A Differentiated Insight into the Emotional Classroom Climate in School Mathematics Lessons: A Comparative Analysis of Grades 3–6 Participant-Produced Drawings in the Context of Arithmetic and Geometry Lessons

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Students experience a wide range of emotions in the classroom, including joy, fear, and boredom, among others, which are linked to motivation and have a significant impact on academic achievement. Research has repeatedly indicated that positive emotions towards school decline as early as primary school age. This study aims to investigate the development of emotions in mathematics lessons during primary school (Grades 3–6) using participant-produced drawings and to determine whether there are differences in emotional classroom climate between arithmetic and geometry lessons. The results indicated a decline in positive emotions and, consequently, a growing disengagement from mathematics from lower to higher grades, which was particularly evident in arithmetic lessons. Additionally, the findings demonstrated a decline in negative emotions in geometry lessons from lower to higher grades, whereas arithmetic lessons exhibited an opposite trend. Conversely, geometry lessons elicited a mixture of both positive and negative emotions, which increased from lower to higher grades. Although the results are consistent with the literature in some respects, they offer new insights into how different mathematics lessons impact the perceived emotional classroom climate and its development throughout the primary school years. The results are discussed in terms of their theoretical, practical, and methodological implications.

Introduction

When observing young children acquiring new skills, such as walking, talking, or discovering new objects or phenomena in their environment, it is evident that they invariably experience feelings of joy and euphoria upon attaining each subsequent milestone. However, sustaining such positive emotions throughout the entire school period is not always achieved. "Just as one cannot not learn, learning and teaching cannot take place without emotions, be it in the learners, in the teachers, or in the interaction between the two"[1] (Huber & Krause, 2018, p. 8). With this quote, Huber and Krause (2018) emphasize that the teaching-learning arrangement cannot take place without an emotional bond between a teacher and a learner, and is therefore understood as an essential component of educational processes (Hastedt, 2009). Building on this, Meyer (2019) formulated the teaching climate conducive to learning as a characteristic of effective teaching, thereby underscoring the importance of emotions in educational contexts.

Particularly in the context of education, where student motivation is a driving force, considering their experienced emotions holds particular value. Numerous empirical findings on emotions in the classroom demonstrated the influential interaction between emotions and learning processes at school as well as a close connection between the classroom climate and student learning performance, the exhibited behaviour, and the emotional and social experiences of students (Denn et al., 2019; Frenzel & Stephens, 2017; Pekrun, 1992). As Reindl and Hascher (2013) and vom Hofe et al. (2002) have demonstrated, students experience a range of emotions, both positive and negative, during their school time, with

[1] Translated from German to English by the author.

these emotions being influenced by the subjects they are studying. On the one hand, positive emotions such as joy, pride, and relief influence attention, learning motivation, memory processes, and regulatory strategies, and have a positive effect on academic learning and performance (Pekrun, 2018). On the other hand, negative emotions such as anger, anxiety, and boredom have a negative effect on academic learning and performance (Pekrun, 2018). This effect has been observed in all subjects taught in primary schools. Thus, emotions determine the behaviour of those involved in lessons (Evans et al., 2009) as well as the willingness to learn and perform, which are important components of well-being at school (Schiepe-Tiska & Schmidtner, 2013).

The significance of emotions in mathematics lessons is paramount, as they are generally perceived as difficult and therefore offer an increased potential for the emergence and intensification of negative emotions (Sutter & Hascher, 2022). The topic of emotions has been extensively researched in the field of mathematics education (e.g., Dahlgren Johansson & Sumpter, 2010; Laine et al., 2013, 2015; Reindl & Hascher, 2013; Tuohilampi et al., 2016; vom Hofe et al., 2002). Research (e.g., Hascher & Reindl, 2013; Pekrun et al., 2006) has shown that students' positive emotions experience a decline over their school years. However, the majority of these studies focused more on secondary school and the transition phase to secondary school at the end of primary school (Sutter & Hascher, 2022). Both cross-sectional and longitudinal studies (e.g., Dahlgren Johansson & Sumpter, 2010; Kuzle, 2021; Laine et al., 2013, 2015; Reindl & Hascher, 2013) have demonstrated that the emotional classroom climate can be characterized as positive and relatively stable across all primary grades. Yet, a notable increase in negative emotions has been reported from lower to upper grades. Although negative emotions exhibit a slight recovery effect during the transition from primary to secondary level (van Ophuysen, 2008), it is nevertheless essential to place a stronger emphasis on the primary level.

