers' concerns about the reform are a crucial variable, as concerns influence teachers' behavior and may obstruct the whole effort. Charalambous and Philippou (2010) examined the connection among elementary mathematics teachers' concerns about the introduction of a new curriculum reform, regarding problem solving, and their TEBs. Data sources included self-report data from 151 elementary teachers' regarding their concerns and efficacy beliefs, 5 years into the mandated curriculum, and qualitative data from 53 teacher logs. The study provided support for a model suggesting that teacher' concerns in preceding stages inform their concerns of succeeding stages, and that TEBs about using the reform affect their task and impact concerns and are in turn, informed by their self-concerns. TEBs about employing pre-reform instructional approaches were found to influence all types of teacher concerns. Data from 53 teacher logs provided additional support to this model.

Gabriele and Joram (2007) explored the sources of efficacy among first- and second-grade teachers by analyzing the events in a lesson they had just taught. Ten teachers participating in a reform-oriented mathematics teacher development project, voluntarily participated in a talk-aloud process regarding the criteria they used to evaluate their teaching effectiveness, after the lesson. The authors compared veterans and newcomers in reform-based mathematics teaching, in terms of their evaluations of the success of the lesson, with regard to events they attended to and used as evidence to support their evaluations of success. The analysis showed that veterans focused more on student thinking and described it in more precise and specific terms, while newcomers tended to talk more about their curricular goals for the lesson. Even in cases they did talk about students' thinking, they described it in less-precise terms. Newcomers, however, more frequently reported positive affective reactions when describing their progress toward achieving instructional goals and outcomes. The authors concluded that involvement in reform-based programs promotes TEBs.

Teacher Efficacy Beliefs and Coping with Stress

Teachers' stressors spring from various sources including students' misbehavior and poor motivation for work, heavy workloads and time pressure, improper relationships with school administration, and pressure from parents (Chan 2008b). In confronting these stressors teachers may develop psychological symptoms of varying severity. The question is why some teachers are less vulnerable than other teachers in the face of similar work stress? What kind of relations between which personal variables interfere as coping resources in the context of the stress–illness or stress–distress

relationship. Chan (2008b) assessed emotional intelligence – the competence in perceiving emotion, facilitating thought, understanding and monitoring emotions- and TEBs to represent personal resources, facilitating active and passive coping, in a sample of prospective and in-service teachers. Intrapersonal and interpersonal emotional intelligence were found to predict active coping strategies, but TEBs did not contribute independently to predicting of active coping, even though for male teachers there was some evidence of interaction with intrapersonal emotional intelligence in the prediction of active coping.

Betoret (2009) examined the relationship between school resources, potential stressors and coping resources, i.e. physical, psychological, social, or material factors which help teachers overcome job related stressors. The results indicated that external (school support resources) and internal (self-efficacy in classroom management and instruction) have a negative and significant effect on potential job stressors, mainly for secondary school teachers. Job stressors were found to have a positive and significant effect on teachers' emotional exhaustion, depersonalization, reduced job satisfaction, and burnout.

Teacher turnover appears to be a worldwide phenomenon with detrimental educational and economic effects. In the USA about one quarter of novice educators leave the profession within 3 years (Martin et al. 2012). Apart from the consequences for the teachers themselves, intent-to-leave can result in decreased school effectiveness. Identifying the variables that contribute to reducing this phenomenon is a prerequisite to creating effective teacher retention and job satisfaction programs. Martin et al. (2012) examined the TEBs about student engagement and instructional management, in relation to job satisfaction and student behavior stressors. Positing that the teacher's approach to instructional management sets the tone for the overall classroom atmosphere and ultimately student behavior stressors, they analyzed data from 631 elementary and middle school teachers using several scales – including the student engagement subscale of the TSES – and inventories measuring teacher burnout, job satisfaction, intent–to leave, and teacher stressor. The analyses fitted models showing a complex relationship between TEBs in student engagement and intent-to-leave (teacher turnover) mediated by variables related to the classroom context, such as TEBs in relation to instructional management, student behavior stressors, aspects of burnout, and job satisfaction.

