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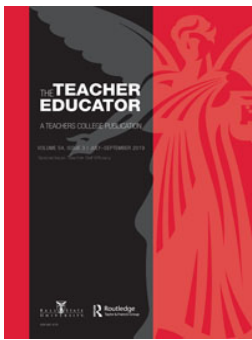
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Preparing Science Undergraduates for a Teaching Career: Sources of Their Teacher Self-Efficacy

Els Cornelia Maria van Rooij^a , Marjon Fokkens-Bruinsma^b , and
Martin Goedhart^a 

¹Institute for Science Education and Communication, University of Groningen; ²Department of Teacher Education, University of Groningen

ABSTRACT

One of the causes of the science teacher shortage is the low enrollment in science teacher education. In the Netherlands, science undergraduates can enroll in a half-year teaching course that leads to a teacher qualification for junior secondary education. The goal is that these undergraduates continue in teacher education to obtain a full qualification. The present study investigated how self-efficacy was related to continuing in teacher education, and to commitment, perceived workload, and stress. Moreover, we investigated how mastery experiences, vicarious experiences, social persuasions, and emotional states influenced self-efficacy. Findings based on 69 science undergraduates showed that self-efficacy was positively related to commitment and negatively to workload and stress, but unrelated to continuing in teacher education. Mastery experiences and positive emotional states explained variance in self-efficacy. We call for more research that investigates all sources of self-efficacy and for more attention to preservice teachers' emotional states in research and practice.

Introduction

Many countries face a shortage of science and mathematics teachers in secondary education, such as the United Kingdom, the United States, Israel, Bulgaria, Denmark, and the Netherlands (Adriaens, Fontein, Uijl, & Vos, 2016; Kearney, 2016; Sutchter, Darling-Hammond, & Carver-Thomas, 2016). More specifically, in Organisation for Economic Co-operation and Development (OECD) countries, about one fifth of 15-year-old students are attending schools that are suffering from shortages of qualified science and mathematics teachers (Asia Society, 2012). Such a shortage is a societal problem with tremendous impact. Highly educated science professionals are needed in the future workforce globally (e.g., Joyce, 2014; Wang, 2013). To achieve this, high-quality and enthusiastic science teachers are essential. They can arouse and sustain students' interest and engagement in science and help them develop self-perceptions and an identity related to science, technology, engineering, and mathematics (STEM), which are important determinants of young people's STEM career choices (Hall et al., 2011; Osborne,

CONTACT Els Cornelia Maria van Rooij  e.c.m.van.rooij@rug.nl  Institute for Science Education and Communication, Nijenborgh 99747, AG Groningen, The Netherlands

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Simon & Collins, 2003; Sadler, Sonnert, Hazari, & Tai, 2012; Sellami, El-Kassem, Al-Qassass, & Al-Rakeb, 2017).

To deal with the science teacher shortage, schools have to rely on unqualified teachers (Sibieta, 2018). This undermines student achievement, as teacher certification is related to student achievement (Goe, 2007). Moreover, a positive correlation has been reported between the degree to which students report to like science and the number of science courses taken by their teachers (NRC, 2001). Another solution to tackle the shortage is that shortage subjects are being taught by teachers with a certification in another subject (Sibieta, 2018; Vloet, Den Uijl, & Fontein, 2017); that is, by underqualified teachers. This is problematic because teachers qualified to teach one subject lack the content knowledge and pedagogical content knowledge of the other subject, which are both related to students' learning (Sadler, Sonnert, Coyle, Cook-Smith, & Miller, 2013).

The shortages are mainly caused by the retirement and attrition of current teachers and a decreasing enrollment in teacher education (KNAW, 2017; OECD, 2018; Sutcher et al., 2016). Here we focus on the problem of low enrollment in mathematics and science teacher education. In the Netherlands, there are different routes to becoming a qualified secondary school teacher. A common one is to pursue a university master in education after having finished a university bachelor or master in a specific discipline that is related to a secondary school subject. Unfortunately, the number of graduates from this master in education has been decreasing for years (Adriaens et al., 2016). Therefore, as a way to combat the teacher shortage, in 2009, several teacher education institutes at universities in the Netherlands also established a short teacher education course: the minor in education. This is a one-semester teacher education course for third-year undergraduate students. For the science disciplines, for example, bachelor students in chemistry, physics, mathematics, and life sciences can pursue the minor in education to teach chemistry, physics, mathematics and biology, respectively. The goal of this program is twofold: first, to allow undergraduates to orient themselves on a teaching career, and second, to provide them with a teacher qualification for the lower grades of secondary school (grades 7 to 9) (Onderwijsraad, 2013). By offering this minor, more university students can become familiar with teaching as a career possibility, and, as such, it is seen as a means to attract more students to teaching and subsequently battle the science teacher shortage, in particular the shortage of university-educated teachers.

The minor consists of both general pedagogical and subject-specific coursework at the university (i.e., pedagogical knowledge and pedagogical content knowledge) and a teaching practicum at a secondary school, closely supervised by a mentor teacher, which lasts the whole semester. Ideally, the undergraduates who find out they like teaching, and who have received a positive evaluation, continue to pursue the master in education, and consequently obtain the full teacher qualification (i.e., the qualification to teach in all grades of secondary education). However, only about 25% of students who finish the minor in education continue to the master in education (Onderwijsraad, 2013).

Teacher self-efficacy refers to individuals' capability beliefs regarding teaching tasks (Dellinger, Bobbett, Olivier, & Ellett, 2008). The literature has shown that self-efficacy plays a key role in preservice teachers' intention to start a teaching career and beginning teachers' decision to remain in the profession (Ingersoll & Smith, 2004; Klassen & Chiu, 2011). As such, the teacher self-efficacy of the science undergraduates who have

completed the minor in education may also influence their decision to continue in teacher education and obtain a full teacher qualification. In this study, we therefore investigate how these science undergraduates' self-efficacy influences their intention to continue in teacher education and how their teacher self-efficacy is built. Because there is—to our knowledge—no previous research available that specifically focuses on teacher self-efficacy of undergraduates who pursue a short teaching course, we focus on preservice teachers in our literature review.

Literature review

The importance of teacher self-efficacy

According to Bandura's social cognitive theory (1989, 1997), people learn in a social context, in which behavior, cognition and other personal factors, and environmental factors reciprocally influence each other (reciprocal causation, Bandura, 1989). In short, this bidirectionality of influence between behavior and environment implies that people are both products and producers of their environment (Bandura, 1989). Self-efficacy is the central concept in this theory and refers to someone's judgment of how well one can execute actions that are required to deal with prospective situations (Bandura, 1982). Following the principle of reciprocal causation, self-efficacy both influences and is influenced by behavior, thought, and environment (Bandura, 1989).

