



Pre-service primary teachers' shame experiences during their schooling time: characteristics and effects on their subject-choices at university

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Abstract

Emotions play an essential role in pre-service teachers' competence development, particularly in mathematics. However, the emotion of shame in mathematics has been largely neglected so far. This article deals with shameful experiences of pre-service primary school teachers during their mathematical education at school and the various effects of shame on their decision to study mathematics as a subject at university. The research consists of a qualitative and a quantitative study with 311 prospective primary school teachers who responded to a survey about their experiences of shame in mathematics at school when they were students. Results of the qualitative study emphasize the different experiences in mathematics during the school years and reveal the characteristics of these situations, for example, social exposure or competition games. In the quantitative study, pre-service primary teachers' subject choice was analyzed in relation to their experienced shame in mathematics at school. Results reveal that shame experienced at school has effects on the initial choice in favor of mathematics at university. Implications for primary teacher education are finally discussed.

Keywords Shame · Mathematics · Pre-service primary teachers · Teacher education

Research on pre-service teachers' emotions has received rising interest over the last decades (Coppola et al., 2013; Hannula, 2012). Particularly, studies have revealed that emotions can influence both pre-service teachers' competence development throughout teacher

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education (Cooke, 2015; Jenßen et al., 2021) and their actual teaching practice (Coppola et al., 2012; Frenzel, 2014; Ripski et al., 2011). But what exactly are emotions?

Emotions consist of affective, cognitive, physiological, and motivational components (Pekrun et al., 2018) and can range from being pleasant to unpleasant emotions (Feldman Barrett & Russell, 1998). According to Hannula (2012), emotions can be conceptualized as an immediate emotional reaction within a situation (emotional state) and also as a situation-independent emotional disposition (emotional trait). Theories such as control-value theory (Pekrun & Perry, 2014) and attribution theory (Weiner & Kukla, 1970) suggest that the development of emotions can be explained by evaluations (appraisals) of situations. For instance, some studies revealed that experiences teachers had during their own schooling could influence these evaluations and, thus, their current emotions in a particular domain such as mathematics (Bekdemir, 2010; Brady & Bowd, 2005; Coppola et al., 2013; Scott, 2005).

Emotions associated with mathematics have been of interest for several years as they are important for the learning and teaching of mathematics (Hannula, 2012; Schukajlow et al., 2017). Although the importance of shame for mathematics teachers has repeatedly been emphasized (Bibby, 2002; Frenzel, 2014; Panagi, 2013), this emotion plays almost no role in current educational research. For the significance of shame in educational contexts, both the population of pre-service primary school teachers and the subject of mathematics seem to be particularly relevant (Bibby, 2002). Accordingly, Panagi (2013) assumed that shame-inducing situations in mathematics during school education are highly relevant for the professionalization of pre-service teachers, as they may influence choosing or avoiding mathematics as a subject in teacher education for primary school. However, this aspect has not been examined so far. The current study raises the question of how pre-service teachers' shame experiences at school can be characterized and how these experiences of shame affect their choice of mathematics as a subject during their university teacher education.

1 Phenomenology, causes, and effects of shame

Shame is defined as an unpleasant and activating emotion that can be described by different components (affective, cognitive, physiological, motivational; Pivetti et al., 2016). Shameful situations are affectively described as distressing, painful, and embarrassing, often accompanied by feelings of insufficiency. The embarrassed person feels humiliated or disgraced. In the foreground are self-referential pejorative cognitions that evaluate the person in a less differentiated and global way (e.g., "I'm not right the way I am."). Cognitions of shameful feelings are always self-referential (Lewis, 2003). Physiologically, shame manifests itself in a loss of muscle tension or blushing (Dickerson et al., 2001). Shame has a motivational effect, resulting in a tendency to restore, avoid (withdrawal), endure, or overcompensate (e.g., aggression; Ashby et al., 2006; Stuewig et al., 2015).

As for emotions in general, the experience of shame can be described in terms of frequency and intensity (Bailen et al., 2019; Diener et al., 1985). Shame, understood as an emotional disposition, develops through the interplay of biological, psychological, and social factors across the personal life span (Orth et al., 2010). Also, shame can be seen as an acquired emotion (Lewis et al., 1992). Consequently, the experience of shame is significantly determined by social experiences and social standards (Lewis, 2003). For example, situations that promote social comparison or involve social exposure may enhance shameful experiences (Smith et al., 2002). Studies have revealed that shame increases from early

childhood to adolescence, decreases in middle adulthood and increases again in old age (Orth et al., 2010). In primary school, children are more and more able to differentiate emotions and also to identify shame (Seidner et al., 1988). Around the age of ten, children tend to relate shame to their achievement (Ferguson et al., 1991). As unpleasant emotions increase from primary school to secondary school due to increasing achievement requirements (Pekrun et al., 2018; Vierhaus et al., 2016), one could assume that shame experiences also increase from primary to secondary school. In view of these findings, it could be fruitful to differentiate between developmental stages when examining an individual's levels of shame.