Pre-service elementary teachers' mathematics anxiety was examined by Gresham (2008) in relationship to mathematics TEBs. Data sources included the MTEBI, the Mathematics Anxiety Rating Scale (Richardson and Suinn 1972) and interviews. Applying Pearson Product–moment Correlation (the two MTEBI subscales were analyzed both as separate subscales and combined) Gresham found a significant, negative correlation between mathematics anxiety and mathematics TEBs. The pre-service teachers with the lowest degree of mathematics anxiety had the highest levels of mathematics teacher efficacy. The interview data indicated that mathematics anxiety is associated with TEBs and with efficacy in mathematics, and that pre-service teachers' attitudes toward mathematics affect their mathematics TEBs.

Teacher Efficacy Beliefs in the School Context

Instead of the social cognitive perspective, Takahashi (2011) considered a sociocultural perspective regarding the development of TEBs, on the argument that teachers' meaning-making in their communities of practice shape their efficacy beliefs (p. 733). Viewing the context as both constituting and constituted by individuals, rather than as something separate, the author focused on "communities of practice" as a framework where learning occurs in shared work activities. In such a framework teachers' practices are characterized by evidence-based decision-making, so the focus of this case study was to look for connections between teachers' evidence-based decision-making practices and their TEBs. In other words, Takahashi examined how teachers engaged in shared practices when co-constructing understandings of their teaching responsibilities, describe the relationship between their experiences of evidence-based decision- making and their individual and collective efficacy beliefs. He analyzed data from semi-structured interviews with four Junior High school teachers, who taught in one of two academic areas, English Language Arts and Mathematics, on three separate occasions, spanning a 3 month period: one interview not connected to any observations, one after a day of classroom observation, and one after observation of a teachers' evidence-based decision-making meeting. All interviewed teachers expressed high efficacy beliefs, as evident in their discussions about students who struggle academically. The analysis indicated that teachers co-constructed their TEBs in shared practices, suggesting the usefulness of communities of practice theory to more fully understand teachers' efficacy. The author concluded that through reflections on their evidence-based decision-making practices, the participants appeared to reify the processes of collectively examining data as tools of instructional improvement, and also about student learning as they reflected on their teaching. These constructions were fundamentally connected to an identification of teachers as responsible for student learning and contributed to the improvement of their TEBs.

Coupling "refers to an organizational and interpersonal structure that serves to link together selected elements of the environment" (Kurz and Knight 2004, p. 114). Research has suggested that schools are viewed as simultaneously loosely and tightly coupled organizations. This means that schools are coupled along a continuum, with different dimensions of the organization varying in their degree of coupling. One such dimension of organizational coupling that has been strongly linked to school effectiveness is goal consensus/vision, which refers to one coupling dimension linked to school effectiveness. Teachers in high consensus schools hold shared goals, beliefs, and values which emphasize teacher and student success (Creemers and Reezigt 1999). Kurz and Knight (2004) explored the relationship between high school teachers' TEBs and CTEBs, and among these two types of teachers' efficacy and their perceptions of goal consensus/vision. Data were collected from 113 teachers of several subjects including mathematics and science, during teacher in-service meetings, using the scales by Gibson and Dembo (1984) and by Goddard (2002). They found that CTEBs were correlated with all of the other variables examined,

and most highly correlated with goal consensus/vision. Individual TEBs were found to be related to CTEBs, but not to goal consensus/vision. These authors realized (p. 125) that this result might be due to shortcomings of the Gibson and Dembo scale; the TSES could have yield different outcomes.

There are multiple ways of considering how learning occurs within any organization, how an organization moves toward change, and the role of collective reflective practice in this movement (Kennedy and Smith 2013). The culture of a school community improves through advancement of individual efficacy and jointly facing difficulties finding collective solutions to challenges. Research has found links between collective efficacy of a school community and students' achievement (Goddard et al. 2000). Kennedy and Smith (2013) studied the role of collective reflective practices that affect sources of teacher efficacy as they occur within the school community. They sought to identify the behaviors within a school organization that affected change by assessing impact on physiological sources of teacher efficacy and specifically to determine if there was a relationship between the reflective practice behavior within a Professional Learning Community model and either internal or external sources of teacher efficacy. Analyzing survey data from 661 teachers from 42 elementary and secondary school as regards the impact of school level organizational behaviors and practices on the individual teacher efficacy, they found a relationship between collaborative organizational culture and physiological efficacy sources. Furthermore, the authors identified efficacy sources that have a positive or negative relationship with organizational behaviors supporting the professional learning community behaviors. Specifically, more collective reflective practice was associated with external input such as administrative observations, student outcome data, and colleague observation, while high involvement in school leadership and vision related to uncomfortable feelings with making comparisons to other teachers or engaging parents.

