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Emotional experiences of secondary pre-service teachers conducting practical work in a science lab course: individual differences and prediction of teacher efficacy

Robbert Smit^{*} , Nicolas Robin and Florian Rietz

Abstract

The present study explored pre-service science teachers' emotions during a semester-long laboratory science course. Emotions were measured with the experience sampling technique, which is a research method that facilitates the observation of emotional states over a long period. We studied the relationships between pre-service teachers' emotional states (enjoyment, stress, and insecurity), self-efficacy traits and beliefs, and their momentary intentions to apply the experiment in later teaching. A total of $N = 101$ pre-service teachers completed a short, electronic questionnaire twice during each of the nine course sessions. Data analysis utilised random-slope multi-level models. Pre-service teachers' emotions became more negative over time. In addition, emotional states accurately predicted teachers' momentary intentions to use the experiment in the future. However, this relationship differed significantly for each course session and between teachers. Emotional states also predicted pre-service teachers' habitual self-efficacy beliefs for teaching biology experiments with small but significant variances between teachers. The results indicate that emotions experienced during teacher education might influence the teacher students' professional attitudes towards science teaching.

Keywords: Emotions, Science experiments, Pre-service secondary school teachers, Experience sampling method

Introduction

Becoming a teacher involves an important emotional dimension (Kelchtermans & Deketelaere, 2016). For example, a practicum can have a deep emotional impact on a pre-service teacher by inducing feelings of helplessness or powerfulness in front of a class (Tsybulsky & Oz, 2019). Thus, emotions are affective phenomena that are stimulated by specific situations and judged based on their positive or negative consequences for a person's well-being (Scherer, 2005). The content of each subject that a pre-service teacher must teach is associated with specific emotions. For example, the relevance of negative emotions is particularly well studied for mathematics

education, and 'mathematics anxiety' is a well-known phenomenon (S. Murphy, MacDonald, et al., 2019; Novak & Tassell, 2017). Borrachero et al. (2014) found that for prospective secondary school science teachers, some subjects, namely physics and chemistry, are more associated with negative emotions while teaching than others. In addition, their study showed that female student teachers exhibited more stress and concern when teaching science than their male counterparts. Furthermore, not only general subjects but also specific subject contents might produce high emotional arousal.

As part of pre-service teachers' education to become a secondary school science teacher, learning to teach science inquiry practically in a science laboratory is a particularly demanding skill often associated with negative emotions

* Correspondence: robbert.smit@phsg.ch
St. Gallen University of Teacher Education, St. Gallen, Switzerland

like insecurity or stress (Antonio, 2018; Miller & Lang, 2016). This might be because students experience too much ‘noise’ (or cognitive overload) in the laboratory due to overwhelming input of information on both theoretical background and practical issues (handling, organising and conducting the experiments) (Dyrberg et al., 2017). Contrariwise, other studies have reported that hands-on activities with more open inquiry approaches in teacher education produce positive emotions like enjoyment (Bulunuz et al., 2012). Further, Riegle-Crumb et al. (2015) demonstrated that inquiry-based science content courses that actively involve primary school pre-service teachers in collaborative processes of learning and discovery promoted an increase in confidence and enjoyment, a decrease in anxiety, and stronger perceptions of the relevance of science. Although positive experiences from coursework do not guarantee that scientific inquiry teaching will be implemented through experimental designs, any favourable attitudes acquired during teacher education can help build resilience towards obstacles that may be encountered later as a professional in the classroom setting (Fazio et al., 2010). This indicates that the experience of emotions in a science course is expected to impact pre-service teachers’ attitudes towards science teaching (Tsybulsky & Oz, 2019).

Until recently, observations of pre-service science teachers’ emotions have often been conducted using qualitative approaches (Bellocchi et al., 2014; Ritchie et al., 2016). Case-studies give deep insights into specific situations and describe in detail the student teachers’ experiences. Contrariwise, quantitative methods might help to answer questions on more general relationships between emotional states and the students’ habitual traits, as posited in latent state-trait theory (Steyer et al., 2015). While latent-strait theory is more methodologically driven, the control-value theory of achievement emotions by Pekrun (2006) describes the psychological functioning of

emotions and its implications specifically for teaching and learning (see Fig. 1). Based on his suggestion of a dynamic research approach, we quantitatively explored whether individual pre-service teachers in inquiry-based science laboratory courses experience emotions differently over time with the help of the experience sampling method. This data-collection method generates time-series data for each student teacher, as elucidated in the subsequent sections. We further investigated how these individual and momentary experiences influence their habitual self-efficacy beliefs and intentions to use the knowledge and skills they acquire in future classes.

Generally, the role of emotions during learning encounters in science teacher education is under-researched (Bellocchi et al., 2014), and very few studies have focused on pre-service secondary school teachers’ emotions during science teacher education. Differences between primary and secondary student teachers’ experiences have been reported as well: Low levels of enjoyment and high anxiety seem to be a larger issue for future primary school science teachers than for those in secondary school (Wilder et al., 2019). Therefore, our study aims to contribute to both areas of research: the emotions of pre-service secondary science school teachers and the development of such states of emotions during a science practices course. Furthermore, we enrich the discussion of how to educate science teachers by studying two specific attitudes (usefulness, self-efficacy) as dependents of the emotional experiences. As Tsybulsky et al. (2020) point out, the role of affects in science student teachers’ attitudes has largely been ignored in research up to now.

Theoretical framework

Emotions as part of pre-service teachers’ science education

Emotions are defined as intense and short-lived affective states that arise in response to particular stimuli and are characterised by situation-specific appraisal functions (Fiedler & Beier, 2014). For instance, insecurity is an

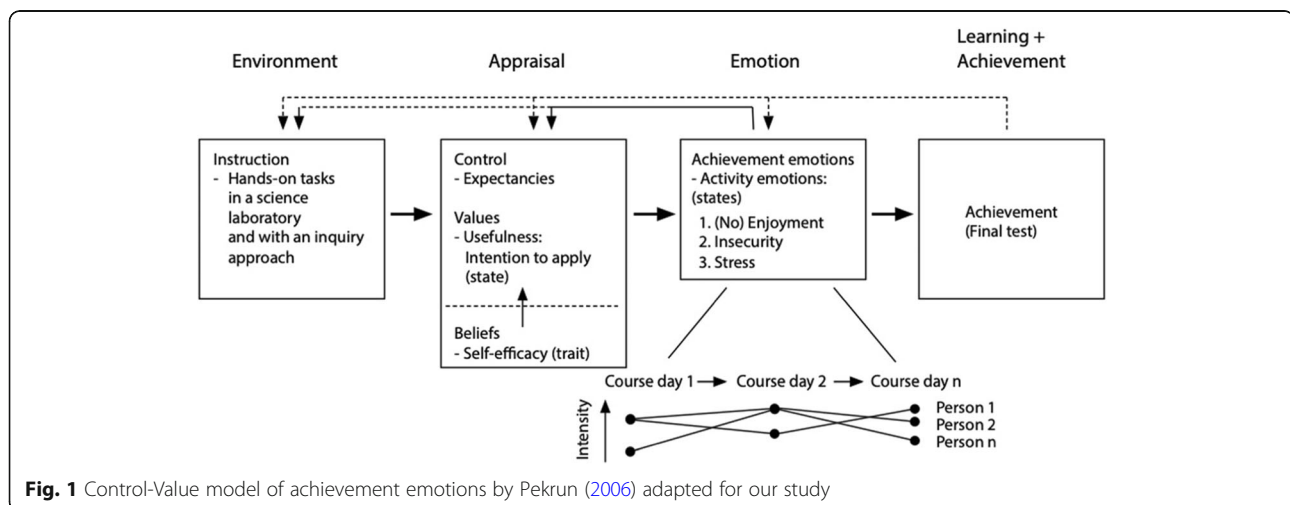


Fig. 1 Control-Value model of achievement emotions by Pekrun (2006) adapted for our study