As mentioned earlier, emotions do not result because of the situations per se. Moreover, emotions such as shame are conceptualized as emotional reactions to appraisals regarding these situations (Tracy & Robins, 2006). Both attribution theory and control-value theory explain how shame is experienced due to specific appraisals. According to attribution theory, shame represents an emotional reaction to the global negative evaluation of one's own performance, for example, after a failure (Lewis et al., 1992; Russell & McAuley, 1986). In terms of control-value theory, individuals experience shame when they believe that they do not have enough resources (e.g., knowledge) in a valuable domain (e.g., mathematics; Pekrun & Perry, 2014; Turner & Schallert, 2001). However, appraisals are affected by general beliefs which are formed through recurrent experiences. For example, a parental style using frequent punishments can cause shame already at pre-school age (Alessandri & Lewis, 1993). These parental evaluations may form an individual's general belief system about one's own performance. From the perspective of social learning theory (Bandura, 1977), it can be assumed that emotional experiences may be triggered by both experiences which individuals had by themselves or by observing others experiencing this emotion. This assumption has already been validated for the experience of shame (Schmader & Lickel, 2006). Additionally, studies revealed that shame can also be experienced by persons although it was another person who had shown for example failure or misbehavior, just because the persons identified themselves with the other person (Salice & Sánchez, 2016).

The experience of shame leads to various consequences. According to the control-value theory, unpleasant emotions show negative effects on achievement via mediating variables such as motivation (Pekrun & Perry, 2014). Hence, shame can be conceptualized as an *achievement emotion* that is closely related to requirements and knowledge in a domain (Thompson et al., 2004). Studies have also revealed that ashamed individuals motivationally tend to avoid shame-eliciting contexts (Schmader & Lickel, 2006).

To sum up the described findings, shame is understood as an unpleasant and activating emotion. It occurs predominantly in social situations due to specific beliefs concerning these situations, especially in relation to oneself. These appraisals show various effects and lead, for example, to poor performance and a high avoidance tendency.

1.1 Shame and mathematics

Research has shown that the development of emotions in mathematics depends on a variety of aspects such as one's beliefs or teacher's instruction (Schukajlow et al., 2017). Both aspects can be related to appraisals or attributions in terms of control-value theory (Pekrun & Perry, 2014) or attribution theory (Weiner & Kukla, 1970) in relation to the subject of mathematics. For example, subject specificity of shame in mathematics may be due to mathematics-specific beliefs (Panagi, 2013). Mathematical achievement is commonly understood as an innate ability or is seen as a proxy for general intelligence (Goldin, 2014).

However, at the same time, there is a collective belief that mathematics is an important cultural asset and that the correct understanding and use of mathematical tools is an essential twenty-first-century skill (Goldin, 2014). Thus, there is the threat of attributing failures globally to one's own abilities in a subjectively significant domain. This observation can facilitate the experience of shame. The conceptualization of mathematics based on a static perspective as a collection of algorithms and formulas (as opposed to a dynamic and developing perspective) can increase the potential for subjective failure (Roesken et al., 2011). Also, correct solutions are attributed an enormous importance in mathematics (at least in rather traditional mathematics classrooms), in that solutions of given problems in class are constantly evaluated as either right or wrong. Such a permanent evaluation may lead to unpleasant emotions for students when they fail to find the right solution (Bibby, 2002; Goldin, 2014).

Moreover, studies showed that specific instructional methods can influence students' emotional experiences (Bieg et al., 2017). Finlayson (2014) has suggested that methods like direct instruction promote a higher right-or-wrong orientation than reform-based practices valuing a discourse orientation in the mathematics classroom. In addition, it may be also likely that methods with high social exposure (e.g., calculating at the blackboard, competition games) enhance a student's experience of shame over time. These methods are still more frequently used in teaching mathematics than in other subjects (Bieg et al., 2017).

To summarize, the theoretical assumptions and the empirical studies emphasize that the occurrence of shame in mathematics can be seen as specific because of an individual's characteristic belief system about mathematics, the predominant conceptualizations of mathematics, and mathematics-specific instructional methods applied in mathematics education.

1.2 Pre-service primary school teachers' shame

Pre-service primary school teachers report shame during their school years more often compared to other subjects, for example sports, but rather less often compared to other emotions (Jenßen et al., 2020). This can also be due to modes of assessments or because shame is a rather fleeting emotion (Frenzel, 2014), which rapidly expresses itself in other emotions like anger (Tangney et al., 1992). However, shame is usually experienced intensively. One shameful situation can be enough for teachers to doubt their own abilities as teachers (Basso, 2014). Shame can be found especially among teachers, because they are constantly socially exposed in the classroom (Frenzel, 2014), and they are constantly subject to social evaluations and comparisons (Miles, 2017). Moreover, shame can be understood as an identity-determining emotion of teachers (Zembylas, 2003). Shame is particularly relevant for prospective primary school teachers because they are often trained as generalists (Bibby, 2002; Cooke et al., 2019). They therefore have less specialized content knowledge (Bibby, 1999), and this is one of the most important facets of teacher knowledge (Loewenberg et al., 2008). This means that they have fewer resources to meet mathematical requirements (this leads in turn to a lower control-appraisal which can promote the experience of shame). This is problematic because mathematics is a core and compulsory subject matter of practicing primary school teachers.