Conclusions

At the opening of their paper Klassen et al. (2011) questioned whether the field has made progress, or whether early promises remained unfulfilled. In concluding, they referred to some progress in terms of methodological diversity, domain specificity, and a focus on collective efficacy. On the pessimistic note they mentioned insufficient attention paid to sources of teacher efficacy, a dearth of research showing links between teacher efficacy and student outcomes, and lack of conceptual clarity in measuring the construct. Research published after 2009 has resulted in progress but has not overcome the above problems.

In the next paragraphs we summarize the current state of research as regards the foundations and measurement of the construct, the sources and development, and the relevance of TEBs with educational practice. We also provide ideas for further research.

The Construct and It Measurement

In a theory focused review Wyatt (2014) highlighted the continuing misalignment between theory and method with reference to 'conceptually suspect' studies (Klassen et al. 2011). The classical definition of TEBs refers to capability to undertake a specific task, irrespective of the accuracy of reported ability. With emphasis on specificity, the definition might read as "beliefs in capabilities to perform a specific task at a specified level of quality in a specified situation", that is classified as an agent-means definition (Wyatt 2014, p. 166). Considering teachers' interest about the outcome of their effort, any proper definition should retain specificity and include both the agent-means and the agent-end capacity, incorporating both efficacy expectancy and outcome expectancy. Furthermore, it can be argued that Wheatly's (2005) plea for the potential value of efficacy doubt, involves a broader understanding of PTE beliefs, in connection to other beliefs worth exploring in their own right. Doubt and reflection are central to an understanding of how beliefs change. However, any attempt to incorporate all these meanings would result in an omnibus definition making the operational use of the construct too difficult to manage.

As regards efficacy scales, Bandura (2006b, p. 308) advised that efficacy items should accurately reflect the construct which concerns perceived capability. Recent research shows that the demand for clarity in measurement has to some extend being resolved. Scholars have practically recognized that TEBs refer to a teacher or a group of teachers' sense of capability. The TSES scale (Tschannen-Moran and Woolfolk Hoy 2001) has become popular, as an instrument that can be used for teachers in all subjects in all contexts, though it does not embrace all aspects of a wide definition of the construct. Most recent studies on mathematics TEBs have used either an adapted version of the TSES, validated in the specific context, or the MTEBI, which measures mathematics TEBs and caters for both efficacy expectancy and outcome expectancy. The TSES does not provide for outcome expectancy and is limited to three aspects of teachers' work. Important as they are, these three aspects do not cover all aspects of teachers work. Bandura (2006b) refers to six domains of teachers' work: instruction, discipline, influence decision making, enlist parental involvement, enlists community involvement, and creation of positive school climate. The scale by Chan (2008a) measures TEBs in six domains – some of them different from Bandura's. There is a need for further research in this direction.

The importance of CTEBs has been well recognized; yet we know little about how they are formed in school settings and how they are affected by the context, while the question of measuring this concept is still open. The scale by Goddard (2002), designed to assess a faculty "perceptions of group competence and the level of difficulty inherent in the educational task faced by the school" (p. 97), has seldom being used in empirical research. Furthermore, uncertainty prevails as to whether the hypothesized sources of personal TEBs hold true at the group level (Klassen et al. 2011).

The question of specificity in measuring TEBs versus generalizability remains a challenge, while qualitative research is needed to refine patterns of efficacy sources as teachers are observed and interviewed. At the same time further research on teachers' organizational behavior is needed to increase understanding of reflective practice and its relation to teachers' collective efficacy.

The Formation and Development of Teacher Efficacy

Progress with regard to efficacy sources can be acknowledged. Bandura's sources have been examined both quantitatively (Chang 2009) and qualitatively (Usher and Pajares 2009), and efforts to build a stronger measure of the sources of self-efficacy have been reported (Klassen et al. 2011). Some social and contextual sources of TEBs, including the school climate and characteristics of the group of students, have also been examined (Tschannen-Moran and Woolfolk Hoy 2007). More research into the four sources' relative weight in the formation of mathematics TEBs as well as on other external sources will be of interest to teachers' educators.