emotion that may be elicited by a pre-service teacher's lack of experience while handling a specific tool in a science experiment, but it would not accurately describe another situation where, for example, that same teacher may feel proud after correctly interpreting the experiment's desired results (Dunnett et al., 2018). Clearly, different individuals react differently to identical impetuses. This difference is caused by mediating variables, for instance a pre-service science teacher's knowledge, skills, or personality, which determine what emotion they will experience and at what intensity. Emotions evolve from feelings when they are accompanied by specific thoughts, such as one's judgement of an event (Frenzel et al., 2016; Scherer, 2005; Zembylas, 2003). From a psychological point of view, feelings are simply sensational or bodily experiences. For instance, an experienced teacher might feel unconcerned about the warm room temperature of a laboratory because they are accustomed to it. However, for a pre-service teacher, that same feeling would be accompanied by an attribution of dislike or irritation and thus become an emotion. *Affect* is a broader phenomenon that refers to consciously accessible feelings. Emotions are distinct from affect in the sense that the former are relatively more object-oriented and short-lived (Fredrickson, 2001). Nevertheless, in this article, when we refer to affective states, which are also short-lived and situation-based, they include emotions (Linnenbrink, 2006). Emotions are of considerable relevance to instructional processes because they affect teachers' behaviours, play a pivotal role in forming teacher-student relationships, and impact student outcomes (Keller, Frenzel, et al., 2014). In addition, emotions are important for teachers' well-being (Kaldi, 2009) and for the prevention of their burnout (Chang, 2009).

As previously mentioned, emotions are elicited by varying degrees of appraisals made with regard to goal congruence, events' importance/relevance, agency, and control/coping potentials (Frenzel et al., 2009). Furthermore, emotions can be viewed as psychological experiences that are characterised by specific values along different dimensions. The most common dimensions are valence and arousal (Linnenbrink-Garcia et al., 2016) wherein, for example, researchers ask subjects how they feel on a scale from 'unpleasant or negative' to 'pleasant or positive' for valence and 'calm' to 'nervous' for intensity or arousal. Typical negative emotions or valences include anger, anxiety, or stress while positive emotions often relate to joy, pride, or satisfaction. Each emotion can vary in its degree of activation.

With respect to valence in student teachers' education, anxiety seems to be the most frequently occurring emotion. This corroborates the importance of test anxiety research and underscores the high-stakes climate of educational institutions (Pekrun, 2016). However, Pekrun's findings

suggested that most emotions that were experienced pertained to emotional categories other than anxiety. Overall, positive and negative emotions were reported in his study with equal frequency. Positive emotions increase our capacity to generate new ideas and handle difficulties (Fredrickson, 2001). Students who strongly experience positive emotions, such as hope and pride, and weakly experience negative emotions, such as anger, boredom, anxiety, and shame, are more likely to adopt a relatively deeper approach to learning, which is associated with higher learning outcomes (Trigwell et al., 2012). Although we would normally expect negative emotions to obstruct a teacher's continued commitment to a task, it should be noted that negative emotions can also give rise to positive effects. In Darby's (2008) exploration of the success of a school reform programme, negative emotions were a necessary prerequisite for teachers' improvement because these emotions threatened their professionalism and served as learning stimuli. The study further showed that support from coaches and university staff increased the chances of professional development. This is especially important for beginner teachers who are not yet comfortable with their professional role as teachers (Darby, 2008). This result, with respect to positive effects arising from negative emotions, is in line with the research of Pekrun et al. (2002), who distinguished between activating and deactivating negative emotions. Anger, anxiety, and shame are examples of negative activating emotions that induce strong motivations to cope with the negative events that caused them, thereby strengthening specific kinds of extrinsic motivations. However, negative deactivating emotions, such as boredom and hopelessness, may be detrimental to short-term motivation. Thus, there is some ambivalence in the relationship between anxiety and academic achievement, which explains why there is often little explanation for variance in achievement due to test anxiety (Ma, 1999).

Following the control-value theory of Pekrun (2006), some of the emotions observed during scientific activities in laboratory courses can be considered achievement emotions. Achievement emotions can be seen as either momentary occurrences in a specific situation at a certain point in time (e.g. a state of insecurity while working with a yet unknown scientific tool) or habitual or reoccurring emotions that are typically experienced by student teachers during achievement activities and are related to outcomes (e.g. trait subject-specific anxiety). In his theory, Pekrun assumes that achievement emotions are determined by control and value appraisals. For example, if a student teacher finds that the experiment is pleasant and going well, he enjoys the activity. Enjoyment would be a positive, activating, outcome-related achievement emotion. Further, cognitive appraisals like self-efficacy (control) or usefulness perceptions (value) are antecedents of emotions, but emotions can reciprocally affect these

appraisals. This is of course a very shortened version of his theory, but it suffices to indicate the theoretical underpinning for our research questions with respect to the interaction of emotions and attitudes in this study.

The role of emotions in science laboratory courses

Hechter (2011) observed that negative attitudes increase during laboratory courses as pre-service teachers develop more critical self-analysis tendencies after their participation in primary school science methods courses. However, this could be more of a problem for pre-service primary school teachers than for secondary school teachers. For example, in a study by Smit et al. (2017), pre-service secondary school teachers with high self-efficacy beliefs in teaching biology indicated that they experience joy while employing experiments in the classroom.

There are also context effects that seem to influence emotional experiences. When pre-service science teachers enter teacher education courses, they might introduce their negative attitudes towards science from their previously attended schools, which could affect their future learning (Tosun, 2000a). Such negative feelings can be explained by a marked absence of successful experiences in compulsory school science lessons.

What fosters positive emotions in science laboratory work? Small-group teaching and laboratory work are recommended for improving pre-service teachers' self-confidence (Appleton, 1995). Practical activities and laboratory work allow student teachers to interact with equipment and materials or secondary sources of data to observe and understand the natural world (Hofstein & Kind, 2012). For pre-service teachers, the hands-on experiences gained through laboratory work courses, which allow for the inducement of successful science learning experiences, seem to foster self-efficacy beliefs, resulting in lower levels of science anxiety and improved attitudes towards science in general (Avery & Meyer, 2012; Bleicher & Lindgren, 2005). According to Davis et al. (2018), Australian pre-service teachers believe that hands-on activities (including practical activities and experiments) are the best method for enhancing students' interest in science. The authors supposed that this intuitive idea was derived from the pre-service teachers' own experiences in formal education and teacher training. Student teachers had fun during hands-on science education units at university, and these emotions fostered their interest in teaching science and applying scientific techniques in similar ways. However, compared with the pre-service primary school teachers, the secondary school student teachers felt more motivated after discussing different scientific techniques than through active participation in them.

Finally, Cross and Hong (2009) point out that if pre-service teachers are not able to develop a positive view

of themselves as being competent at conducting science experiments by the end of their education, they will not place a strong focus on student-oriented science practices in their own teaching because, for them, doing so is not connected with positive emotions.