Emotions play an essential role for choosing and working in the teacher profession (Skaalvik & Skaalvik, 2011). Unpleasant emotions in particular play a role in the avoidance of mathematics-related professions (Chipman et al., 1992; Huang et al., 2018). Because

shame triggers a high avoidance tendency, one can hypothesize that pre-service primary school teachers with a high experience of shame neither choose mathematics as a subject in their studies nor as a specialization. This vicious circle could maintain the experience of shame.

2 Current study and research questions

The investigation underlying this paper took place in the context of teacher education at a university in a greater urban area in Germany. During primary teacher education in Germany, mathematics can be chosen as one of various subjects. However, it is possible to avoid mathematics as a core subject. During the course of their studies (after about 2 years), prospective primary teachers may decide to choose mathematics in advanced courses, when they already have chosen mathematics as a core subject (specialization subject). Students then have more courses in mathematics and mathematics education (Cooke et al., 2019). It has to be noted that in Germany education systems are different in different federal states. In some federal states, it is not possible to avoid mathematics as it is a mandatory subject. In some of these federal states, mathematics can already be chosen as a specialization at the beginning of the first semester.

The current study attempts to close major research gaps in relation to shame of pre-service primary school teachers in mathematics. The paper reports on two studies, a qualitative and a quantitative one. The qualitative study examines the experiences of shame that prospective primary school teachers have had during their own primary school time in mathematics. The research question is:

RQ1: “What are the characteristics of shame-eliciting situations experienced by pre-service primary teachers during their mathematics education at school?”

The second study is based on a quantitative approach and examines the effects of experienced shame during schooling on the choice of mathematics during pre-service primary school teachers' education at university. There are two stages of decisions (first decision, mathematics as a core subject, second decision, mathematics as a specialization), and the second decision depends on the first one, that is only those who have chosen mathematics as a core subject can choose mathematics as a specialization. Therefore, two decisions including two groups each can be distinguished. For the decision about mathematics as a *core subject*, non-choosers and choosers can be distinguished and also non-choosers and choosers regarding mathematics as a *specialization*. In total, four groups have been examined in the present study.

We examined two independent research questions:

RQ2a: “Do pre-service primary teachers who have chosen mathematics as a *core subject* differ from those who have not in their experienced shame at school when they were students?”

RQ2b: “Do pre-service primary teachers who have chosen mathematics as a *specialization* differ from those who have not in their experienced shame at school when they were students?”

Because of theoretical assumptions about the avoidance tendency following the experience of shame and empirical evidence for lower mathematics achievement when highly experiencing shame, we hypothesize that the two groups of RQ2a differ in their

experienced shame at school (H1). We also assume this difference for the two groups described in RQ2b (H2). However, as the choice of mathematics as a specialization only can apply to those pre-service primary teachers who have already chosen mathematics as a core subject, we assume that this effect is lower than the effect proposed in H1. Based on data, we potentially differentiated shame for each school level with respect to theory and empirical findings regarding developmental differences of shame. One might assume that shame at different school levels might affect pre-service teachers' decisions in a different way. Theories and studies suggest that shame develops with increasing achievement requirements in mathematics at school as the potential of failing rises. As achievement requirements at university are also high, one could conclude that the effect of pre-service primary teachers' shame in mathematics experienced in secondary school is more associated with their decisions regarding mathematics during teacher education than their shame in mathematics experienced in primary school.

3 Materials and methods

3.1 Participants

The study was conducted with the participation of $n=311$ pre-service primary school teachers of a university in a greater urban area in Germany. The majority of the participants were female (84%), reflecting the gender composition in the primary school teaching profession in Germany. The average age of the participants was $M=25.66$ years ($SD=6.91$) with a minimum of 16 years and a maximum of 56 years. Participants indicated $M=2.44$ ($SD=1.04$) as their last grade in mathematics at school. In Germany, grades range from 1 (=best grade) to 6 (=worst grade). The participants were recruited from the Bachelor program (76%) and also from the Master program (24%) for pre-service primary teachers. During their studies, all of the participants take courses in arithmetic, geometry, and stochastics,¹ including both a mathematical and mathematics education perspective. Although no specific courses are dedicated to exploring emotions in general or shame specifically, these aspects are discussed within several courses, for instance, when reflecting pre-service primary teachers' experiences during the practical term at school.

Participants worked voluntarily on the survey during regular instruction and did not receive any incentives. At any time, they were given the option to stop participating in the study.

3.2 Data collection

In the present study, a survey was used to collect qualitative as well as quantitative data (Bergin, 2018). At the beginning of the survey, socio-demographic data on the person (gender, age, semester/study program, last grade in mathematics at upper secondary school) were gathered. To ensure that participants understood what we meant by the term "shame," the phenomenology was described at the beginning of the survey:

¹ Stochastics comprises the areas of probability and statistics and it includes data, combinatorics, and chance.

The feeling of shame is understood as an unpleasant emotion, which is often accompanied by negative thoughts (e.g., 'I'm not good enough') in achievement situations. Additionally, shame can lead to the wish that the ground would open and swallow oneself up. Feelings like embarrassment, humiliation and disgrace can also be related to the emotion of shame.