Research studies (Evans 2011; Charalambous et al. 2009) seem to indicate that one or two courses of pre-service or in-service courses cannot impact mathematics TEBs. On the other hand the effect of field work on mathematics TEBs was found to be quite significant (Charalambous et al. 2008); a relationship between teachers involvement in communities of practice with TEBs (Bruce and Ross 2008) was found, and a positive effect of a computer based teaching tool on TEBs was also found (Tran et al. 2012). Further longitudinal studies focusing on pre-service teachers' mathematics TEBs throughout their educational program would help teacher educators to better understand the developmental process and find means to enhance TEBs. Longitudinal designs could also focus on periods of instability and stability of mathematics TEBs in various stages of teachers' career.

Comparative studies can also illuminate the role of the context in the development of mathematics TEBs and investigate the impact of the official educational policy (e.g. the role of administrators and inspectors) on teachers' TEBs. Examining similarities and differences among countries related to contextual factors, like school leadership, resources available, and collaboration with the colleagues may enhance understanding of the sources of TEBs. An interesting avenue of research will also be the comparison between TEBs in relation to mathematics of primary and secondary school teachers. This will possibly lead to a discussion about the impact of mathematics content knowledge in the formation of TEBs.

The effect of TEBs on teaching practices and student outcomes has been well documented (Betoret 2009; Brown 2005; Nie et al. 2013; Tschannen-Moran and Woolfolk Hoy 2001) and the significance of TEBs in coping capabilities in stressful situations has also been demonstrated (Chan 2008b; Gresham 2008). Considering the complexity of the construct, the domain will benefit from further qualitative and mixed method studies including observations, involving teachers with the same level of efficacy beliefs in teaching mathematics but different behavior in the classroom.

Teacher educators draw attention to the role of TEBs in pursuing reform-oriented goals, such as critical thinking and reflective self-directed learning and hence the need for teachers to teach in new ways. The study by Charalambous and Philippou (2010), indicating a relationship between TEBs and teachers' concerns about the implementation of an innovation in mathematics curricula could be extended to include several aspects of reformed curricula.

Some Final Remarks

The role of efficacy beliefs in human behavior and the benefits of high TEBs seem to be taken for granted. Despite the fact that some important ideas for teacher educators have been proposed, the possibility that high efficacy may have negative effects (Wheatley 2005) remains unattended. The voices for a wider and deeper conceptualization of the construct, in clear operative terms, incorporating more components, while retaining specificity and covering all domains of teachers' work add new complexities, that increase the difficulty of distinguishing conditions under which "high efficacy may back fire" (Wyatt 2014). The effects of high teacher efficacy on practice and specifically on teachers' persistence and on the level of their openness to new ideas and change, depends on their personal or group characteristics and on class conditions. It would be of interest to see more interpretive research focusing on the effect of these variables on TEBs and its consequences in relation to efficacy doubt and the need for change. In this direction further research could examine teachers' perceptions of their readiness to change views and approaches and their relationship with TEBs.

TEBs concern capability in a complex activity that involves facilitating access to knowledge, helping learners to develop analytical tools that help them learn on their own, providing a classroom environment conducive to learning, and encouraging the social interactions that support learning goals Wyatt (2014). Therefore, irrespective of the construct's degree of maturation and despite of accumulated findings, the field of teacher efficacy continues to hide a treasure waiting to be unearthed. This treasure would be of major importance in teaching mathematics, a subject in which students face difficulties and develop phobias, while teachers experience stressful situations.

References

Bagaka's, J. G. (2011). The role of teacher characteristics and practices on upper secondary school students' mathematics self-efficacy in Nyanza province of Kenya: A multilevel analysis. *International Journal of Science and Mathematics Education, 9*, 817–842.

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

Bandura, A. (2006a). Adolescent development from an agentic perspective. In F. Pajares & T. Urdan (Eds.), *Self-efficacy beliefs of adolescents* (Vol. 5, pp. 1–43). Greenwich: Information Age Publishing.

Bandura, A. (2006b). Guide for constructing self-efficacy scales. In F. Pajares & T. Urdan (Eds.), *Self-efficacy beliefs of adolescents* (Vol. 5, pp. 307–337). Greenwich: Information Age Publishing.

Bandura, A., Barbaranelli, C., Caprara, G. V., & Pastorelli, C. (1996). Multifaceted impact of self-efficacy beliefs on academic functioning. *Child Development, 67*, 1206–1222.

Bates, A. B., Latham, A., & Jin-ah Kim, J. (2011). Linking preservice teachers' mathematics self-efficacy and mathematics teaching efficacy to their mathematical performance. *School Science and Mathematics, 111*(7), 325–333.

Betoret, F. D. (2009). Self-efficacy, school resources, job stressors and burnout among Spanish primary and secondary school teachers: A structural equation approach. *Educational Psychology, 29*(1), 45–68.