In secondary school, working in laboratories is connected with acquiring skills on scientific processes and practices. Engaging students in scientific processes and practices (e.g. discussion, argumentation, modelling, representation, and learning through investigation) builds science proficiency (National Research Council, 2012). In the US science standards the term scientific practices replaces or expands meanwhile the more known term scientific inquiry (Bybee, 2011). In science, *inquiry* is associated with the processes and methods that are used by practising scientists. Inquiry-based teaching is used to describe the learning process engaged in by the students that, on some level, follows the process of scientific inquiry, namely teaching through inquiry (Cairns & Arepattamannil, 2019). However, the term is of limited practicability for school science. On the one hand, there is seldom time in the science classroom to complete a full circle of inquiry. On the other hand, practical research is a messy, complex, and dynamic process with many twists, turns, and reversals and not a straight sequence of independent procedures, as seen in many classrooms (Bevins & Price, 2016). Hence, educators have proposed a couple of less demanding and less complex conceptions of science inquiry teaching adapted for school science (Murphy, Smith, & Broderick, 2019). Classroom science inquiry activities are emotionally charged, particularly for beginner teachers (Roehrig & Luft, 2004), since the required hands-on activities necessitate more freedom, student independence, and spontaneity, posing a challenge to classroom discipline (Gyllenpalm et al., 2010; Hong, 2012). Therefore, from the perspective of pre-service teachers, adopting an inquiry approach to teaching science is a risky, messy, and challenging task that makes many of them miss typical science lessons, which are characterised by the certainty and authority of scientific knowledge (Kim & Tan, 2011). It is estimated that many experienced science teachers find teaching scientific inquiry to be very demanding because of the numerous objectives that the students need to attain, such as understanding various concepts, theories, laws, and higher-order learning skills (Hodson, 1996).

Pre-service teachers who present negative attitudes towards inquiry-based science have less self-confidence and self-efficacy in teaching it as a subject (Tosun, 2000b). As reported by di Fuccia et al. (2012), open-ended or inquiry-based experiments are rare in German classrooms. Science teachers' unfavourable attitudes could be the reason why student practical work aligned with scientific inquiry

concepts is not common in every classroom (di Fuccia et al., 2012).

Emotions related to attitudes

In pre-service education, exposure to science curriculum resources (e.g. lesson plans, teaching methods) has been shown to produce positive feelings and values that foster student teachers' intentions to use these resources in their future teaching (Tsybulsky et al., 2020). Cooper et al. (2012) reported that student teachers' engagement with hands-on science materials produced emotions of enjoyment and led to positive attitudes towards science teaching approaches that utilise the provided resources. More confident pre-service teachers were associated with higher intentions to apply their acquired knowledge and resources to future teaching. Generally, not only did emotions play a central role in the construction and development of student teachers' attitudes during teacher education but were also responsible for a potential change in their attitudes (Kelchtermans & Deketelaere, 2016). Emotions may intensify resistance to change, but they concurrently constitute potential levers for modifying or replacing attitudes. For example, in the case of using technology for teaching, pre-service teachers' attitudes towards usefulness and ease of use benefited from accompanying positive emotions (Teo & Noyes, 2011). In addition, the authors showed that, the experience of joy is important for strengthening student teachers' intentions to use these acquired skills in their future teaching.

In addition to appraisals about the value of a task, control beliefs, e.g. self-efficacy expectations, also play a role in the interaction with emotions. Bandura (1977, p. 3) defined self-efficacy as 'beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments'. Feelings of low self-efficacy can lead to less effort and more stress in response to demands. Self-efficacy is context-specific, which means that the level of perceived ability changes for each person depending upon the situation or task (Tschannen-Moran & Hoy, 2001). It is important to clarify whether momentary experiences in practical science teacher education courses accompany negative emotions due to high task demands that might hinder a pre-service teacher's future classroom implementation of their acquired skills. This negative impact might be mediated by pre-service science teachers' low efficacy beliefs (Cantrell et al., 2003).

DeMauro and Jennings (2016) conducted a study among pre-service teachers at several school levels with the aim of analysing the relationships between teacher efficacy beliefs and three negative emotions: depression, anxiety, and stress. Emotions were recalled as memories of the previous week. While depression showed a negative relationship with teachers' efficacy beliefs, anxiety and stress did not seem to exert an influence. The

authors suggest that, in line with Bandura, depressive moods may be considerably debilitating to one's sense of efficacy due to a reciprocal feedback loop. Stress and anxiety, however, still allow the student to respond with additional focus and preparation for classroom instruction. According to the author, failure to determine the relationship of stress and anxiety with self-efficacy might reflect individual differences in responding. Cakiroglu et al. (2012) recommended that future studies focus on the sources of teachers' efficacy beliefs, of which emotions are a crucial feature (Usher & Pajares, 2008). Such an emphasis on emotions would enable teacher educators to modify their courses and field experiences to enhance pre-service teachers' efficacy beliefs.

Research questions

As outlined in the introduction section by utilizing the control-value theory of achievement emotions and suggestions by Pekrun (2006) and Frenzel et al. (2009), we expect pre-service teachers' state emotions to influence their state intentions and trait efficacy-beliefs. This is also depicted in Fig. 1.

The following questions have arisen:

- a. How do pre-service secondary school teachers' emotions develop over the duration of the course?
- b. Will these momentary emotions foster student teachers' intentions to apply the scientific practices and experiments they have experienced in their future teaching?
- c. Is the development of science teaching self-efficacy dependent on the emotions associated with conducting science experiments?
- d. Do the trajectories of these developments differ between student teachers?

These questions lead to the following related hypotheses. The first question a. is answered as a preparatory part while the last question d. is answered as an integral part of the two hypotheses.

- (1) Over time and from person to person, there is an inverse relationship between the experience of negative emotions and the momentary intention to apply the accompanying science experiment(s) in future science teaching.
- (2) The experience of negative emotions (state) has a negative effect on science teaching self-efficacy beliefs (trait) after course completion.

Methods

Research design

We used an intensive, nonexperimental, longitudinal design for the measurement of the state emotions.

Intensive indicates that we collected repeated measurements frequently in order to characterise a separate change process for each subject (Bolger & Laurenceau, 2013). *Characterising* means that we also looked at the causes and consequences of the changes.

The experience sampling method

Ritchie et al. (2013) noted that because emotions are fleeting and often difficult to recall later, the exercise of measuring emotions should concentrate on teachers' in-the-moment emotional experiences, for instance, through the use of interviews or questionnaires that are administered directly after the intervention. The experience sampling method (ESM) is a research method that addresses this issue (Goetz et al., 2016). It is a data collection method that is temporally close to the connected event; in our study, that event is the student teacher in a series of laboratory work situations. Study participants are asked to provide systematic self-reports at random occasions during this time. ESM also helps to overcome problems with reconstructing experiences after the event (Larson & Csikszentmihalyi, 2014). Compared to retrospective questionnaires and interviews, ESM offers several advantages: (a) enhanced ecological validity because participants are assessed in their normal daily environments, (b) minimised retrospective bias because participants' experiences are assessed in the moment, and (c) enhanced reliability because participants' experiences are assessed repeatedly (Csikszentmihalyi & Larson, 1987). With the help of electronic devices such as tablets and mobile phones, real-time emotions can be collected quickly via short questions during coursework. Quantitative analysis is most often applied to this method of research. The specific analysis will be described further down.