In contrast to constructs such as self-concept and self-esteem, which concern an individual's general appraisal about themselves and include cognitive and affective self-perceptions, self-efficacy deals with the cognitively perceived capability of the self in a specific domain of functioning (Bong & Clark, 1999). Self-efficacy determines how people feel, think, and behave and high self-efficacy has been related to many positive outcomes, such as perceiving difficult tasks as challenges instead of threats (Bandura, 1989). Moreover, self-efficacy is closely related to having an internal locus of control (i.e., the perception that one has control over the outcomes of events in their lives, as opposed to being only a "victim" of external forces; Judge, Erez, Bono, & Thoresen, 2002).

Social cognitive career theory (Lent, Brown, & Hackett, 1994) is derived from Bandura's social cognitive theory and focuses specifically on the process of choosing a career. It postulates that individuals with higher self-efficacy in successfully executing the behaviors related to a specific job will be more interested in that job, will hold more positive outcome expectations regarding that job (i.e., rewards when performing the job, such as a feeling of fulfillment, job stability, and pleasant work hours), and will be more likely to choose to enter that job (Lent, Brown, & Hackett, 1994). Drawing from Bandura's (1997) social cognitive theory, Dellinger et al. (2008) defined teacher self-efficacy as "individuals' beliefs in their capabilities to perform specific teaching tasks at a specific level of quality in a specified situation" (p. 752). A meta-analysis by Chesnut and Burley (2015) confirmed the link between teacher self-efficacy and preservice teachers' intention to start a teaching career. Research also suggests that self-efficacy is in flux in the beginning of one's teaching experiences, but stabilizes in a later stage (Morris & Usher, 2011; Woolfolk Hoy & Burke Spero, 2005). This changeability in the beginning, combined with its importance in the choice to become a teacher, makes the

development of self-efficacy an important goal of teacher education programs, including the teaching course for science undergraduates that we focus on in this study.

Next to the role self-efficacy may play in sustaining or increasing the quantity of teachers, there is an abundance of research pointing to its impact on teacher quality and subsequently students' achievement. A few examples regarding the impact on teachers are that teachers high in self-efficacy are more enthusiastic (Allinder, 1994), more committed to the teaching profession (Chesnut & Burley, 2015), less likely to experience stress and burnout (Aloe, Amo, & Shanahan, 2014; Vesely, Saklofske, & Nordstokke, 2014), and experience greater job satisfaction (Klassen & Chiu, 2010).

Despite all this knowledge about positive correlates of self-efficacy, substantially less is known about what influences self-efficacy: Why do some (preservice) teachers have a high teacher self-efficacy and others do not?

The sources of self-efficacy

In order to stimulate the development of self-efficacy, it is crucial to know what sources affect it. Bandura (1997) stated four sources of self-efficacy: mastery experiences, vicarious experiences, social persuasions, and physiological and affective states. Compared to research on correlates of teacher self-efficacy, little attention has been paid to these sources (Anderson & Betz, 2001; Labone, 2004). More specifically, there are hardly any studies that have investigated all sources simultaneously and have quantitatively assessed the degree to which they make an independent contribution to self-efficacy (Morris, Usher & Chen, 2017). Hence, there is a need for more research that includes all sources (Glackin, 2018). Second, there is a lack of research into the fourth source of self-efficacy: physiological and affective states (Morris & Usher, 2011). Moreover, whenever this fourth source is taken into account, the focus tends to be exclusively on negative affective states (Morris et al., 2017). Below we will describe these sources and discuss previous empirical findings in preservice teachers.

Mastery experiences

Mastery experiences, also referred to as enactive mastery experiences or performance accomplishments, involve achieving goals through direct, personal action (Morris et al., 2017). If a certain behavior is "mastered," self-efficacy raises. For example, when a teacher has applied certain classroom management strategies in a class with disruptive students, and the result was that these students did what the teacher asked them to do, the teacher's self-efficacy in classroom management will increase. In contrast, when the disruptive students continued their disruptive behavior and kept disturbing the lesson, despite the teacher's efforts to make them cooperate, the teacher's self-efficacy in classroom management is undermined. The effect of mastery experiences on self-efficacy is particularly salient if the same actions are *repeatedly* successful (Bandura, 1977). Moreover, the effect will be larger if a task is particularly *demanding*; for example, if a teacher successfully manages a class that is known as one of the most difficult classes in school (Morris et al., 2017). Third, it matters how a teacher *evaluates* the experience (Bandura, 1982). If they attribute the success to external circumstances, it may not increase their self-efficacy compared to

if they attribute it to their own effort and skill. Bandura (1997) argued that mastery experiences are the most important source of self-efficacy.

Research that investigated all sources corroborates the importance of mastery experiences for the development of self-efficacy in preservice teachers (Bautista & Boone, 2015; Hand & Stuart, 2012; O'Neill & Stephenson, 2012; Oh, 2011; Poulou, 2007; Yüksel, 2014). However, Tschannen-Moran and Woolfolk Hoy (2007) claimed that other sources than mastery experiences may be more important in preservice teachers, because, for this group, there may not yet be many mastery experiences available. Still, they found that in both beginning and experienced teachers, mastery experiences made a significant additive contribution to the prediction of self-efficacy (Tschannen-Moran & Woolfolk Hoy, 2007).

Vicarious experiences

Vicarious experiences refer to learning by observing others perform the targeted behavior (Bandura, 1997). This source is prominently available in most teacher education programs: Usually preservice teachers start an internship at a school by observing classes taught by their mentor teachers. Theoretically, when watching someone else succeed in a task, it will raise one's own confidence in being able to succeed (Bandura, 1977). Vicarious experiences are said to be particularly important when the individual does not yet have much experience (Tschannen-Moran & Woolfolk Hoy, 2007). However, a vicarious experience may hardly impact the student teacher's self-efficacy when the student teacher does not identify him- or herself with the mentor teacher who is modeling the behavior (Bandura, 1982). This may be due to a large difference in experience (Tschannen-Moran & Woolfolk Hoy, 2007). In this regard, observing peer student teachers may be more beneficial to someone's self-efficacy than observing experienced teachers (Bruce, Esmonde, Ross, Dookie, & Beatty, 2010).

Empirical studies on the relationship between vicarious experiences and self-efficacy have revealed equivocal results. While some qualitative studies reported that preservice teachers learn from watching their mentors or peers (e.g., Bruce et al., 2010; Cakir & Alici, 2009; Gunning & Mensah, 2011), quantitative studies failed to find an effect of vicarious experiences on self-efficacy (e.g., Capa Aydin & Woolfolk Hoy, 2005; Morris, 2010; Rots, Aelterman, Vlerick, & Vermeulen, 2007).