A literature review on emotions related to mathematics education revealed a predominant focus on mathematics in general, with little attention paid to specific mathematical content areas. The existing research on emotions in arithmetic (Reindl & Hascher, 2013; Schmude, 2005) and geometry (Glasnović Gracin & Kuzle, 2018; Kuzle, 2021) is particularly limited. This also applies to the development of emotions concerning the primary school years in different mathematical content areas. Consequently, a differentiated examination of emotions across diverse mathematical domains is of importance. That said, the primary objective of the research presented in this paper was to gain a differentiated insight into the emotional classroom climate in primary school arithmetic and geometry lessons. The secondary objective was to determine the extent to which different mathematical content areas influence the development of positive and negative emotions as well as their development through the primary school years.

Theoretical Background

In this section, the constructs of classroom climate and emotional classroom climate are presented, followed by a discussion of their relevance in the school context and how these develop over time. Furthermore, research findings are presented that offer a subject-specific perspective of the emotional classroom climate. The section concludes with the two research questions that guided the study.

Emotional Classroom Climate and Emotions

The classroom environment represents a critical context for children's development, gradually evolving to create a distinctive atmosphere or climate over time (Ashkanasy, 2003). This environment significantly influences students' core perceptions, thereby facilitating the acquisition of new concepts and procedures, which are supported by the guidance provided by the teacher and the instructional choices made by the teacher (Ahtee et al., 2016). Evans et al. (2009) and Hannula (2012) defined classroom climate as a collectively experienced and subjectively interpreted set of salient classroom characteristics. However, the factors contributing to this climate may vary. Götz et al. (2011) emphasized the "emotional aspects" of classroom climate, encompassing both positive and negative group emotions. This perspective aligns with Russell (1980), who categorized various emotions into active and passive, as well as pleasant and unpleasant. In the context of learning processes, a distinction can be made between positive emotions (e.g., joy, hope, relaxation) and negative emotions (e.g., fear, anger, boredom). Additionally, the activating or deactivating character of the emotion must also be considered (Huber & Krause, 2018). Accordingly, within the context of the school environment, Pekrun (2006) categorized the emotions as illustrated in Table 1.

Table 1
Two-dimensional Classification of Performance Emotions (Pekrun, 2006)

	positive	negative
activating	joy	anger
	hope	fear
	pride	shame
deactivating	relief	boredom
	relaxation	hopelessness

Furthermore, Götz et al. (2011) identified "perceived affective attitudes" (p. 506) as key elements, which include emotional responses toward the school, individuals within the school, academic disciplines, and specific subjects. Consequently, the perception and description of a given climate can vary among individuals, as it is a subjective assessment based on the experiences and environment of the affected individuals (Reindl & Gniewosz, 2017). Evans et al. (2009) delineated classroom climate into three interrelated dimensions: the academic component, concerning instructional and curricular elements; the management component, addressing disciplinary approaches and classroom order; and the emotional component, focusing on affective dynamics within the learning environment. They further asserted the necessity of recognizing the emotional classroom climate as a distinct and overarching element, given its integrative role in shaping both academic and managerial aspects of effective educational settings. The present study focuses on the emotional dimension of classroom climate, conceptualized as the emotional relationship between teachers and students.

The perception of the classroom climate triggers a range of emotions in those involved and is determined and influenced by several components (Eder, 2002). In his model, Hannula (2012) conceptualized emotional classroom climate from both psychological and social perspectives (see Table 2). The psychological dimension is operationalized at the individual level and encompasses affective conditions, including emotions and emotional responses (e.g., fear, joy), thoughts (e.g., "This is difficult."), meanings (e.g., "I could do it."), and

personal goals (e.g., “I want to solve this task.”), as well as affective traits, such as attitudes (e.g., “I like math.”), beliefs (e.g., “Math is difficult.”), values (e.g., “Math is important.”), and motivational orientations (e.g., “I want to understand.”). Conversely, the social dimension pertains to the classroom as a collective entity. Within this theoretical framework, affective conditions relate to momentary aspects of classroom life, encompassing interpersonal interactions, patterns of communication, and the general atmosphere in the classroom. At the social level, affective properties encompass enduring elements such as classroom norms, social structures, and the overall emotional tone. Here, the focus is on the former.