The first part of the survey consisted of two dichotomous items, one multiple-choice item and one open response item. In the first dichotomous item, participants were asked to answer whether they have experienced a shame-eliciting situation in mathematics as an observer and in the second dichotomous item, as a directly ashamed person when they were students at school. After the two dichotomous items, participants were asked to remember their subjectively worst shame-eliciting situation when they were students at school (cf. Bekdemir, 2010). The next multiple-choice item asked for the school level in which this situation was experienced. The open-response item then asked the participants to describe in detail their most unpleasant experience that initiated a shameful experience. Participants were encouraged to name persons involved in the situation, mathematical content domains, and instructional methods used, when possible. These items were part of the qualitative study while the next items were part of the quantitative study.

In the quantitative study, participants rated on a 5-point scale ranging from 0 (=never) to 4 (=always) three questions regarding frequency (one for each of the three school levels: "How often did you experience shame in mathematics at this school level?"), and a 5-point scale ranging from 0 (=not intense) to 4 (=very intense) to answer three questions regarding the intensity (one for each of the three school levels: "How intensely did you experience shame in mathematics at this school level?"). At the end of the survey, participants were asked for their subject choices ("Have you chosen mathematics as a core subject at university?" and, if applicable "Have you chosen mathematics as a specialization subject at university?").

Prior to administration, we tested the survey to ensure practical application. We assume high face validity and poor item subtlety of the items as we have *directly* asked for the experiences of shame at school. The combination of high face validity and poor item subtlety seems to be desirable in terms of item validity (Holden & Jackson, 1979). Reliabilities of scores are reported in the next section.

3.3 Data analysis

The qualitative data were analyzed using content analysis techniques (Bergin, 2018; Mayring, 2014). In the first deductive step, the main aim was to find patterns in the data and to examine which themes tended to appear frequently in the participants' responses to the open-response item mentioned above. All the passages in which participants directly or indirectly mentioned "persons involved," "mathematical content domain," and "instructional methods used" were coded for this purpose. These categories were derived from the research literature about shame with regard to its social relatedness (e.g., Lewis, 2003) and literature about specific instructional methods (e.g., Bieg et al., 2017) and mathematical content domains (e.g., Goldin, 2014) which can affect emotional experiences. In the second step, the category "persons involved" was divided into deductive categories (teacher, classmates, student themselves). For the two other categories, responses were coded inductively from the material to get sub-categories, so that we were able to examine which specific instructional methods and which specific mathematical content domains are related to shame experiences at school. About 30% of the given responses were coded twice by two

independent and trained raters to ensure inter-rater-reliability. Findings showed high inter-rater-reliabilities for sub-categories (Cohen's Kappa between 0.84 and 1.00, $M=0.89$).

The quantitative analyses of the six shame items comprised testing for differences in shame experiences across school levels in dependence of two groups (first analysis: pre-service primary teachers who have chosen mathematics as a core subject at university vs. those who have not; second analysis with a subsample of the first analysis: pre-service primary teachers who have chosen mathematics as a specialization vs. those who have not). To reduce the number of dependent variables of our survey data without losing empirical information, based on the correlational pattern of the shame items (see Appendix Table 4), we performed a principal component analysis (PCA) to extract the most important independent factors. The Kaiser–Meyer–Olkin measure of sampling adequacy was 0.71, representing a relatively good factor analysis fit (Kaiser & Rice, 1974), and Bartlett's test of Sphericity was significant ($p < 0.001$), indicating that correlations between items were sufficiently large for performing a PCA. The varimax-rotated solution revealed three factors with each item loading on one factor (see Appendix Table 5). Each factor represented shame experiences (frequency and intensity) for one of the three school levels. Shame scores were generated by adding the frequency item and the intensity item for each school level separately. Reliabilities (Cronbach's) of the shame scores were high ($\alpha_{\text{primary}} = 0.89$, $\alpha_{\text{lowersecondary}} = 0.90$, and $\alpha_{\text{uppersecondary}} = 0.91$).

These shame scores were used as dependent variables in the further analysis. In light of the aim of the analyses, we decided for a multivariate analysis of variance (MANOVA) (cf. Pituch & Stevens, 2019). As the sample of the second analysis represents a sub-sample of the first analysis and consequently, sample sizes differ, we decided for two one-way MANOVAs. As basic assumptions of a MANOVA were given in our application (interval level of dependent variables, two categorical groups as independent variable, independence of observations), we have checked empirically for further assumptions of a MANOVA (neither univariate nor multivariate outliers, multivariate normality, no multicollinearity, linear relationships, homogeneity of error variances and covariances). Multivariate normality was analyzed through normality of each of the residuals for each group of the independent variable, because all analyses were performed by using SPSS 25.0 (IBM Corp., 2017) and the possibility to test for multivariate normality is not implemented in SPSS. However, it has to be noted that violations of some assumptions still allow the application of MANOVA. According to Finch (2005), MANOVA delivers robust results if the assumption of normality is violated. If linear relationships between the variables do not exist, statistical power decreases, but the application of a MANOVA is still allowed (Pituch and Stevens, 2019). Partial η^2 was estimated as effect size (Ellis, 2010). In case of significant results, post hoc univariate ANOVAs and discriminant analyses were performed to detect significant differences between the groups in detail. Level of significance was Bonferroni-corrected.