Social persuasions

Bandura's (1997) third source of self-efficacy are social persuasions—sometimes also called verbal persuasions (Bandura, 1977). These are the evaluative comments that individuals receive from others about their performance (Bandura, 1997). For student teachers, social persuasions mainly come from the school mentor, teacher educators, peer student teachers, and—not to be forgotten—the students they are teaching (Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998). When the message is positive, self-efficacy will rise (Bandura, 1977). Like vicarious experiences, social persuasions are said to specifically matter when someone has little experience in a task (Bandura, 1997). Factors that

influence the interpretation of social persuasions are the perceived credibility and sincerity of the messenger and the content of the message (Bandura, 1986).

Qualitative research findings reported that social persuasions are an influential source of self-efficacy for preservice teachers (e.g., Cakir & Alici, 2009; Milner, 2002; Mulholland & Wallace, 2001; Poulou, 2007; Tschannen-Moran & Woolfolk Hoy, 2001). Quantitative studies provided evidence for its influence as well (Mohamadi & Asadzadeh, 2012; Morris, 2010; Oh, 2011; Poulou, 2007).

Physiological and affective states

The last source are physiological and affective states (Bandura, 1997), also referred to as emotional or physical arousal (Bandura, 1977) or emotional states (Morris et al., 2017)). This refers to the physiological and emotional state someone is in while performing the task (Bandura, 1997). Positive feelings, such as enthusiasm and confidence, may strengthen self-efficacy, while negative ones like anxiety and fatigue lower self-efficacy, because they provide the individual with physiological evidence that they are not “ready” to perform the task (Morris et al., 2017).

Little empirical research pays attention to emotional states as a source of teacher self-efficacy (Morris et al., 2017). This is surprising, because teaching is known as an emotional activity (e.g., Frenzel et al., 2016) and a quarter of all teachers report that teaching is very or even extremely stressful (Kyriacou, 2001). Especially for student teachers, the emotional nature of teaching is prominent (Mansfield, Beltman, Weatherby-Fell, & Broadley, 2016). In this sense, researchers often talk about the phenomenon of “reality shock,” which refers to student teachers feeling overwhelmed, disappointed, or frustrated when they face a discrepancy between their expectations about teaching (e.g., spending a lot of time on teaching subject knowledge and inspiring young people) and the everyday reality in the classroom (e.g., having to spend a lot of energy on classroom management and administrative tasks) (Dicke, Elling, Schmeck, & Leutner, 2015). Results of the small number of studies that investigated emotional states mainly showed that negative emotional states did not affect self-efficacy (Cakir & Alici, 2009; DeMauro & Jennings, 2016) or that their relationship to self-efficacy was substantially weaker than that of the other sources (Heppner, 1994; Mohamadi & Asadzadeh, 2012; Morris & Usher, 2011; Poulou, 2007).

Interestingly, in the vast majority of studies on emotional states as a self-efficacy source, authors focused on negative states only, like stress, anxiety, fatigue, or depression (e.g., DeMauro & Jennings, 2016). It is not clear why positive emotions have been neglected in most studies so far, since the increasing body of literature on teacher emotions in general states that emotions are extremely relevant, because they influence teacher behavior, shape teacher–student relationships, affect student achievement, and are important for teachers’ wellbeing (Keller, Frenzel, Goetz, Pekrun, & Hensley, 2014). A possible reason could be that many studies focus on negative correlates, such as leaving the teacher profession, which may make negative emotions a more logical point of focus than positive ones. This imbalance of negative and positive emotions as a source of self-efficacy is a general problem in research on the sources of self-efficacy (Morris et al., 2017), but fortunately some researchers have started to

address this by explicitly including positive emotions as a distinct source of self-efficacy (e.g., in the case of career-decision making self-efficacy: Bike, 2013; Lent, Ireland, Penn, Morris, & Sappington, 2017).

This study

This study aims to expand the knowledge on correlates with student teachers' self-efficacy, as it is unclear if and how self-efficacy is also related to positive correlates in a short teacher education course for undergraduates—most studies on correlates of teacher self-efficacy focus on either in-service teachers or on preservice teachers in bachelor's or master's programs that have a duration of three or four or one or two years, respectively. Hence, we ask: How is science undergraduates' teacher self-efficacy related to commitment to the teacher education course, perceived workload, stress, and intention to continue in teacher education? Second, we wish to gain insight into the sources of self-efficacy: How are Bandura's hypothesized sources of self-efficacy—mastery experiences, vicarious experiences, social persuasions, and emotional states (split into positive and negative emotions)—related to undergraduates' teacher self-efficacy?

Method

Participants and procedure

Sixty-nine Dutch science university students who were pursuing the minor in education (52% male) at three universities in the Netherlands completed a questionnaire in the last month of the course (response rate 92%). Average age of the participants was 22 ($SD = 4.3$, range 19–44). In our sample of undergraduates, 35% taught mathematics during their practicum, 20% physics, 18% chemistry, 16% biology, and 11% another science subject.

Data were collected during one of the last lectures at the university. The survey was part of a larger study about the teacher education course for undergraduates. The surveys—all administered on paper—took the participants on average 40 minutes to complete. Before handing out the surveys, the researchers explained the purposes of the study and the ways in which the data would be managed. Anonymity and confidentiality were guaranteed and it was emphasized that participation was voluntary. Moreover, participants were allowed to withdraw from the study at any time, without having to provide a reason for doing so. All participants consented to this and completed the survey. The data were processed in SPSS.

Instruments

Self-Efficacy

Self-efficacy was measured with the Teachers' Self-Efficacy Scale (TSES; Tschannen-Moran & Woolfolk Hoy, 2001). This instrument is the most commonly used instrument to measure teacher self-efficacy (Morris et al., 2017). It consists of 24 items that assess the degree to which teachers feel efficacious about their capabilities to deal with issues in relation to student engagement, instructional strategies, and classroom management.

Sample items are “I can control disruptive behavior in the classroom” and “I can respond to difficult questions from my students.” All of these items were rated on a 5-point Likert scale, ranging from 1 (not at all true) to 5 (very true). Cronbach’s alpha for the TSES was .85, which is somewhat lower than the alphas found in other studies (>.90, e.g., Garvis, 2009; Tschannen-Moran & Woolfolk Hoy, 2001) but good.

Sources of self-efficacy

We adapted Usher and Pajares’ (2009) sources of mathematics self-efficacy questionnaire to measure mastery experiences, vicarious experiences, and social persuasions in our sample of science undergraduates in the teaching course. This instrument was chosen because there were issues with existing instruments that specifically aimed to measure the sources of teacher self-efficacy. Poulou’s (2007) Teaching Efficacy Sources Inventory did not have separate scales for mastery experiences and social persuasions, and measured vicarious experiences with items that concerned comparisons of the participant’s teaching with others. Kieffer and Henson (2000) reported that their Sources of Self-Efficacy Inventory consisted of many items that were associated with other factors than the ones to which they were supposed to belong. In contrast, Usher and Pajares’ (2009) instrument seemed promising for our purpose because its operationalization of the sources was in line with Bandura’s theory and its psychometric qualities were good. Moreover, Usher and Pajares (2009) specifically stated that their instrument could be adapted for use in different applications. Table 1 shows an example of the adaptation from mathematics self-efficacy sources to teacher self-efficacy sources for each of the three sources. Initially, Cronbach’s alpha for mastery experiences was poor ($\alpha = .61$). After inspection, the problem was caused by the item “I have always been successful in teaching” (adapted from “I have always been successful in math”). This item was not appropriate in the student teacher context, which justified our decision to remove this item. Consequently, the alpha for mastery experiences increased to .72, which can be seen as sufficient. The alpha for vicarious experiences was poor but sufficient ($\alpha = .63$). Careful inspection did not lead to justified reasons for omitting certain items in this scale. Moreover, poor reliabilities for vicarious experiences are a well-known problem in research about the sources of self-efficacy (e.g., Usher & Pajares, 2008). Finally, Cronbach’s alpha for social persuasions was good ($\alpha = .84$).