Sample

Our convenience sample consisted of all the participants who were listed in two consecutive first-year science experimentation courses ($N = 101$). All pre-service secondary school teachers in our institution need to study four school subjects to earn a Master of Science in secondary education (MSc). The 'science and technology' school subject is comprised of biology, chemistry, and physics material. In their second semester, pre-service secondary school teachers need to take a mandatory course on practical biology. The mean age was 23 years old ($SD = 4.6$) and gender was distributed equally in the sample (47% male/53% female). There were no specific ethnic groups.

Instruments

Attitudes (traits)

Before the start and at the end of the semester-long course, the student teachers completed a questionnaire to measure their self-reported attitudes. For this study, only one attitude of this questionnaire was included, namely self-efficacy, which was measured with five items from the STEBI-B (Bleicher, 2004) (see Appendix). Three self-efficacy items were slightly reformulated so that they better fit the construct of scientific inquiry teaching. All five items were summarized in a scale and the reliability index for both time points (Cronbach's $\alpha = .77/.88$) was computed. We used a 6-point Likert scale (6 = *absolutely agree*, 5 = *agree*, 4 = *somewhat agree*, 3 = *somewhat disagree*, 2 = *disagree*, and 1 = *absolutely disagree*).

Momentary emotions (states) and related aspects

Self-reporting takes time. As such, it is not optimally suited to assess the real-time dynamics of emotions in a classroom (Pekrun, 2016). One circumvention strategy is to reduce the number of questionnaire items in order to avoid compromising the assessment of momentary emotions (Goetz et al., 2016). The application of a few single items has been recommended and successfully applied by other researchers as a means of avoiding overly intrusive state-based questionnaires (Becker et al., 2014; Goetz et al., 2010). Although it would be desirable to capture more emotions, the repeated use of a long questionnaire in each lesson was not feasible as it would have taken up too much course time. We limited the online questionnaire (which was accessed via handheld devices) to a few single items that asked about the subjects' emotional states; this was comparable to the study by Keller, Chang, et al. (2014) and other similar studies. For each of the course's lessons, a short questionnaire with single items was supplied with two items related to a negative emotional state or sense of well-being (insecurity, stress), one item related to a positive state (enjoyment), and one item related to the intention to apply the experiment(s) or practical task(s) in the future (see Appendix). The choice presented by the first three items reflects the descriptors used by the student teachers to characterise their feelings toward science courses (Tosun, 2000a). The descriptors used by Tosun's study participants were overwhelmingly negative and he suggested that achievements in science are overshadowed by negative feelings that influence science teaching self-efficacy. Given that pre-service teachers often experience experiments as challenging (Bellocchi & Ritchie, 2015), we chose insecurity (i.e. 'can I handle the scientific tools?') and stress (the threat of failing to conduct the experiment) since these emotions relate to action-control expectations as described in Pekrun's control-value theory of

achievement. The anxiety of failure is high when action-control expectancy is low (Pekrun, 2006). On the other hand, enjoyment is prominent among the range of positive emotions mentioned in relation to science courses (Bulunuz et al., 2012; Palmer et al., 2016). With regard to the activity-related emotions that surface during achievement activities, the attentional focus is on action. A student teacher who is experiencing enjoyment and flow while engaged in a hands-on experiment, for example, will focus their attention on the activity of handling the scientific tools rather than on potential outcomes (Csikszentmihalyi & Schiefele, 1995). Similarly, for the fourth state variable that we included in this study, namely 'momentary intention to apply the experiment in the future', a valid measurement was produced by this method as opposed to when the pre-service teachers were retrospectively interrogated about whether they would use the experiments as a whole after the course was completed. With retrospective interrogation, it would remain unclear which of the experiments they could recall or which would be most salient. Conversely, with the alternative approach, it is possible to test whether their intentions vary from one course unit to another.

All participants were asked to complete a short survey twice during each lesson: once just before they started conducting experiments and once immediately after the end of the last experiment. We used a 6-point Likert scale that enquired whether the student teacher was at that moment joyful, stressed, and so on (6 = *absolutely agree*, 5 = *agree*, 4 = *somewhat agree*, 3 = *somewhat disagree*, 2 = *disagree*, and 1 = *absolutely disagree*). Measuring an item twice during each course session added up to 18 measurements for each student teacher and item over time.

During the process of building a scale for momentary emotions (insecurity, stress, enjoyment), we recoded 'enjoyment' to 'no enjoyment', which allowed us to create a new scale for 'negative emotions'. Recoding or reversing means that the numerical scoring scale runs in the opposite direction; that is, a six becomes a one and vice versa. Scales allow for computing internal consistency reliability statistics. In addition, random measurement errors are more likely to be cancelled out with multiple items. Based on empirical research (Lohbeck et al., 2018; Robotham & Julian, 2006), we included the context variables age, gender, and test (grade) in our analysis.

Research tools and data collection

The data for this study were collected during two pre-service secondary school teacher training courses on conducting practical tasks and experiments in biology during both the 2018 and 2019 autumn semester at the St. Gallen University of Teacher Education. In Switzerland, secondary school science teachers are prepared to teach several science, technology, engineering, and mathematics (STEM)

subjects as well as non-STEM subjects; therefore, every pre-service science teacher in their second semester of study needs to take the science course. Basic scientific practices, including training on how to pipette, operate Bunsen burners, open a CO₂-bottle, and write lab protocols, etc. were learned in a one-week course in the first semester. In addition, they had to conduct a self-study course on the basics of science, the content of which was tested at the end of the second semester. It was assumed that the content knowledge required for the science lab course had been acquired at a basic level in high school. During the course's nine two-hour lessons, student teachers worked on experiments in the fields of plant and human physiology (e.g. the action of enzymes), plant and human anatomy (e.g. examining calf lungs for chest and diaphragmatic breathing), and microbiology (e.g. thin layer chromatography). All the experiments were destined for future teaching at secondary school. There was always a short theoretical introduction to the topic of the course and the theoretical material was available online for each course in advance. It was expected that the student teachers would prepare themselves independently. One of the course's aims was to explicitly model how experiments are designed and conducted as part of scientific inquiry teaching. A special focus was placed on applying the control of variables strategy (CVS). Since the course required that pre-service teachers had laboratory skills that can meet a high level of demand, the inquiry process was rather structured (Banchi & Bell, 2008). In order to facilitate fruitful learning exchanges, the course was facilitated in small groups of about eight student teachers. Since scientific equipment was limited, the student teachers often worked in pairs.

As mentioned in the section "Instruments", in each course session every student teacher had to complete a short electronic questionnaire with single items using a tablet or a mobile device twice. Before and after the course, a longer questionnaire was implemented to measure the student teachers' general attitudes, e.g. self-efficacy beliefs. In the last week, the two course leaders administered an individual oral test that took 15 min and was graded from 1 (lowest) to 6 (highest). Each student teacher had to draw a theme and notes from the course could be used. Validity was ensured by relating the posed questions specifically to the practical and theoretical aspects of the course content while reliability was based on a shared rating of the student teacher's performance. All the student teachers passed the test and a one-time repetition was possible. Failure to pass would have resulted in compensation with a different course but this would have been possible only once.

Data analysis

A multi-level structure in which measures are nested within persons (two-level structure) should be considered

to analyse the longitudinal data, as it allows for the investigation of within-person processes (level 1) as well as between-person differences (level 2). For example, we can ask which emotional states go together at a given moment. However, we can also examine the long-term development of emotional states and how they might predict people's traits (e.g. self-efficacy beliefs).