4 Results

4.1 Qualitative study: characteristics of situations eliciting shame at school

In the qualitative part of the study, pre-service primary school teachers were asked for situations that they subjectively experienced as shameful. To describe typical situations eliciting shame at school, we first distinguish between situations experienced as an observer or as a directly ashamed person. We then report at which level (primary, upper, or lower

secondary) the worst shame-eliciting situations were experienced. Finally, we categorize the reported situations with respect to “involved persons,” “mathematical content,” and “instructional methods.” Sub-categories of these three main categories describe characteristics of situations eliciting shame at school besides the characteristics “observer vs. directly ashamed person” and the school level. Coded categories, sub-categories, and descriptions are given in Appendix Table 3.

The majority of the 311 participants stated that they had observed shameful situations during mathematics lessons at school (78%). Each participant reported one situation. All of these participants reported that they had an unpleasant feeling in this situation, except for two participants who experienced a pleasant feeling while observing the situation. Nearly 69% of all participants reported they have experienced shameful situations themselves during mathematics lessons in which they were the ashamed person. The worst shame-eliciting situations were more often reported for secondary school (lower secondary school, 48%; upper secondary school, 35%) than for primary school (only 17%).

In the following, we classify the situations that the pre-service primary teachers considered as shameful in mathematics during schooling with respect to the persons involved, the mathematical content at hand and the instructional methods used by the teacher. In 38% of the situations described, the *teacher* was significantly involved in the induction of shame. Hostile behavior patterns on the part of the teacher were cited as particularly shameful (37%), with physical aggression also being reported in two cases (objects thrown at students). A participant (P) reported:

I had to calculate a homework task on the blackboard. I didn't understand the homework at home, which I also told the teacher before the lesson. But the teacher insisted that I work on the homework on the blackboard. None of my classmates were allowed to help me and the teacher did not support me in working on the homework, but rather embarrassed me in front of the class. The whole thing lasted about 10 minutes, then I was allowed to sit down again and another student was supposed to work on the task. (P79)

In this case, the teacher's hostility is evident in that he or she forced the participant to work on the task on the blackboard even though the teacher knew that participant P79 was not able to do so. The teacher also deprived participant P79 of social support from classmates, making a strategy use impossible to overcome his or her perceived helplessness.

In 10% of cases, *classmates* were identified as the main actors in the situation. In most of the cases, the combination of teacher and classmates as inducers was reported, for example, in the situation of participant P1:

I had to work on math tasks on the blackboard. The teacher forced me to do so. The teacher commented on my lack of knowledge at the blackboard and made fun of me so that the whole class laughed at me. (P1)

In 14% of the situations, no other actors than the *student herself* were named. Only the participant's own failure without the reaction of others was named as the cause of the experience of shame. P256's response also emphasizes the avoidance tendency, which may exist in anticipation of shame (fear of failure).

In primary school I was one of the best pupils. Whenever I had problems with a task, I always went to the rest rooms. So, I could not get to the discussion of the solutions. Everyone always thought that I could do everything in math. (P256)

The response shows that shame in mathematics can also occur in people who otherwise tend to see themselves as high performers in mathematics. P256's strategy seems to be to maintain this attribute also before others.

Regarding "mathematical content," *arithmetic* (50%) or *stochastics* (30%) were reported most often by the participants in the worst-shame-eliciting situation. *Geometry*, *calculus*, or *elementary linear algebra* were reported less often (7% each) by the participants. Other mathematical content domains were not mentioned.

Most frequently, "instructional methods used" by the teacher with high social exposure in mathematics teaching were reported: *Calculating at the blackboard* (86%), *public feedback on performance* (20%), *competition games* (19%), and the *presentation of homework* (11%). In about 2% of the situations, the shameful experience of mathematics occurred during *group work* in the sense that the person was excluded from normal group work. Regarding *competition games*, P36, for example, reported the following aspects:

We had a competition with mental arithmetic in class. Very difficult tasks were set by the teacher, which I could not solve. But you were only allowed to sit down when you had solved a task correctly. If you did something wrong, the teacher laughed at you. I was the last one standing there and everyone could see that I was the worst in math. (P36)

The situation shows that subjective task difficulty can also be a condition that can promote a shameful experience. It becomes clear that P36 subjectively perceives the tasks as difficult, although everyone else can solve them. The comparison with the group's achievement level is particularly evident in this public competition.

The reported situation of P197 also describes the *public feedback on performance* as a shame-eliciting feature:

During independent silent work, the teacher checked my solutions and then said loudly in front of the class "I think you're just worse in math." (P197)

The teacher provides P197 with an explanation of his or her achievement, attributing it to be stable, internal, and uncontrollable factors. As a result, negative self-concepts and dysfunctional beliefs can become established, which can continue to negatively influence the participant's mathematical achievement.

4.2 Quantitative study: experiences of shame at school and subject choice in mathematics at university

4.2.1 Descriptive results

Descriptive results for shame scores of each school level for all four groups are presented in Table 1. The possible range of each score was between minimum = 0 and maximum = 8 (as each score consisted of two items). It is obvious that the parameters indicate fewer shame experiences regarding frequency and intensity across school levels. Mean values seem to increase from primary school to secondary school. The highest mean value was found at lower secondary school level in both samples. It has to be noted that N_2 (mathematics as a specialization) is a subsample of N_1 (mathematics as a core subject), because pre-service primary school teachers decide on mathematics as their specialization after they have decided on mathematics as a core subject.