We specifically wanted to focus on emotional states—both positive and negative—as a source of teacher self-efficacy. Usher and Pajares’ (2009) instrument only measured negative states. We developed and tested a new scale to measure teachers’ emotional states, based on a selection of Usher and Pajares’ (2009) items for negative physiological states, Pettegrew and Wolf’s illness symptoms (1982), Rosenberg’s (2010) emotional symptoms and physical symptoms of stress, and Fimian and Fastenau’s (1990) emotional manifestations and fatigue manifestations. As there was a clear lack of focus on positive emotions in research on the sources of teacher self-efficacy, we drew from the Positive And Negative Affect Schedule (Watson, Clark, & Tellegen, 1988) to develop items measuring positive emotional states that we deemed as appropriate to the situation of preservice teachers. The final to-be-tested scale consisted of 17 items, 10 negative ones and 7 positive ones. The item-stem was “Think about the last two weeks at

Table 1. Overview of measurement of mastery experiences, vicarious experiences, and social persuasion.

Source	Sample item from Usher and Pajares' (2009) sources of mathematics self-efficacy	Sample item from our instrument to measure sources of preservice teacher self-efficacy	Number of items	Cronbach's alpha
Mastery experiences	I got good grades in math on my last report card.	I got good grades for my internship.	4	.72
Vicarious experiences	When I see how another student solves a math problem, I can see myself solving the problem in the same way. Seeing adults do well in math pushes me to do better.	When I see how another student teacher solves a class management problem, I can see myself solving the problem in the same way. Seeing teachers give good lessons pushes me to become a better teacher.	6	.63
Social persuasions	I have been praised for my ability in math.	I have been praised for my teaching ability.	5	.84

your internship. How often have you felt the following?" Sample items are "Feeling nervous during teaching" and "Feeling enthusiastic during teaching." Answer categories ranged from 1 (never) to 5 (always). Exploratory factor analysis with varimax rotation was conducted to uncover the structure of the latent factors present in the items measuring emotional states. A minimum loading of .40 was used as a criterion for inclusion. A two-factor solution offered a good fit to the data. Five items of negative states loaded on the first factor; seven items of positive states loaded on the second factor. Table 2 provides an overview of the factor loadings and which items were retained in the analysis and which ones were removed. Cronbach's alpha for negative emotional states was .82 and for positive emotional states .78.

Commitment, workload, stress, and intention to pursue the master in education

To measure commitment, workload, stress, and intention to pursue the master in education after having finished the teacher education course, we developed items based on existing instruments, because existing scales were not suitable for the context of the minor in education. Commitment to the teaching profession was measured with four items. Three of those were based on Skaalvik and Skaalvik's (2011) measurement of motivation for leaving the teacher profession, which we adapted to the context of the present study (e.g., "I often considered to quit the minor in education"). The fourth item, "I identify with the teaching profession," was taken from Meyer, Allen, and Smith's (1993) measurement of affective commitment. We measured workload by drawing from Pettegrew and Wolf's (1982) measurement of role overload (e.g., "The teacher education course can easily be combined with my personal life" [reverse-scored]); Rosenberg's (2010) measure of time management (e.g., "I find it easy to organize my time in such a way that I manage to finish all the work for this teacher education course in time" [reverse-scored]); and Fimian and Fastenau's (1990) work-related stressors (e.g., "The pace of an everyday school day is too high"). To measure preservice teachers' experience of stress, we asked them to indicate to what extent they find some specific everyday class situations stressful on a scale of 1 to 5. Here, we drew from Rosenberg (2010, item about student behavior), Foxworth, Karnes, and Leonard (1984,

Table 2. Items that measured emotional states and their factor loadings.

Items	Factor loadings negative emotional states	Factor loadings positive emotional states
Worrying about your internship.	.59	
Feeling nervous during teaching.	.82	
Feeling stressed when you are at your internship school.	.52	
Feeling insecure during teaching.	.85	
Feeling tense during teaching.	.72	
Having trouble sleeping at night.	.14	
Experiencing at least one of the following symptoms: headache, stomachache ache, accelerated heart rate.	.22	
Feeling depressed when you think about teaching.	.25	
Feeling tired after teaching.	-.14	
Getting irritated quickly during teaching.	-.09	
Looking forward to teaching when you get up in the morning.		.61
Feeling energized after teaching.		.71
Feeling enthusiastic during teaching.		.63
Feeling cheerful from contact with students.		.71
Feeling confident during teaching.		.45
Feeling proud when you notice that students accept you as their teacher.	-.20	.80
Feeling satisfied after teaching.	-.04	.43

Note. Items in bold were retained.

Table 3. Overview of measures of commitment, workload, and stress.

Measure	Sample item	Number of items	Cronbach's alpha
Commitment	I identify myself with the teaching profession.	4	.62
Workload	I have sufficient time to prepare my lessons.	6	.73
Stress	<i>How stressful is this for you?</i> Students are constantly talking during your instruction.	9	.83

four items about working with students), and Fimian and Fastenau (1990, two items about discipline and motivation). In addition, we formulated two items about possibly stressful student behavior ourselves. Sample items, number of items, and Cronbach's alphas can be found in Table 3. Finally, the undergraduates were asked to what extent they considered to continue in teacher education (i.e., pursue the master in education). This was measured on a five-point scale, from "definitely not" to "definitely."

Analyses

First, we looked at the descriptives (e.g., means, standard deviations) to obtain an overall view of the data. Next, for our first research question about the relationship between self-efficacy and positive correlates in the undergraduates, we performed correlational analysis. For the second research question, which asked which sources of self-efficacy were (most strongly) related to self-efficacy, we conducted multiple linear regression analysis.

Results

Descriptives

Means, standard deviations, minimum and maximum scores of all measurements are presented in Table 4. Undergraduates' teacher self-efficacy was well above average (3.68,

Table 4. Means, standard deviations, minima and maxima.