The simplest growth model is an “unconditional” model without level-2 predictors, e.g. negative emotions dependent on time (Heck & Thomas, 2015, p. 231–232). This could be expressed at level 1 as following:

$$\gamma_0 = \pi_{0i} + \pi_1 \text{time}_{it} + \varepsilon_{it},$$

where π_{0i} is defined as the initial status intercept, and π_1 is the expected linear growth rate for individual i during a fixed unit of time (here the nine course units). The residuals ε_{it} represent random error in measuring student's emotional state at occasion t . Each individual student has its own growth trajectory (developed from the intercept and slope). Between students (individuals), at level 2 the initial status and slope coefficients for the individual-level can be described as follows:

$$\pi_{0i} = \beta_{00+} r_{0i}$$

$$\pi_{1i} = \beta_{10+} r_{1i}.$$

The two equations at level 2 suggest that each random coefficient (β_{00} and β_{10} , respectively) has its own intercept, which describes the average across the set of students and a random coefficient (r_{0i} and r_{1i} , respectively). The variance term (r) suggests that there is a variability in the estimates of the respective intercept and growth slope across the sample of students.

As indicated above, in order to analyse the data, random-slope multi-level models were applied. *Random slope* means that not only there are differences between student teachers intercepts, but slopes are allowed to differ between them as well. We used Mplus 8.0 to compute the models. The internal validity of the negative emotions construct was inspected by means of confirmatory factor analyses and maximum-likelihood (ML) estimation. For small sample sizes and multi-level latent variable models with random effects in particular, Bayesian analysis is an attractive alternative to ML estimation (Muthén, 2010; Muthén & Asparouhov, 2012). The Bayesian estimates are obtained as the means, modes, or medians of their posterior distributions. This includes the calculation of estimates for missing data. Priors can help to optimise small variance parameters. Mplus uses a series of default priors that we did not alter due to missing information from other studies. However, we checked for posterior distributions' plausibility. Estimations for different iterations were conducted to determine convergence and PSR values were

checked as well (van de Schoot & Depaoli, 2014). In addition, we studied plots for controlling 'burn in'. A 95% confidence interval was produced for the difference in the f statistic for the real and replicated data (Muthén & Asparouhov, 2012).

Results

Table 1 provides the means and standard deviations for the variables used in this study. Any missing data was due to illness or certain student teachers' conflicting responsibilities during the science lab course, thus missing completely at random (MCAR) with respect to our research. While there was no missing data for the trait questionnaire, those missing in the time series data were estimated based on the Bayesian posterior distribution, a procedure closely related to the technique of multiple imputation. The mean values for the three variables of the negative emotions scale give the impression that working on the experiments was not strongly marked by negative feelings. However, looking at the standard deviations, it becomes clear that variation between student teachers was high at least for (no) enjoyment and stress. Figure 2 shows for each student teacher the regression line for the development of emotions over time. The mean momentary intention to apply one of the experiments in future teaching is positive but not very high. Here, there is a larger standard deviation, meaning that for some pre-service teachers, the intention was high and for some the intention was quite low. Changing to trait variables, the means of self-efficacy for teaching biology show no significant differences between the two time points. However, the correlation of the measurements is $r = .31$, indicating that for the individual person, some changes in her or his self-efficacy beliefs might have occurred over the course time period.

As a further step in the analysis of the data, a CFA multi-level model for student teacher negative emotions over time was calculated. All items loaded significantly on the latent factor 'negative emotions' on the within (time) and the between (student teachers) level. The standardized factor loadings on the within level were .58

Table 1 Descriptive statistics

	Mean	SD
No enjoyment (states)	2.98	1.69
Stress (states)	2.43	1.94
Uncertainty (states)	2.41	0.84
Applying experiments in future (states)	4.14	1.84
Self-efficacy t1 (traits)	4.47	0.83
Self-efficacy t2 (traits)	4.56	0.69

$N = 101$, 'states' are mean values aggregated over time; 6-point Likert scale (6 = *absolutely agree*, 5 = *agree*, 4 = *somewhat agree*, 3 = *somewhat disagree*, 2 = *disagree*, and 1 = *absolutely disagree*)

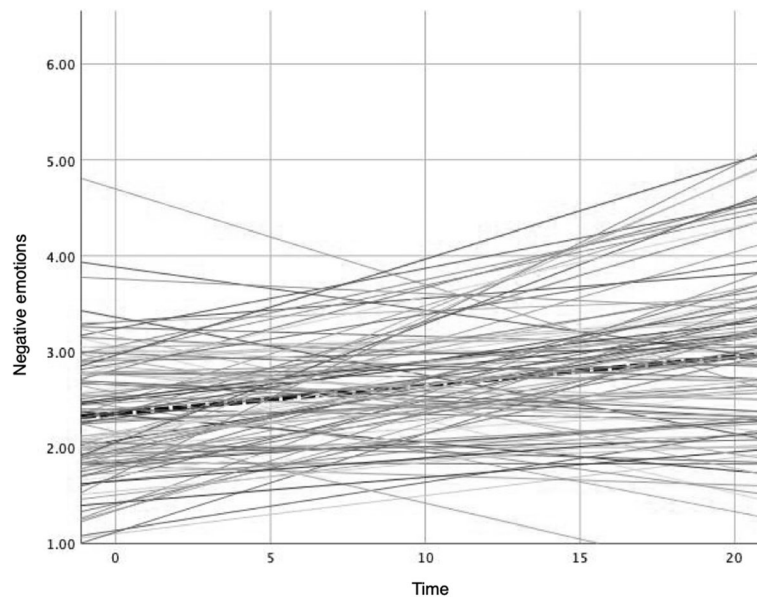


Fig. 2 OLS-Regression for negative emotions on time separated for each student. The dotted line represents the mean regression line

(no enjoyment), .71 (stress), and .52 (insecurity) and on the between level .45 (no enjoyment), .82 (stress), and .46 (insecurity). The model with three manifest items showed good fit values: $\chi^2(7) = 5.59, p = .59, CFI = 1.00, TLI = 1.00, RMSEA = .00, SRMR_{within} = .001, SRMR_{between} = .06$. For each of the three items, a substantial amount of variance lies between the student teachers (Insecurity: $ICC = .21$; no enjoyment: $ICC = .23$ and stress: $ICC = .37$). Age ($\beta = .11$), gender ($\beta = -.05$), and content knowledge (CK) test ($\beta = -.29$) were included in the model as control variables, but only the CK-test was significant. Student teachers who scored higher on the oral CK-test at the end of the course showed lower momentary mean negative emotions.

Next, we established two random-slope multi-level models (Table 2) to gain information on the development of student teachers' negative emotions. The difference between the two models is that we included the CK-test result as a control variable in model 2. The grade of the CK-Test (1–6) was shown to be a significant predictor in the CFA mentioned above. Over time, there was a small increase in negative emotions (averaged over student teachers $\beta = .23$). The individual line graphs based on OLS regressions depicted in Fig. 2 are presented as an illustration only. They show that a growth of negative emotions was not the case for all student teachers, however. A few of them, as shown in Fig. 2, reduced their negative emotions over time. In the two random slope models, the variable 'negative emotion' was included as a latent variable, measured by insecurity, no enjoyment, and stress. The computational burden for multi-level random slope models with latent variables

that need numerical integration is considerable. Therefore, we switched to Bayesian estimation, which allows for better estimation of parameters for random slope models (see also the method section).