Table 1 Mean and standard deviations for the shame variables by sample

	Chose mathematics as a core subject? ($N_1=289$)				Chose mathematics as a specialization? ($N_2=168$)			
	Yes ($n=273$)		No ($n=16$)		Yes ($n=24$)		No ($n=144$)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Shame in primary school	1.92	1.80	3.81	2.04	1.54	1.96	2.03	1.86
Shame in lower secondary school	2.78	2.10	4.00	2.03	2.29	2.16	2.94	2.05
Shame in upper secondary school	2.54	2.19	4.56	2.00	1.79	2.15	2.78	2.20

M=mean; *SD*=standard deviation.

4.2.2 Shame and choice of mathematics as a core subject

The majority (94%) of the participants have chosen mathematics as a core subject. Only $n=16$ participants did not choose mathematics as a core subject. Before we analyzed the data by the application of a MANOVA, we had checked empirically for the assumptions of such an analysis. No univariate or multivariate outliers were found, as assessed by the Mahalanobis distance ($p>0.001$). Normality was given for the groups who have not chosen mathematics as a core subject, but not for the groups who did so (assessed by the Shapiro–Wilk test, $\alpha=0.05$). Correlations between the shame scores of the school levels (dependent variables) were low (r between 0.40 and 0.59), indicating that multicollinearity was not a confounding factor in the analysis. Linearity between each pair of the shame scores within each group (chooser vs. non-chooser) was given. Homogeneity of the error variances for all the shame scores was given as assessed by Levene's test ($p>0.05$). There was also homogeneity of the covariances, as assessed by Box's test ($p>0.001$).

The one-way MANOVA showed a statistically significant difference between the participants who had chosen mathematics as a core subject and the participants who did not on the combined dependent variables, $F(3, 285)=7.395$, $p<0.001$, partial $\eta^2=0.072$, Wilk's $\Lambda=0.928$. According to Ellis (2010), the effect size can be regarded as medium.

In the next step, post hoc univariate ANOVAs were conducted for every dependent variable (see Table 2). Results showed a statistically significant difference between both groups (chooser vs. non-chooser of mathematics as a core subject) for shame experienced in primary school, for shame experienced in lower secondary school, and also for shame experienced in upper secondary school. Effect sizes were small to medium in accordance with Ellis (2010).

Table 2 Results of the univariate ANOVAs (mathematics as a core subject)

Dependent variables	Chose mathematics as a core subject?				<i>F</i>	Partial η^2
	Yes ($n=273$)		No ($n=16$)			
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Shame in primary school	1.92	1.80	3.81	2.04	16.471**	0.054
Shame in lower secondary school	2.78	2.10	4.00	2.03	5.095*	0.017
Shame in upper secondary school	2.54	2.19	4.56	2.00	13.011**	0.043

* $p=0.025$, ** $p<0.001$; $df_1=1$ and $df_2=287$ for all three univariate ANOVAs; *M*=mean; *SD*=standard deviation.

The MANOVA was followed up with a discriminant analysis, which revealed one discriminant function (canonical $R^2=0.07$). The discriminant function significantly differentiated both groups (chooser vs. non-chooser of mathematics as a core subject), $\Lambda=0.93, \chi^2(3)=21.40, p<0.001$. The correlations between outcomes and the discriminant function revealed that shame experienced in primary school, in lower secondary school, and in upper secondary school loaded highly onto the function ($r=0.86$ for shame experienced in primary school, $r=0.48$ for shame experienced in lower secondary school, and $r=0.76$ for shame experienced in upper secondary school). The coefficient was lower for shame experienced in lower secondary school than for the other two school levels.

4.2.3 Shame and choice of mathematics as specialization subject

As a specialization is only possible in the second half of the bachelor study, this aspect was analyzed only for a subsample of $N_2=168$ pre-service primary school teachers. In this analysis also, no univariate outliers were found. However, two multivariate outliers were found, as assessed by the Mahalanobis distance ($p>0.001$). Nevertheless, both cases remained in the sample, because the scores of these two participants were theoretically possible and justifiable.² The correlations between the dependent variables were low (r between 0.37 and 0.57), indicating that multicollinearity was not a confounding factor in the analysis. Therefore, linearity was assured. There was homogeneity of the error variances for all shame scores ($p>0.05$) as assessed by Levene's test, and also there was homogeneity of covariances, as assessed by Box's test ($p>0.001$).

The one-way MANOVA found no statistically significant differences between the participants who had chosen mathematics as specialization and those participants who did not on the combined dependent variables, $F(3, 164)=1.458, p=0.23$, partial $\eta^2=0.026$, Wilk's $\Lambda=0.974$.