Measure	Mean	SD	Minimum	Maximum
Self-efficacy	3.68	.38	2.90	4.55
<i>Sources of self-efficacy</i>				
Mastery experiences	3.69	.62	2.00	4.75
Vicarious experiences	3.88	.45	3.00	5.00
Social persuasion	3.86	.61	2.20	5.00
Negative emotions	2.43	.67	1.00	4.20
Positive emotions	3.84	.42	2.57	5.00
<i>Possible correlates with self-efficacy</i>				
Commitment	4.19	.56	2.75	5.00
Workload	3.16	.60	1.83	4.33
Stress	2.66	.61	1.33	3.89

SD .38). Scores on all five sources of self-efficacy, with the exception of negative emotions, were high (>3.69). Negative emotions were below average. The means of the possible correlates with self-efficacy reveal that undergraduates' commitment was high (4.19), workload somewhat above average (3.16), and stress somewhat below average (2.66). Of the undergraduates, 15.6% said they definitely planned to continue in teacher education by pursuing the master in education and another 10.9% said they would probably do so; 26.6% were undecided and 46.9% were probably or definitely not continuing.

There were no significant differences on self-efficacy, the sources of self-efficacy, commitment, workload, stress, and intention to continue to the master in education related to gender or university.

Relationships between self-efficacy and commitment, workload, stress, and intention to continue in teacher education

As Table 5 shows, self-efficacy had weak relationships with three of the four expected correlates with self-efficacy: a positive relationship with commitment, and negative relationships with workload and stress. Thus, whenever undergraduates scored higher on teacher self-efficacy, they felt more strongly committed to the profession and perceived a lower workload and less stress in the classroom. Planning to continue in teacher education, however, was unrelated to self-efficacy. The only two factors that had weak relationships with intending to pursue the master in education were social persuasions and commitment: Undergraduates who reported to have received more positive messages about their teaching from their mentors or peers and those who felt more committed to the profession were more likely to intend to start a master in education.

Multiple regression of self-efficacy on the sources

Self-efficacy had medium to high relationships with all hypothesized sources of self-efficacy (see Table 5). The highest correlations were between self-efficacy and mastery experiences ($r = .68$) and negative emotions ($r = -.62$). So, whenever undergraduates scored higher on teaching experiences, whenever they learned by observing others succeeding in tackling teaching challenges, whenever they had more positive feelings and less negative feelings on teaching, they would score higher on teaching self-efficacy.

Table 5. Correlations between all factors included in the study.

Measure	1	2	3	4	5	6	7	8	9
1. Self-efficacy	—								
2. Mastery experiences	.68**	—							
3. Vicarious experiences	.49**	.47**	—						
4. Social persuasions	.52**	.61**	.45**	—					
5. Negative emotions	-.62**	-.60**	-.25**	-.33**	—				
6. Positive emotions	.49**	.33**	.41**	.44**	-.23	—			
7. Commitment	.29*	.24*	.30*	.29*	-.18	.54**	—		
8. Workload	-.30*	-.35**	-.17	-.11	.34**	-.04	-.20	—	
9. Stress	-.27*	-.12	-.14	-.04	.31**	-.07	.03	.15	—
10. Master	-.01	.18	.07	.33**	.01	.10	.28*	-.08	.16

* $p < .05$, ** $p < .01$.

To investigate the individual contribution of each of the hypothesized sources to self-efficacy, we performed multiple regression analysis with self-efficacy as the dependent variable. The results are displayed in Table 6. Two of the sources made an independent contribution to explaining the variance in self-efficacy: mastery experiences ($\beta = .36$) and positive emotions ($\beta = .23$). Mastery experience and positive emotions together were able to explain 56% of the variance in undergraduates' teacher self-efficacy (adjusted $R^2 = .56$).

Discussion

Main findings

Fewer and fewer university science students enroll in teacher education, which contributes to an increasing teacher shortage in these subjects in secondary school. In order to make science undergraduates familiar with teaching as a career possibility and to increase their interest in teaching, they have the possibility to enroll in a half-year teacher training course during their bachelor studies, the minor in education. In previous research on preservice teachers' intention to become a teacher, self-efficacy is posited as one of the factors that influences this intention (e.g., Bruinsma & Jansen, 2010, Chesnut & Cullen, 2014, Poulou & Spinthourakis, 2002; Smith, 2000). Hence, it seems important that preservice teachers' self-efficacy is enhanced during teacher education, also in the short teacher education course that we focus on in this study. In order to do this effectively, we need knowledge on which factors affect self-efficacy. This is why we investigated which of Bandura's (1997) hypothesized sources of self-efficacy (mastery experiences, vicarious experiences, social persuasions, and physiological and affective states) would predict the science undergraduates' self-efficacy. Because of the shortage of research that includes all sources and the frequent omission of positive emotions, we chose to include all sources simultaneously into a multiple regression model and divided the source emotional states into positive and negative emotions. Our findings revealed that all sources had medium to high bivariate correlations with self-efficacy, but in a multivariate regression model only mastery experiences and positive emotional states independently contributed to explaining self-efficacy. Furthermore, we looked at the relationship between teacher self-efficacy and commitment to the teaching profession, workload, stress, and intention to continue with a master in education. These relationships have been investigated before, but not for short teacher education courses. Low

Table 6. Regression analysis of self-efficacy on the sources.

	Unstandardized coefficients	SE	Standardized coefficients	t (sig)
Constant	1.70	.58		2.95 (<.01)
Mastery experiences	.22	.08	.36	2.63 (.01)
Vicarious experiences	.15	.10	.17	1.60 (.12)
Social persuasion	.03	.08	.40	.34 (.74)
Negative emotions	-.13	.07	-.23	-1.91 (.06)
Positive emotions	.21	.10	.23	2.20 (.03)

Note. $R^2 = .60$; adjusted $R^2 = .56$.

but significant correlations were found between undergraduates' teacher self-efficacy and commitment (positive), workload (negative), and stress (negative), but teacher self-efficacy was unrelated to the intention to become a teacher. The correlation matrix did show, however, that the self-efficacy source social persuasions as well as commitment were related to the intention to continue in teacher education.

Sources of student teachers' self-efficacy

Bandura (1997) and Tschannen-Moran and Woolfolk Hoy (2007) stated that mastery experiences may be relatively less important in preservice teachers than in in-service teachers because the former lack mastery experiences on which to draw. However, our study showed that mastery experiences did matter in this group of undergraduates; they were, in fact, the most important source. An explanation could be that for undergraduates who teach for the first time many "small" success experiences may already count as a mastery experiences (e.g., explaining a scientific concept successfully to a student with learning difficulties or getting a group of noise-makers to be quiet and pay attention for 10 minutes). Another explanation lies in the timing of our data collection, which was at the end of the teacher education course. After half a year of internship, it can be reasonably assumed that many preservice teachers have obtained mastery experiences. The importance of mastery experiences is in line with much previous research about the sources of teacher self-efficacy (Bautista & Boone, 2015; Hand & Stuart, 2012; O'Neill & Stephenson, 2012; Oh, 2011; Poulou, 2007; Yüksel, 2014).