It is important to consider the deviations of the individual growth trajectories from the mean growth trajectory. This information is presented in Table 2 in the section labelled 'random part'. The estimates for variance over time and for between-person variance were both significant. This outcome indicates that negative emotions differed over time and between student teachers as well. Although the variance of the growth rate was also significant, the value was approximately 0. Hence, the growth of negative emotions was quite

Table 2 Random slope model for pre-service teachers' negative emotions (states) over time

	Model 1		Model 2	
	B	SE B	B	SE B
Fixed part				
<i>Between</i>				
Test (grade)			-.14**	.08
Mean growth rate	0.04**	0.00	0.05**	0.01
Covariance	-0.01	0.01	0.00	0.01
Random part				
Within variance (time)	0.72**	0.08	0.70**	0.08
Between variance (person)	0.29**	0.15	0.30**	0.15
Slope variance	0.00**	0.00	0.00**	0.00

Variables are presented as unstandardized Bayesian estimates and standard error (SE)

** $p < .01$

comparable for all student teachers; however, the negative emotions were not at the same level. The covariance of intercept and slope was not significant. Therefore, we cannot say anything about the direction of change for the individuals based on the intercept. As already mentioned, a covariate was added in Model 2. Based on preceding CFA analyses and confirmed by conversations with the student teachers, the verbal CK-test at the end of the course related to the growth of negative emotions. Test grade predicted negative emotions with a significant β of $-.20$, meaning that student teachers with a high grade on the verbal test had fewer negative emotions. Including CK-test as a control variable did not lower the growth rate of negative emotions, thus conducting the lab exercises produced negative feelings over time.

In the following section, the first hypothesis will be examined, namely whether there was a relationship between experienced emotions and the momentary intention to apply the science experiment(s) in future science teaching. A null or random-intercept as well as a random-slope model are presented in Table 3. In the random-intercept model (Model 0) for the intentions to use the experiment(s) in the future, the mean intercept is similar to the value from Table 1 ($M = 4.14$). In addition, in Table 3, variances are found for this variable within the pre-service teachers over time and between them. Although both values were significant, variance within a teacher was much larger than between teachers. Hence, the different experiments and related topics might have had an effect on the pre-service teachers' future intentions. Some experiments and practical tasks seem to have had more appeal for future school practice than others. However, an in-depth analysis of the differences between the state variables for each experiment is beyond the scope of this article. Although it is not presented here in detail but merely as additional

information, over time, the intention to use the experiments in the future declined slightly ($\beta = -.17$).

Again, an illustration with individual line graphs based on the OLS regressions is shown in Fig. 3. It can be detected that the relation between momentary negative emotions and the intention to use the actual experiment in future teaching differed from student teacher to student teacher. This result can be derived from Model 1 in Table 3 as well. In the random part, variances within pre-service teachers over time and between teachers are presented and both were significant. With respect to the relationship between negative emotions and future use of the experiment, on average, there was a correlation of $\beta = -.69$. The more negative the emotions were at the moment, the less the momentary intention was to use the experiment in the future. However, as mentioned, this relationship varied significantly for each experiment and between student teachers on different levels (intercept): at the same level of negative emotions, the student teachers' intention to use the experiments varied around two scale levels. The slopes varied slightly, meaning that some pre-service teachers reacted stronger with their intention on negative emotions than others and vice versa.

Next, the second hypothesis will be examined: was there a negative effect of experienced negative emotions (state) on science teaching self-efficacy beliefs (trait) after the course? To answer this question, we again established two multi-level random slope models (Table 4). The difference between the two models is that pre-service teachers' self-efficacy beliefs before the course started were included as a covariate in the second model but not the first. Basically, many values are comparable to those in Table 2 (e.g., the random part). What we can see in the fixed part of Model 1 is that the pre-service teachers' momentary negative emotions had a considerable negative effect on teachers' self-efficacy

Table 3 Random slope model for pre-service teachers' momentary intentions to apply the experiments in the future (states)

	Model 0		Model 1 – random slope	
	B	SE B	B	SE B
Fixed part				
<i>Between</i>				
Mean experiments in future	4.14**	.06	4.15**	0.06
Mean growth rate			-0.93**	0.05
Covariance			0.02	0.04
Random part				
Within variance	1.56**	.06	0.88**	0.06
Negative emotions variance			0.57**	0.19
Between variance	0.29**	.06	0.25**	0.05
Slope variance			0.05**	0.02

Variables are presented as unstandardized Bayesian estimates and standard error (SE)

** $p < .01$

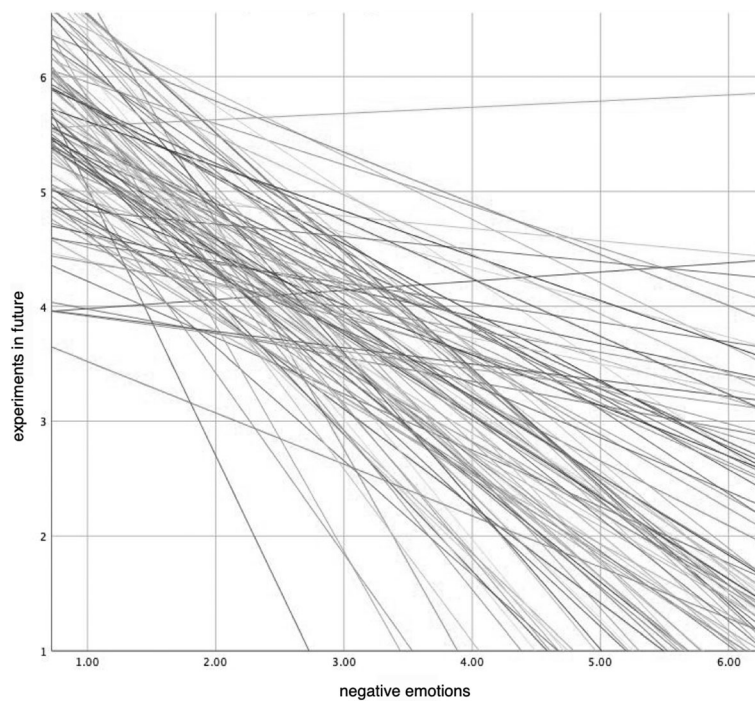


Fig. 3 OLS-Regression for momentary intention to apply experiments in the future on momentary negative emotions separated for each student. The dotted line represents the mean regression line

beliefs after the course ($\beta = -.42$). This effect dropped only slightly when we controlled for self-efficacy beliefs before the course ($\beta = -.39$). Based on these beta-effects for the prediction of self-efficacy t2 by negative emotions, we deduce that part of the rather low correlations of the pre-service teachers' self-efficacy beliefs over time ($r = .31$) could be explained by the negative emotions

they experienced in the course modules and might have led to some changes in their beliefs.