5 Discussion

Our results show that all the pre-service primary teachers in our sample reported shameful experiences in mathematics during their schooling time, either as observers or as directly involved persons and that these shame-eliciting situations cover many different characteristics. That is, different characteristics in terms of the persons involved (teacher, classmates, and the student themselves), the mathematical content at hand, and the instructional methods used by the teacher are relevant. It might therefore not be enough to consider only one single element or characteristic for the explanation (and also for the reduction) of shame experiences in mathematics at school. Our qualitative data show that the role of the teachers is particularly important, both in terms of their own behavior and the choice of instructional methods. Categories that covered these aspects were the most frequently reported ones (e.g., in comparison to classmates). Competitive games have also been reported as aspects of shame-eliciting situations. Reasons for that might be that social exposure and social comparisons are assumed as shame-eliciting factors in general (Smith et al., 2002) and

² To validate our results, the MANOVA was also performed without the two multivariate outliers. Results did not differ between both analyses.

competitive games highly expose individuals and encourage them to compare themselves with others with regard to mathematical achievement. Our results also show that shame might be experienced when doing group work at school, when students are, for instance, abandoned from the group by its members as reaction to the student's poor performance in mathematics. There is also some social exposure in group work situations which can cause shame.

Regarding the role of the mathematics content, our findings reveal that shame can be experienced across different mathematical domains. We suppose that arithmetic was so often mentioned as a context because it represents the majority of mathematics in school across all school levels. In addition, the handling of numbers dominates in this area, and traditional teaching styles focus on executing procedures and not on inquiry-based learning (Finlayson, 2014). Thus, such a mathematics classroom can quickly trigger students' negative associations or unpleasant emotions. Shame is experienced in the domain of stochastics too. One reason could be that the potential for cognitive confusion is high (Goldin, 2014) due to intuitive approaches that often conflict with the mathematically required ones.

From a theoretical perspective, our research extends the findings from other studies on pre-service primary teachers' unpleasant experiences in mathematics. Our results differ from those in the study of Bekdemir (2010) who has investigated negative experiences of math-anxious pre-service teachers at school. Bekdemir (2010) reported more frequent associations between situations such as exams and mathematics anxiety. In contrast, we found an association between situations with high social exposure and shame in mathematics. Thus, different characteristics of situations in mathematics classes might be related to different unpleasant emotions (in this case anxiety vs. shame). Additionally, we did not find any hints for negative attitudes towards mathematics per se. In addition to identifying the teacher and classmates as sources of shame, our participants also identified themselves, as devaluating their self-view. One could assume that self-related beliefs in mathematics may be more relevant for shame, while beliefs concerning the nature of mathematics are more related to the experience of mathematics anxiety. It has to be noted that participants in Bekdemir's study (2010) had already completed mathematics courses during their teacher education. In our study, participants who did not choose mathematics as a core subject and consequently did not take mathematics courses during teacher education were also included in our qualitative examination. Therefore, we can assume that their shame in mathematics is mainly based on previous experiences, prior to their teacher education. The participants' statements in Bekdemir (2010) may be confounded by their emotional experiences during teacher education, given that the study excluded pre-service primary teachers who did not choose mathematics. It is precisely the group avoiding mathematics that is of interest when it comes, for example, to increasing the number of pre-service primary teachers in mathematics. Our findings suggest that these pre-service primary teachers show higher levels of shame and therefore present a vulnerable group. However, the number of these participants was small in our study ($n = 16$).

In the quantitative study, shame was assessed as an emotional disposition. The results of our quantitative analyses indicate that experiences of shame in terms of frequency and intensity (Bailen et al., 2019; Diener et al., 1985) are associated with the decision to study mathematics at university, at least with a medium effect. The association between shame experiences and the decision to study mathematics at university was found for each school level. Unexpectedly, these experiences are not related to

the choice of mathematics as a *specialization*. This may show that selection processes already take place in advance.

The results of our studies have to be seen against the background of some limitations. Design of the present study and the survey methodology do not allow causal conclusions. Because of the retrospective assessment, a limited memory performance, especially for primary school, must be assumed. The results may be affected by this memory bias. Moreover, our study is based on an occasional sample from only one university. Sample sizes appear small in the cases of non-choosers of mathematics as a core subject and choosers of mathematics as a specialization. Nevertheless, it has to be noted that homogeneity of error variances and covariances was given, what seems to be more important for performing ANOVAs than sample sizes. Furthermore, Monte Carlo simulation studies revealed the ANOVAs to be robust when analyzing data with unequal sample sizes (Blanca et al., 2017).

The results of both studies have implications for pre-service primary teachers' education at university. In light of our quantitative results, one might argue that mathematics should be a mandatory subject at university for becoming a primary teacher, so that avoidance of mathematics is not possible. Nevertheless, pre-service teachers' shameful experiences should be considered during teacher education. However, our results do not deliver concrete hints for interventions during pre-service primary teachers' education at university. Based on theories and empirical findings on shame in general, some points can be discussed. In regard to the motivational facet of shame in general (e.g., Tangney et al., 1992), pre-service teachers might endure mathematics courses at university or overcompensate during teacher education (e.g., getting angry when working on mathematical tasks without a deeper understanding of mathematical ideas behind these tasks). Furthermore, pre-service teachers' shame in mathematics might affect their shame experiences when teaching mathematics later at school (Bibby, 2002) and following the teacher emotion model by Frenzel (2014), also their instructional quality. With regard to the phenomenology of shame, interventions on reducing primary teachers' shame in mathematics should pay attention to one's own identity, and, in particular, the importance of the social context must be made clear. In this sense, mathematics must also be understood as a social process. An essential aim of teacher education should also be becoming aware of emotions related to mathematics (Goldin, 2014; Liljedahl et al., 2007). A systematic and guided sharing of experiences of unpleasant emotional situations during schooling can be a helpful building block in teacher education. Here, the self-reference of good mathematical performance should also be positively connoted, for example "I can acquire mathematical knowledge" or "I am able to solve mathematical problems." With respect to our results, from a point of view with regard to teacher education, it seems to be not enough to reflect only on experiences from primary school, but also those from secondary school. Additionally, pre-service primary teachers might be supported in strengthening their shame resiliency through fostering their mathematics self-efficacy and to develop goals related to teaching mathematics at school (e.g., "I will