We found that the experience of positive emotions was also related to undergraduates' teacher self-efficacy in the regression analysis of self-efficacy on the sources. So far, emotional states has been the least investigated source of teacher self-efficacy, and when it was included, the focus tended to be on negative emotions (Morris et al., 2017). Our study showed that positive emotions should not be forgotten, as the undergraduates who felt—among other things—enthusiastic, energetic, confident, and proud had higher self-efficacy. There can be several explanations for this relationship. First, individuals who experience positive emotions are more creative and flexible in solving problems (Pekrun, 2016). Consequently, teachers who experience positive emotions are more likely to successfully solve immediate classroom problems, which in turn may lead to more self-efficacy. Second, secondary school students respond more positively and are more engaged when their lesson is being taught by a cheerful, enthusiastic teacher (Keller, Woolfolk Hoy, Goetz, & Frenzel, 2016). This positive student behavior (e.g., paying attention, asking questions, being engaged) may in turn affect the teacher's confidence in his or her ability to teach. Third, the relationship can be cyclical: A teacher

high in self-efficacy may experience more positive emotions than a teacher with low self-efficacy, because high self-efficacy goes hand in hand with positive expectations of one's performance and less worries about possible challenges or environmental threats (Bandura, 1993).

In contrast to positive emotions, negative emotions were not related to self-efficacy in the regression analysis. Examining the correlation between the positive and negative emotions scales (which was insignificant) and inspection of the tolerance and Variance Inflation Factors did not indicate multicollinearity problems in the regression analysis. One reason that negative emotions were not a significant predictor of self-efficacy could be that for some undergraduates, emotions such as feeling nervous or tense may not be negative per se: They may put the undergraduate in a state of focus and alertness that could enhance his or her performance (Bandura, 1997; Morris et al., 2017). In addition, those undergraduates with the most negative emotions may have already dropped out of the teacher education course.

Vicarious experiences made no individual contribution to self-efficacy when the other sources were taken into account. This is in line with previous quantitative studies that found no effect of vicarious experiences on teacher self-efficacy (e.g., Capa Aydin & Woolfolk Hoy, 2005; Morris, 2010; Rots et al., 2007). One reason might be the specific context of the minor in education. As this is a short program, undergraduates start teaching rather soon. This means that there is no "easy start" with many weeks in which the undergraduates only observe their mentor and other teachers. Like Bandura (1997) already claimed, mastery experiences can "overrule" vicarious experiences, so when they happen simultaneously, the former may predominate the latter. Another reason may lie in the measurement of vicarious experiences. The internal consistency of the scale was low, in line with research on self-efficacy sources in other fields that found lower internal consistency coefficients for vicarious experience than for the other sources (Ahn, Bong, & Kim, 2017). This is not strange, since different forms of vicarious experiences were included in one scale, such as observing teachers and observing peers (i.e., other undergraduates). It is likely that undergraduates may score differently on the vicarious experience items based on the type of observation (Lent, Lopez, Brown, & Gore, 1996). Bandura emphasized, for example, to take into account the level of identification with the model. Undergraduates may not identify with their mentor, who may have 30+ years of teaching experience. As a result, observing their mentor may not lead to increases in their self-efficacy, while observing peers might (Bruce et al., 2010). Here, however, there is the problem of a lack of time in the half-year course where there is hardly room for peer observations.

Social persuasions were also not found to be an individual predictor of self-efficacy, although previous quantitative research (Mohamadi & Asadzadeh, 2012; Morris, 2010; Oh, 2011; Poulou, 2007) did reveal relationships with self-efficacy. A first reason for the absence of social persuasions as a predictor can be that negative persuasions (e.g., an undergraduate is told he or she has *no* talent for teaching) have more impact on self-efficacy than positive ones (Bandura, 1997) and the items to measure social persuasions were all framed positively. Furthermore, social persuasions by pupils were not included in the scale and these might have been more influential than those by the mentor and peers (Mulholland & Wallace, 2001). Another possible explanation can be that the

undergraduates did not receive much persuasive positive feedback. Mentor teachers may find it hard to judge their mentees on their teaching capabilities in such a short internship and may be careful with extensive positive feedback such as “You *are* a great teacher.” Their focus is on making sure the undergraduates are “good enough” to obtain the qualification to teach, so there is constant pressure—for both the mentor and the mentee—to meet the basic criteria of teaching within half a year. Feedback thus might tend to focus more on what is not yet mastered, and positive social persuasions may be worded carefully (e.g., “You have the *potential* to be a good teacher”).

When interpreting these results, two general notes regarding the sources of teacher self-efficacy should be taken into account. First, the impact of a self-efficacy source on self-efficacy is not direct. It is mediated by cognitive processing (Bandura, 1997; Tschannen-Moran et al., 1998). Among other things, the person’s interpretation of the source and the circumstances play a role. Important in this sense is attribution theory¹ (Weiner, 1985). One teacher may attribute a lesson gone well (i.e., a mastery experience) to sheer luck or to an external factor such as the students having a good day, whereas his colleague may give himself a pat on the back and attribute it to having prepared the lesson well and being focused during teaching. In the latter case, where the mastery experience is attributed to the teacher’s own effort, it is more likely to lead to increased or sustained self-efficacy (Morris et al., 2017).

Second, although we, like many other authors, talk about “sources” and “predictors,” the directionality of the relationship is likely cyclical (Burton, Bamberly, & Harris-Boundy, 2005; Tschannen-Moran et al., 1998). Preservice teachers who feel highly self-efficacious most likely also experience less negative emotions during teaching. Moreover, due to their high confidence they will also be more likely to teach successful lessons (Klassen & Tze, 2014) and consequently receive praise from their mentor. In this way, they will sustain or increase their high level of self-efficacy. Due to this reciprocity, it is important to “get self-efficacy going,” so to say, because it will reinforce itself once it is there. This also resonates in Bandura’s (1997) claim that self-efficacy is most subjective to change early in teaching and stabilizes thereafter.

Correlates of teacher self-efficacy

An abundance of research has identified and corroborated factors that are related to teacher self-efficacy (see Zee and Koomen [2016] for a review). Among these factors are commitment to the teaching profession, workload, perceived stress, and retention. Because this study had a sample of science undergraduates in a half-year teacher education course, we were interested in investigating whether the correlations as reported in the literature would also be present in this sample. We found that commitment, study load, and perceived stress were related to self-efficacy: Highly self-efficacious undergraduates were more committed to the teaching profession, perceived a lower study load, and less stress. These results are in line with previous research (e.g., Klassen & Chiu, 2011; Skaalvik & Skaalvik, 2017).

¹Locus of control (e.g., Azjen, 2002) and growth versus fixed teacher mindsets (e.g., Dweck, 2014) are important here as well.