Table 4 Random slope model for pre-service teachers' self-efficacy beliefs (t2) (traits)

	Model 1		Model 2	
	B	SE B	B	SE B
Fixed part				
<i>Between</i>				
Mean self-efficacy beliefs t2 (traits)	4.58**	0.07	2.95**	0.48
Mean growth rate	0.04**	0.01	0.05**	0.01
Covariance	-0.01**	0.01	-0.01**	0.01
Negative emotions (states)	-0.54*	0.32	-0.52*	0.49
Self-efficacy t1 (traits)			0.34**	0.10
Random part				
<i>Within</i>				
Negative emotions	0.74**	0.08	0.75**	0.08
<i>Between</i>				
Negative emotions	0.28**	0.15	0.26**	0.16
Slope variance	0.00**	0.00	0.00**	0.00

Variables are presented as unstandardized Bayesian estimates and standard error (SE)
 ** $p < .01$, * $p < .05$

Discussion

To our knowledge, this is the first time that the combination of experience sampling and quantitative longitudinal analysis was applied to answer questions related to the learning of pre-service science students. Our aim was to observe the longitudinal development of pre-service teachers' emotions during all the lesson units that are part of a secondary school student teacher's laboratory training in biology. The experience sampling method was applied in support of this goal, having the advantage of obtaining real-time self-reported data with high ecological validity (Goetz et al., 2016). The high ecological validity of the measured momentary emotions is specific to our results when compared to global self-reports in being less resistant to recall inaccuracies. In addition, we employed statistical methods that took the non-independence of the measures (nested within persons) into account. Therefore, it was possible to model differences over time and between persons. This relates to our fourth research question, namely whether the trajectories of the emotional experiences over time differed between student teachers. This question can be answered in the affirmative in advance for all the presented investigations, even if the differences between the student teachers were small.

Before summarising the results and with respect to the research questions and the existing literature, we would like to note that we were able to use a scale for (negative) emotions and not just a single item. Although this is seldom seen in ESM analysis, it offers some advantages with respect to validity and reliability (Gogol et al., 2014; Zembylas & Schutz, 2016). Therefore, we combined three single items that measured pre-service teachers' feelings of stress, insecurity, and enjoyment (reversed to no enjoyment).

How did pre-service secondary school teachers' emotional experiences develop over the duration of the course? Related to this first research question, it showed that negative emotional experiences increased over the duration of the course. This rise can partially be explained by the oral CK-test that was scheduled to occur near the end of the course. The relatively small relationship between test outcomes and negative emotions is in line with studies that have examined the impact of test anxiety on achievement outcomes (Ma, 1999). After speaking to the student teachers and asking for other reasons, it became clear that, in their eyes, the CK-test was the only reason for the increase; more precisely, the prospect of taking an exam caused stress, rather than the exam itself (Robotham & Julian, 2006). Other predictors such as age and gender were tested, but these did not help explain the variance in the student teachers' emotional experiences over time. Hence, contrary to Borrachero et al. (2014), we could not detect any gender differences for pre-service teachers' negative emotions. In addition, and as a specific finding for this study, we observed differences in negative emotions from one course unit to another and between course participants. Although it would certainly be interesting to explore which course topics caused more versus fewer negative emotions, such an investigation would go beyond the scope of this article.

Our second research question asked whether these momentary emotions fostered student teachers' intentions to use science practices and experiments that they experienced in their future teaching. With respect to this question and our first hypothesis, and in line with previous studies (Borrachero et al., 2014; Cross & Hong, 2009), we can confirm a strong relationship between the momentary experience of negative emotions and the intention to apply the experiment in future teaching. This relationship differed between student teachers and between specific course units and experiments. However, the differences between student teachers are basically due to variance in each variable rather than variance in the relationship between two variables. In other words, the correlation between momentary negative emotions and future application was almost the same for each student teacher – slope variance was almost 0. Most differences were found across course units and within individuals with respect to the intention to use the

experiments in the future. This outcome means that some experiments seemed more attractive for future science teaching than others. To sum up, fewer negative emotions foster student teachers' intentions to use the learned experiments, but this varies according to different practices and experiments.

Finally, with our third question, we were interested to find out if the development of science teaching self-efficacy was dependent on the emotions that are associated with conducting science experiments. Exploring this question and our second hypothesis produced results that are well known from other studies (Cantrell et al., 2003; Hascher & Hagenauer, 2016); that is, pre-service teachers' emotions were related to their self-efficacy beliefs. More precisely, for our study, momentary negative emotions had a rather strong negative effect on student teachers' habitual self-efficacy beliefs as they pertain to teaching biology. The more negative the student teachers' average emotions were over time, the less self-efficacy they showed at the end of the course. This effect remained if we controlled for previous self-efficacy beliefs at the beginning of the module.

Implications

The current study contributes to the literature, as the longitudinal design and the multilevel analysis allow for the study of developments of student teachers over a longer period, thereby disentangling individual and between processes. In addition, based on latent state-trait theory (Steyer et al., 2015) we could show how emotional states have an influence on traits—here, self-efficacy beliefs and teaching intentions. In the following we will discuss specific outcomes of our study and their implications for research. Contrary to normal expectations, increasing habituation to a situation did not lead to a reduction in negative feelings. It is noteworthy that negative emotions do not need to be seen as completely obstructive to learning (Pekrun et al., 2002). Negative activating emotions that induce strong motivations to cope with the negative events that caused them should have the effect of strengthening specific kinds of extrinsic motivation. Why was there not a reduction in negative feelings? It might be supposed that the pre-service teachers experienced each course session as a completely new challenge, and they were not able to familiarise themselves with the laboratory setting. This is supported by our results, as there was substantial variance in the individual intention to use the practices and experiments in future teaching. Hence, the course contents were perceived as rather different. A growing feeling of confidence, as reported in other studies, did not take place (Riegler-Crumb et al., 2015). This might be related to the demanding objectives of scientific inquiry activities (Hodson, 1996). With reference to enjoyment specifically, a habituation effect has

certainly also set in, leading to deeper arousal and thus to a decline of the values for emotional experiences.

Even in-service teachers often have difficulty implementing inquiry-based activities, thereby fuelling negative emotions (Ritchie et al., 2013). When we looked at an individual pre-service teacher, the results became less disappointing with respect to increasing negative emotions, and this is the advantage of our statistical procedure. A smaller number of pre-service teachers showed a positive development, and finding out who they are could be the next step in related research. This could either be done in a more explorative way by interviewing them or in a more hypothesis-based approach. Some theoretical-based ideas for such predictors might be found in Uitto et al. (2015). From their overview of teacher emotions, the concept of emotional intelligence and skills could be a starting point for a study of other explaining factors. The derived results might also help those student teachers belonging to the larger group in developing their emotional skills. Until then, one suggestion would be to give more emotional support, which would mean providing individually-adapted feedback (encouragement, praise, advice, or reassurance) as suggested by Dennis et al. (2016). We will take up this argument in relation to the control-value theory (Pekrun, 2006).

In line with other research (Linnenbrink & Pintrich, 2003), it was seen that negative emotions affect the development of teachers' self-efficacy beliefs. While this has been discussed in the context of practical science teacher education for pre-service primary teachers, our results showed that this is an issue for some pre-service secondary teachers too. While DeMauro and Jennings (2016) proposed that self-efficacy serves as a protector against stress, in our study it seems that the student teachers' beliefs were challenged during the science lab course and that form of protection did not work. Compared with the self-efficacy values over several time periods ($r = [.76, .88]$) of Canadian pre-service teachers in a field practicum (Klassen & Durksen, 2014), our derived value ($r = .31$) indicated some changes in beliefs. Nevertheless, similar to our study but in reverse, they found in their study that a general pattern of growing self-efficacy beliefs correlated with decreasing stress is a dynamic process. Furthermore, they also detected individual differences, implying that for some pre-service teachers it was the other way round (i.e. self-efficacy beliefs declined and stress increased). The mentor–student relationship in their study was important, which suggests that for our research, teacher educators could be more sensitive in supporting pre-service teachers with low beliefs. The practicum could also be a place where pre-service teachers — with the encouraging support of a mentor teacher — would repeat those science experiments that were biased with a negative affect from the teacher education course. Gaining confidence in implementing science inquiry activities in the classroom gives rise to the change that student

teachers will implement the presented science experiments encountered in teacher education, later in their own lessons. Individual guidance will allow for more successful experiences. Therefore, a close cooperation of teacher trainer and mentor is crucial when it comes to closing individual knowledge and competence gaps.