Brand, B. R., & Wilkins, J. L. M. (2007). Using self-efficacy as a construct for evaluating science and mathematics methods courses. *Journal of Science Teacher Education, 18*, 297–317.

Brown, E. T. (2005). The influence of teachers' efficacy and beliefs regarding mathematics instruction in the early childhood classroom. *Journal of Early Childhood Teacher Education, 26*, 239–257.

Bruce, C. D., & Ross, J. A. (2008). A model for increasing reform implementation and teacher efficacy: Teacher peer coaching in grades 3 and 6 mathematics. *Canadian Journal of Education, 31*(2), 346–370.

Chan, D. W. (2008a). Dimensions of teacher self-efficacy among Chinese secondary school teachers in Hong Kong. *Educational Psychology, 28*(2), 181–194.

Chan, D. W. (2008b). Emotional intelligence, self-efficacy, and coping among Chinese prospective and in-service teachers in Hong Kong. *Educational Psychology, 28*(4), 397–408.

Chang, Y.-L. (2009). A case study of elementary beginning mathematics teachers' efficacy development. *International Journal of Science and Mathematics Education, 8*, 271–297.

Charalambous, C. Y., & Philippou, G. N. (2010). Teachers' concerns and efficacy beliefs about implementing a mathematics curriculum reform: Integrating two lines of inquiry. *Educational Studies in Mathematics, 73*, 1–21.

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*, 125–142.

Charalambous, C. Y., Panaoura, A., & Philippou, G. N. (2009). Using history of mathematics to induce changes in pre-service teachers' beliefs and attitudes: Insights from evaluating a teacher education program. *Educational Studies in Mathematics, 71*, 161–180.

Creemers, B., & Reezigt, G. J. (1999). The concept of vision in educational effectiveness, theory and research. *Leaning Environments Research, 2*, 107–135.

Duffin, L. C., French, B. F., & Patrick, H. (2012). The teachers' sense of efficacy scale: Confirming the factor structure with beginning pre-service teachers. *Teaching and Teacher Education, 28*, 827–834.

Enochs, L. G., Smith, P. L., & Huinker, D. (2000). Establishing factorial validity of the mathematics teaching efficacy beliefs instrument. *School Science and Mathematics, 100*(4), 194–202.

Evans, B. R. (2011). Content knowledge, attitudes, and self-efficacy in the mathematics New York City teaching fellows (NYCTF) program. *School Science and Mathematics, 111*(5), 225–235.

Gabriele, A. J., & Joram, E. (2007). Teachers' reflections on their reform-based teaching in mathematics: Implications for the development of teacher self-efficacy. *Action in Teacher Education, 29*, 60–74.

Gibson, S., & Dembo, M. (1984). Teacher efficacy: Construct validation. *Journal of Educational Psychology, 76*, 569–582.

Goddard, R. (2002). A theoretical and empirical analysis of the measurement of collective efficacy: The development of a short form. *Educational and Psychological Measurement, 62*(1), 97–110.

Goddard, R. D., Hoy, W. K., & Woolfolk Hoy, A. (2000). Collective teacher efficacy: Its meaning, measure, and effect on student achievement. *American Education Research Journal, 37*(2), 479–507.

Goddard, R. G., Hoy, W. K., & Woolfolk Hoy, A. (2004). Collective efficacy beliefs: Theoretical developments, empirical evidence, and future directions. *Educational Researcher, 33*(3), 3–13.

Gresham, G. (2008). Mathematics anxiety and mathematics teacher efficacy in elementary preservice teachers. *Teaching Education, 19*(3), 171–184.

Henson, R. (2002). From adolescent angst to adulthood: Substantive implications and measurement dilemmas in the development of teacher efficacy research. *Educational Psychologist, 37*, 137–150.

Kennedy, S. Y., & Smith, J. B. (2013). The relationship between school collective reflective practice and teacher physiological efficacy sources. *Teaching and Teacher Education, 29*, 132–143.

Klassen, R. M., Bong, M., Usher, E. L., et al. (2009). Exploring the validity of a teachers' self-efficacy scale in five countries. *Contemporary Educational Psychology, 34*, 67–76.

Klassen, R. M., Tze, V. M. C., Betts, S. M., & Gordon, K. A. (2011). Teacher efficacy research 1998–2009: Signs of progress or unfulfilled promise? *Review of Educational Research, 23*, 21–43.