Planning to continue to do the master in education, however, was unrelated to self-efficacy. Being highly self-efficacious in their teaching ability thus did not make students more likely to do the education master, leading to a teacher qualification to teach all grades. In the literature, relationships were found between preservice teacher self-efficacy and continuing in teacher education; that is, not dropping out (Bruinsma & Jansen, 2010) and a lower intention to quit (Pfitzner-Eden, 2016). A meta-analysis on the relationship between self-efficacy and commitment by Chesnut and Burley (2015) also concluded that teacher self-efficacy beliefs are a significant predictor of retention among preservice teachers. That we did not find this relationship can be explained by the different context of the program we investigated: Our sample consisted of undergraduates in a half-year teacher education course, whereas most researchers conducted their studies in multiple-year bachelor or master teacher education programs. Unpublished anecdotal evidence such as conversations with students revealed that they had different reasons for choosing a short teacher education course that does not interfere with their discipline-specific undergraduate studies; for example, to improve their presentation skills or because they want to do something practical (the minor in education is the only minor among the science minors from which university students can choose that has a very strong focus on an internship). Regardless of how high their teacher self-efficacy was, many of the 74% who did not want to continue in teacher education perhaps had already decided to do another master before starting the minor. Another reason for the lack of a relationship between teacher self-efficacy and continuing to do the master may be that the undergraduates with a high level of self-efficacy in teaching are also the ones with high levels of self-efficacy in skills related to other careers (e.g., high self-efficacy in important skills for a career in business, industry, or research). When being highly self-efficacious in many aspects, self-efficacy in teaching is not a decisive factor to become a teacher. Looking into university science students' reasons for choosing or not choosing to become teachers is of vital importance with an eye on the science teacher shortage in secondary education. Reasons such as low status, few career advancement opportunities, less intellectual challenge, and low salary, especially compared to alternative careers, may play a role in keeping even highly self-efficacious and enthusiastic undergraduates from deciding on a career in teaching (OECD, 2018).

Limitations

There were several limitations in this study that should be taken into account. First, the sample size ($N = 69$) was small and the data were collected at one point in time. As a consequence, more elaborate analyses such as longitudinal structural equation modeling to test a model of sources and correlates of self-efficacy were impossible, although this would have been a more appropriate design and method (De Vries, 2016). Despite the use of the word “sources”—which implies causality—we cannot make causal inferences on the basis of the results of our current study and it is likely that the relationships between self-efficacy and the sources, and self-efficacy and the correlates, are reciprocal.

In addition, the sample consisted of a very specific group of students in teacher training. This short teacher education course is not one-to-one comparable to longer teacher education programs for secondary education. It is, however, valuable to know what

sources impact these students' self-efficacy, particularly in such a course, because, with the teacher shortage in mind, shorter programs may become increasingly common (e.g., as an introduction to teaching for undergraduate students like our sample or to efficiently teach second-career teachers the basics of teaching).

Third, some of the scales had low reliabilities, such as vicarious experiences. Also outside of teacher self-efficacy research, it has been reported that vicarious experiences are difficult to measure (Usher & Pajares, 2008). In addition, to our knowledge this was the first time Usher and Pajares' (2009) instrument to measure the sources of self-efficacy in mathematics was used to measure the sources of teacher self-efficacy. Our scales to measure positive and negative emotional states were new as well. Although these scales of the sources of teacher self-efficacy seem promising to measure the sources of teacher self-efficacy, more research needs to be done in order to validate and improve them.

Furthermore, this study drew heavily on Bandura's (1997) use of the concept self-efficacy within his social-cognitive theory. Ever since its existence, there has been criticism on this theory (De Vries, 2016; Williams & Rhodes, 2016). For example, recently, Williams and Rhodes (2016) concluded on the basis of a review that the self-efficacy construct reflects behavioral motives and argued that self-efficacy highly predicts behavior, because people tend to do what they are behaviorally motivated to do (self-efficacy-as-motivation argument). Williams and Rhodes (2016) pointed out that this is especially the case when self-efficacy questionnaires consist of "can do" statements, as do the TSES items used in this study.

Finally, the four sources posited by Bandura (1997) may not be the only factors that affect teacher self-efficacy. Palmer (2006) argued that not only enactive mastery experience (i.e., successful actual teaching) influences teacher self-efficacy, but that the mastery of content knowledge and pedagogical knowledge can also increase someone's efficacy in teaching—hence, these can be seen as additional sources of self-efficacy (Palmer, 2006). As these forms of mastery experience involve successes in understanding rather than success in actively doing (i.e., teaching), Palmer (2006) referred to these sources as "cognitive content mastery" and "cognitive pedagogical mastery," respectively. Moreover, there is also a variation of vicarious experience that could be an additional source of self-efficacy, namely "simulated modeling." This can best be described as role play: It takes place when an expert (e.g., a teacher educator) models teaching behavior, while the student teachers assume the role of pupils (Palmer, 2006). In his study on primary teacher education students' self-efficacy, Palmer (2006) found that these sources influenced self-efficacy, especially cognitive pedagogical mastery. However, it may be that their influence on self-efficacy is mediated by enactive mastery (Palmer, 2006). Nonetheless, it would be useful for future research to include these additional sources, because—to our knowledge—these additional sources have not been included in self-efficacy sources research in secondary teacher education students. Second, if cognitive content mastery, cognitive pedagogical mastery, and simulated modeling affect secondary teacher education students' self-efficacy, this would be relevant for teacher education practice, as—in contrast to mastery experiences—these three sources can be "fed" at the teacher education institute, before students start their teaching practicum at schools. This would indicate that students' self-efficacy can already be built *before* they start teaching and would argue against immediately in the beginning of teacher education

having student teachers start their practicum at school, which happens in some teacher education programs (e.g., in the minor in education that we discussed in this article).

These limitations imply that the results of this study should be perceived as preliminary and exploratory. Further research, with larger samples of different student teacher populations, should verify the findings before strong claims can be made. Moreover, effort should be put into establishing a sound measure of the sources of self-efficacy in teaching, including positive and negative states.

Implications

Implications for research

To the best of our knowledge, this study was the first one to investigate the impact of all sources of self-efficacy simultaneously—including a specific focus on positive emotions—among science undergraduates who took a secondary school teaching course. The added value of this is knowledge of which sources are relatively the most important when the impact of other sources is controlled for. Often the focus has been primarily on mastery experiences (Glackin, 2018). While valuable, because its importance was also corroborated in our study, this should not be the sole focus, as we found that positive emotions also influenced self-efficacy. Looking only at one or two sources neglects the possible influence of the other sources. For example, if positive emotional states were excluded from our regression model, negative emotions were significant. If only mastery experiences and vicarious experiences were included, both were significant. So, more quantitative research should be performed that includes all four sources, and, specifically, that does not neglect positive emotions.