Pre-service teachers aim to overcome difficulties by putting in more efforts but they need to be supported by their trainers. Teaching assistants could, for example, offer additional lesson times for student teachers who are struggling. Increased support from instructors might be especially helpful for non-routine actions, such as scientific inquiry activities, which exhibit a high degree of openness and generate insecurity in inexperienced learners. This measure should increase student teachers' sense of control according to the control-value theory (Pekrun, 2006). Insecurity may also have been caused by the fact that every scientific task was accompanied by new and demanding subject content, which needed to be applied immediately to obtain the hypotheses and results of the experiment. This is supported by our result that student teachers with higher degrees of achievement in the oral test showed fewer negative emotions. A possibility to reduce negative effects would be to give the pre-service teachers more choice in selecting experiments appropriate to their learning level and offer individual guidance in conducting them. This should increase the student teachers' sense of control and the value of the lab material. Pekrun (2006) proposed that student teachers should be given autonomy and allowed to self-regulate their learning process. This should foster the student teachers' sense of competence and boost their emotions in a positive way. Finally, the teacher educator's own enthusiasm in dealing with the experiments might spread to the student teachers and could facilitate the student teachers' absorption of values. Student teachers' value beliefs signify judgments about the quality of tasks or experiments based on their usefulness. Value beliefs are closely related to the intention to use the experiments in the future.

Limitations

There are several limitations to the present study that warrant attention because of their implications for future studies and educational practices. Firstly, the current study used self-reported data to assess emotions. Self-reports are highly useful sources of information in terms of how people perceive and interpret situations, but their validity has been questioned by some. The use of self-reports always involves the risk that subjects will answer in a socially desirable manner (Koziol & Burns, 1986; Wubbels et al., 1992). Nevertheless, correlations of self-reports for one person over time seem to be quite high, indicating the reliability of these measurements (Larson & Csikszentmihalyi, 2014). Second, we limited our study to three

emotions that we thought were most appropriate to our situation. However, other important academic emotions exist that could have been considered for our research (see e.g. Pekrun et al., 2002). This reduction has made comparisons to the results of other studies less simple. In addition, we cannot rule out that other emotions would have led to slightly different results. Third, while DeMauro and Jennings (2016) found that only depression and not anxiety or stress is related to pre-service teachers' efficacy beliefs, our factors (consisting of three items, namely stress, insecurity, and no enjoyment) worked well. This outcome might be because their self-efficacy items were worded for classroom-management experiences and their items for emotions only vaguely related to the previous week. Again, a comparison of the results is problematic due to different procedures and operationalisations. As recommended by Tschannen-Moran and Hoy (2001), self-efficacy should be measured in a manner that is context and subject-matter specific. Hence, our procedure should be repeated for other contexts and subjects in order to generalise or compare our results. Finally, it was necessary for us to limit our study to a certain number of aspects that were related to emotions even with the knowledge that there are more factors that might explain pre-service teachers' learning, such as teachers' emotional intelligence and their ability to regulate emotions (Uitto et al., 2015).

Conclusions for practice and directions for future research

The results have shown that it is important for science teacher educators to be aware of the development of pre-service secondary school students' emotions during teacher education, not only as a group but also on an individual level. To date, emotions such as anxiety were merely a research focus in primary school teachers' science education. Although compared with primary school student teachers, anxiety in science is less of a problem for secondary student teachers, given that they can choose the subjects they wish to teach, other negative emotions can hinder their implementation of the teacher institution's intended educational goals in the classroom. Specific to science lab courses, the study's suggestion for science teacher educators would be to clarify within the curriculum whether content knowledge and science lab courses are optimally aligned. According to the control-value theory (Frenzel et al., 2009), if a student teacher is already challenged by missing content knowledge, practising in the lab is less meaningful (low valence), and interpretation of the results will be more complicated (low control). A pre-service teacher should be able to identify the presented science practices and experiments as central to the curriculum and their own future teaching goals. Thereafter, it is assumed that course experiences would become positive and enjoyable. However, our

study has shown that this is not the case for all student teachers. Positive emotions foster student teachers' self-efficacy beliefs and strengthen their intentions to apply the skills that they acquired in teacher training institutions. When prospective secondary school teachers practise outside the training institution, it is essential to provide them with support and monitoring to foster an awareness of their emotional experiences with regard to teaching science (Borrachero et al., 2014). The aim is to keep them from falling behind in the teacher-controlled and interventionist-science teaching style whenever they experience fear, frustration, or anger (Ritchie et al., 2013). In alignment with one of the implications from Hong's study (2012) on beginner science teachers leaving the profession, while in training, teachers need to learn how to handle emotions as a prerequisite to dealing with emotionally-charged situations later.

Keller, Chang, et al. (2014) point out that it remains unclear how teacher emotions might change over the course of a career, especially during the crucial transition from pre-service to full-time teaching. In this study, student teachers' emotions were measured as part of a science inquiry course at a teacher university, which is still a relatively sheltered environment. It would be interesting and important to compare our results with a follow-up study on the same pre-service teachers when they start their science practicum in schools. The data could be linked based on an interrupted time-series design. This approach would allow the researcher to identify student teachers who were able to establish favourable attitudes in teacher education. These attitudes would help build resilience to the difficulties encountered in real-world classroom settings while teaching inquiry-based science (Fazio et al., 2010).

Appendix

Table 5 Scale 'Self-efficacy in teaching biology' (adapted from Bleicher, 2004)

Item	Formulation:
sel1	I know the steps necessary to teaching scientific concepts effectively.
sel2	I will be very effective in supporting students' science experiments.
sel4	I will typically be able to answer students' science-related questions.
sel6	When presenting science experiments, I will usually welcome student questions.
sel8	The inadequacy of a student's science background in biology can be overcome through good teaching.

Response categories were as follows: (6 = *absolutely agree*, 5 = *agree*, 4 = *somewhat agree*, 3 = *somewhat disagree*, 2 = *disagree*, and 1 = *absolutely disagree*)

Table 6 Single Items ‘State emotions/feelings’

Item	Formulation:
Please indicate what you perceive right now. At the moment:	
enj	I am enjoying it.
ins	I feel insecure.
str	I feel stressed.
exp	I think I'll use this experiment myself later.

Response categories were as follows: (6 = *absolutely agree*, 5 = *agree*, 4 = *somewhat agree*, 3 = *somewhat disagree*, 2 = *disagree*, and 1 = *absolutely disagree*)

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Authors' contributions

RS conducted the statistical analysis, while NR and FR carried out the investigation. All authors contributed to the writing of the manuscript. All authors read and approved the final manuscript.

Authors' information

Robbert Smit is a senior researcher and lecturer at the St. Gallen University of Teacher Education. He is a former science teacher for secondary school. His research interests are in the area of teacher education and instruction in mathematics and science subjects.

Nicolas Robin is head of the Institute for Science Teacher Education at the St. Gallen University of Teacher Education. His research interests are in the area of teacher education and the teaching of science subjects, particularly in addressing historical issues.

Florian Rietz is a lecturer and researcher at the St. Gallen University of Teacher Education. His research interests are in the field of teacher education and the teaching of science subjects and German literature.

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Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declaration

Competing interests

The authors declare that they have no competing interests.

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