Kowalski, K., Pretti-Frontczak, K., & Johnson, L. (2001). Preschool teachers' beliefs concerning the importance of various developmental skills and abilities. *Journal of Research in Childhood Education, 16*, 5–14.

Kurz, B. T., & Knight, S. L. (2004). An exploration of the relationship among teacher efficacy, collective teacher efficacy, and goal consensus. *Learning Environments Research, 7*, 111–128.

Labone, E. (2004). Teacher efficacy: Maturing the construct through research in alternative paradigms. *Teaching and Teacher Education, 20*, 341–359.

Martin, N. K., Sass, D. A., & Schmitt, T. A. (2012). Teacher efficacy in student engagement, instructional management, student stressors, and burnout: A theoretical model using in-class variables to predict teachers' intent-to-leave. *Teaching and Teacher Education, 28*, 546–559.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston: The National Council of Teachers of Mathematics.

Nie, Y., Tan, G. H., Liau, A. K., Shun Lau, S., & Chua, B. L. (2013). The roles of teacher efficacy in instructional innovation: Its predictive relations to constructivist and didactic instruction. *Educational Research for Policy and Practice, 12*, 67–77.

Pajares, F., & Miller, M. D. (1994). Role of self-efficacy and self-concept beliefs in mathematical problem solving: A path analysis. *Journal of Educational Psychology, 86*, 193–203.

Phelps, C. M. (2010). Factors that pre-service elementary teachers perceive as affecting their motivational profiles in mathematics. *Educational Studies in Mathematics, 75*, 293–309.

Philipp, R. A. (2007). Mathematics teachers' beliefs and affect. In F. K. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 257–315). Charlotte: Information Age Publishing.

Philippou, G. N., Charalambous, C. Y., & Christou, C. (2001). Efficacy in problem posing and teaching problem posing. In M. Heuvel-Panhuizen (Ed.), *Proceedings of the 25th annual PME conference* (Vol. 4, pp. 41–48). Utrecht: Utrecht University.

Richardson, F. C., & Suinn, R. M. (1972). The mathematics anxiety rating scale: Psychometric data. *Journal of Counseling Psychology, 19*, 39–47.

Takahashi, S. (2011). Co-constructing efficacy: A "communities of practice" perspective on teachers' efficacy beliefs. *Teaching and Teacher Education, 27*, 732–741.

Tella, A. (2011). An assessment of mathematics teachers' internet self-efficacy: Implications on teachers' delivery of mathematics instruction. *International Journal of Mathematical Education in Science and Technology, 42*(2), 155–174.

Tran, N. A., Schneider, S., Duran, L., et al. (2012). The effects of mathematics instruction using spatial temporal cognition on teacher efficacy and instructional practices. *Computers in Human Behavior, 28*, 340–349.

Tschannen-Moran, M., & Woolfolk Hoy, A. (2001). Teacher efficacy: Capturing an elusive construct. *Teaching and Teacher Education, 17*, 783–805.

Tschannen-Moran, M., & Woolfolk Hoy, A. (2007). The differential antecedents of self-efficacy beliefs of novice and experienced teachers. *Teaching and Teacher Education, 23*, 944–956.

Tschannen-Moran, M., Woolfolk Hoy, A., & Hoy, W. K. (1998). Teacher efficacy: Its meaning and measure. *Review of Educational Research, 68*(2), 202–248.

Tuchman, E., & Isaacs, J. (2011). The influence of formal and informal formative pre-service experiences on teacher self-efficacy. *Educational Psychology, 31*(4), 413–433.

Usher, E. L., & Pajares, F. (2006). Sources of academic and self-regulatory efficacy beliefs of entering middle school students. *Contemporary Educational Psychology, 31*, 125–141.

Usher, E. L., & Pajares, F. (2009). Sources of self-efficacy in mathematics: A validation study. *Contemporary Educational Psychology, 34*, 89–101.

Wheatley, K. F. (2002). The potential benefits of teacher efficacy doubts for educational reform. *Teaching and Teacher Education, 18*, 5–22.

Wheatley, K. F. (2005). The case for re-conceptualizing teacher efficacy research. *Teaching and Teacher Education, 18*, 747–766.

Wyatt, (2014). Towards a re-conceptualization of teachers' self-efficacy beliefs: tackling enduring problems with the quantitative research and moving on. *International Journal of Research & Method in Education, 37*(2), 166–189.