need pronounced content knowledge for teaching mathematics effectively at school.”). According to Turner and Schallert (2001), pre-service primary teachers could learn that current experiences of shame are emotional signals that they have to work on reaching their goals. During teacher education, pre-service teachers should also be encouraged to build positive role models to hinder shame experiences for students at school. However, we have not examined the effectiveness of such interventions in the present study. Our results only reveal knowledge about characteristics and effects of pre-service primary teachers' shameful experiences in mathematics at school and do not provide causal explanations.

6 Conclusions

The present study is the first ever to systematically investigate pre-service primary teachers' shame experiences in mathematics. We have used both qualitative and quantitative methods to explore this under-researched area. From a theoretical point of view, our findings reveal the importance of educational characteristics of situations at school for shame in mathematics. By so doing, it extends biopsychosocial models for causes of shame by an educational dimension. Likewise, our analyses validate theories on the complexity of emotions' development in achievement situations, for example, control-value theory. They also highlight the meaning of emotions, shame in particular, for subject choices of pre-service primary teachers at university. Shame experienced in mathematics at school affects the beginning step in a process of various decisions concerning subject choice at university.

Shame thus turns out to be an emotion among prospective primary school teachers that merits attention in teacher education. One could assume that studies on unpleasant experiences in mathematics education, which explicitly include feelings of shame, might lead to an increased knowledge of negative teaching practice in mathematics classes. In particular, future research is needed to better understand a variety of factors: shame experience at university, effects on pre-service teachers' knowledge in mathematics, or the prognostic effects on later teaching.

Appendix

Table 3 Category system

Category	Sub-category	Description
Person involved	Teacher	Teacher shows hostile behavior, such as devaluations, insults or disgracing the student, for example because of student's lack of knowledge in mathematics
	Classmate(s)	Classmates embarrass the student, for example laughing at him or her because of his or her low achievement in mathematics
	Only student themselves	Neither teachers nor classmates are involved in the situation, only the student devaluates themselves (e.g., because of low performance in mathematics)
Mathematical content domain	Arithmetic	Participant responds with "arithmetic" or examples, such as fractions or multiplication and division
	Geometry	Participant responds with "geometry" or examples, such as drawing with the compass
	Stochastics	Participant responds with "stochastics" (no participant gave a concrete example)
	Calculus	Participant responds with "calculus" or examples, such as curve sketching
	Linear algebra	Participant responds with "linear algebra" or examples, such as solving a system of linear equations
Instructional methods	Calculating at the blackboard	Participant describes how he or she or another student had to calculate at the blackboard in front of the classmates (e.g., solving equations) and doing a mistake while working on the task
	Public feedback on performance	Someone (e.g., the teacher) gives feedback on the participant's or a student's performance (e.g., test score) in mathematics in front of others (e.g., classmates) and the performance is subjectively perceived as poor by the participant
	Competition games	Participant describes a game for the whole class with students being in a competitive position to each other (e.g., "Home run!": the student who gives the correct answer is allowed to go to the next corner of the classroom, students who give four correct answers have a "home run" and win the game) where he or she or another student showed subjectively perceived low performance in mathematics
	Presentation of homework	Participant describes that he or she or another student had to present their findings from homework in mathematics in front of their classmates and the presenting person made a mistake in homework
	Exclusion from group work	Participants describes that he or she or another student had to work with other classmates who have excluded the person from the group work, for example, because of his or her low performance in mathematics

Table 4 Correlations between shame items

	Frequency in primary school	Intensity in primary school	Frequency in lower secondary school	Intensity in lower secondary school	Frequency in upper secondary school	Intensity in upper secondary school
Frequency in primary school	-					
Intensity in primary school	0.80	-				
Frequency in lower secondary school	0.45	0.44	-			
Intensity in lower secondary school	0.38	0.40	0.82	-		
Frequency in upper secondary school	0.41	0.35	0.57	0.53	-	
Intensity in upper secondary school	0.38	0.31	0.52	0.53	0.83	-

All coefficients were significant ($p < 0.001$).

Table 5 Varimax-rotated solution (factor loadings)

Item	Factor 1	Factor 2	Factor 3
Frequency (primary school)	0.90	-	-
Intensity (primary school)	0.93	-	-
Frequency (lower secondary school)	-	0.88	-
Intensity (lower secondary school)	-	0.89	-
Frequency (upper secondary school)	-	-	0.89
Intensity (upper secondary school)	-	-	0.91

Only loadings greater than 0.30 are presented.

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