In line with this, effort should be put into the further development of a reliable and valid scale to measure teacher self-efficacy sources. Reliabilities of our scales were sufficient if one takes a lower limit of $r = .60$, but specifically for vicarious experiences, Cronbach's alpha was poor (.63). The problems with measuring vicarious experiences have also been reported elsewhere and are attributed to the multidimensional nature of the construct (e.g., Usher & Pajares, 2008), so particular focus should be paid to solving these psychometric issues. Moreover, the instrument has to be tested in different samples of (student) teachers to examine its psychometric properties (e.g., in student teachers of a 4-year teacher education program, in non-science student teachers, and in primary school teachers).

Self-efficacy was unrelated to the intention to continue to pursue a master in education. We need to know more about why 26% wanted to continue and 74% did not or only maybe wanted to. Hence, future studies should compare the university students' intentions regarding the teaching profession before and after the start of the minor in education and map their motivations to teach pre- and post-minor. In addition, large-scale data on motives and barriers to teach should be collected among science students at universities: What are their motives to not want to be a science teacher? These data may be helpful in policy decisions regarding measures to combat the science teacher shortage.

Finally, it is important to acknowledge that there are other global problems that are related to the mathematics and science teacher shortage. An example are geographic differences, with urban, high minority, and low socioeconomic status schools having more

difficulty to attract qualified STEM teachers and in addition suffering from higher teacher attrition (Sibieta, 2018; Sutchter et al., 2016). In addition, male students, students from a minority background are less likely to enroll in teacher education and are under-represented in the teacher workforce (European Commission, 2018). These issues fell outside the scope of this study but are important to address in future research.

Implications for practice

Our results corroborate the importance of sufficient opportunity for mastery experiences for students who start to teach. The literature already pays much attention to this and in general, teacher education programs are designed in such a way that practice is a main building block. This is also the case in the short teaching course for undergraduates. However, if undergraduates' first teaching experiences consists of repeated failures, their development of self-efficacy can be endangered, because Bandura (1977) stated that especially in the beginning of acquiring a new skill failures have a negative impact on self-efficacy. The risk of failure is higher when the undergraduate gets thrown in at the deep end and receives too many responsibilities too soon with too little guidance—which, according to anecdotal evidence, still happens at some schools. Thus, if possible, undergraduates could start with small responsibilities, such as coaching pupils during a chemistry practical, and then gradually pick up more responsibilities until they are teaching complete lessons. In this way undergraduates can establish their teaching self-efficacy and gradually build its magnitude (the level of difficulty of tasks), its generality (from self-efficacy in specific teaching tasks to a more generalized sense of teacher self-efficacy), and its strength (from a weak to a strong sense of self-efficacy that is not easily extinguished by a failure once in a while) (Bandura, 1977; Tschannen-Moran & Woolfolk Hoy, 2001). To develop a strong sense of self-efficacy through mastery experience, a gradual withdrawing of scaffolding and help in gathering evidence of mastery from the mentor teacher is essential (Hamman et al., 2006; Tschannen-Moran & Woolfolk Hoy, 2001). The importance of such an approach should be emphasized in trainings and support for mentor teachers.

In addition, undergraduates' affective states should be monitored, because these influenced self-efficacy. A first step is that teacher educators and school mentors, but also the undergraduates themselves, are aware of these emotions and realize that they affect their confidence (Britner & Pajares, 2006). Teacher educators at university could pay explicit attention to teacher emotions in their lectures (Hawkey, 2006). For example, they could discuss research that shows how important emotions are in education (e.g., research on the relationship between teacher emotions and burnout and attrition and studies on teacher enthusiasm and its impact on students' engagement, motivation, and achievement) (Schutz & Pekrun, 2007). Also, resilience building could be integrated in teacher education programs, where resilience “involves more than bouncing back from particular difficulties, rather it is the capacity to manage ongoing and multiple challenges over time, while continuing to grow and thrive professionally” (Mansfield et al., 2016, p. 212). For school mentors, more emphasis should be placed on their role as provider of psychological support and increasing and/or sustaining the undergraduates' wellbeing (e.g., reduce stress levels and foster job satisfaction) (Richter, Kunter, Lüdtke,

Klusmann, Anders, & Baumert, 2013). Especially at the start of the internship, students value this kind of support (Richter et al., 2013). This focus on emotions in teacher education as well as explicit emotional support may not only help student teachers be successful and have positive experiences during their training (Hobson, Ashby, Malderez, & Tomlinson, 2009), but may also provide them with important tools for their possible further career as a teacher where they will also have to deal with emotions (Frenzel et al., 2016). However, not all teacher educators and school mentors may be equipped, willing, or have sufficient time to successfully take up this role (Hobson et al., 2009).

We found interesting results related to the problem of the science teacher shortage, more specifically the low enrollment in science teacher education. We saw that undergraduates' intention to continue to do the master in education, and thus receive the full qualification to teach, was related to the self-efficacy source social persuasions and to their commitment to the teacher profession. It is therefore essential that undergraduates in the teacher education course receive explicit supportive messages regarding their (beginning) teacher skills, to positively influence their decision to become a teacher—provided that they are interested in becoming a teacher and are suitable for it. An influential source of such explicit positive messages can be the pupils that the undergraduate has been teaching during his or her practicum (Mulholland & Wallace, 2001). Perhaps it could be included as an assignment at the end of the teaching course that the undergraduates have to ask their pupils to write down three things they appreciate about the undergraduate's teaching, on which the undergraduate subsequently has to reflect. Such an assignment may make the undergraduates aware of their positive teacher attributes and the effect they have on pupils, which can boost the teachers' morale and make them feel affirmed (Arthur, 2009). In addition, there are several ways in which mentor teachers can be guided to give more, and explicit, positive feedback. For example, they could be trained to do so or the lesson evaluation forms used in teacher education can be adapted to incite explicit positive messages, such as including a summarizing question at the end of a form (e.g., "What I <mentor teacher> really liked about the student's lesson, was ..."). Moreover, the undergraduates' commitment to the teacher profession can be enhanced not only by increasing students' self-efficacy, but also by paying attention to students' motives to become a teacher. Research shows that motives such as enhancing social equity, making a social contribution, and shaping the future of children and adolescents are positively related to commitment to teaching (Kissau, Davin, & Wang, 2019). Mentor teachers can highlight how these motives are being fulfilled in the teacher profession (Kissau et al., 2019), thereby hopefully increasing the commitment to teaching of undergraduates who value these motives. In this way, hopefully more science undergraduates who complete the minor in teaching will aspire to become a teacher. As such, the minor could function as an effective mechanism that makes science undergraduates enthusiastic about a teaching career, and in that way help to decrease the science teacher shortage.

ORCID

Els Cornelia Maria van Rooij  <http://orcid.org/0000-0001-8080-468X>

Marjon Fokkens-Bruinsma  <http://orcid.org/0000-0001-7551-6843>

Martin Goedhart  <http://orcid.org/0000-0002-8658-0928>

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