Table 2
Dimensions of the Emotional Classroom Climate (Hannula, 2012)

	Psychological dimension (the level of the individual)	Social dimension (the level of the community)
Affective condition (state)	emotions and emotional reactions thoughts meanings goals	social interaction communication atmosphere in the classroom (momentarily)
Affective property (trait)	attitudes beliefs values motivational orientations	norms social structures atmosphere in the classroom

Relevance of Emotions in the School Context and Their Development

Within the broader context of the school environment, particularly in mathematics lessons, students experience a diverse range of positive and negative emotions (Pekrun, 2006). The negative-activating emotion of anxiety has been extensively studied, particularly in the context of test anxiety (Pekrun et al., 2006; Tulis, 2010). This tendency exhibits an increase throughout primary school, subsequently stabilizing from the fifth grade onward (Sutter & Hascher, 2022). Similarly, the deactivating-negative emotion of boredom has been reported to occur frequently, with its frequency increasing over the school years (Haag & Götz, 2012; Hascher & Hagenauer, 2018; Pekrun et al., 2006). Conversely, the positive-activating emotion of joy has been reported to decrease over school years (Hascher & Reindl, 2013; Pekrun et al., 2006). Thus, research indicates that positive emotions in mathematics lessons decrease throughout schooling, whereas negative emotions increase (Ahmed et al., 2013). However, this trend is only moderately pronounced in primary school and is not observed universally among all students (Hascher & Hagenauer, 2011).

As previously noted, the phenomenon of emotional perception is the result of the interplay of numerous factors. For example, emotional feelings in mathematics lessons are found to be closely associated with individual mathematical performance. This suggests that students who demonstrate lower levels of mathematical ability may be particularly vulnerable to developing adverse emotional feelings during mathematics lessons (Götz, 2004). In addition to individual performance, the collective performance of the learning group exerts an influence on the perceived enjoyment of learning and possible anxiety in lessons (Götz et al., 2004). Furthermore, Laine et al. (2020) were able to determine the

pivotal influence of the teacher on the emotional classroom climate in mathematics lessons. For example, the classroom climate was rated positively when the teacher promoted student-student mathematics interaction. Conversely, it was rated negatively when students were required to work independently and feared criticism and embarrassment (Laine et al., 2020).

Emotional Classroom Climate Research in Mathematics

Studies on emotions and emotional classroom climate employ both classical data collection methods (e.g., interviews, questionnaires) as well as visual methods (e.g., drawings), which have shown significant benefits in qualitative inquiry when working with (young) students (Einarsdóttir, 2007). Regardless of the chosen data collection method and study design (i.e., cross-sectional or longitudinal study), it was found that enthusiasm for learning mathematics declined in the initial years of schooling and was increasingly accompanied by negative emotions during the primary school period. In their longitudinal study, Hascher and Reindl (2015) investigated five discrete emotions (i.e., joy, interest, anger, fear, and boredom) of Austrian children in eight primary school classes (Grades 1–4) using a questionnaire with a 4-point Likert scale. The results from variance analyses with repeated measures indicated a decline in positive emotions and, consequently, an increasingly distanced attitude towards mathematics, with significant differences demonstrated for the overall scale of positive emotions, as well as for the emotions of joy, interest, and boredom. However, the study also demonstrated a decline in negative emotions (i.e., boredom, fear) and a recovery effect, which occurred during the summer holidays. Conversely, Schiefer et al. (2018) conducted a study that utilized a questionnaire employing a 5-point Likert scale to assess students' interest in mathematics among those in Grades 4–11. The findings also revealed a negative trend concerning interest in mathematics (4.06 in the fourth grade, 3.41 in the fifth grade, and 3.14 in the sixth grade). The most recent study conducted by Mata et al. (2022) surveyed Portuguese students in Grades 3 and 4 using a questionnaire with a 5-Likert scale to assess their enjoyment of mathematics. Consistent with the findings of preceding studies, a decline in enjoyment was observed in mathematics lessons, both within individual measurement periods and across various grades.

Although studies are increasingly subject-specific, few research endeavours examine the individual content areas within mathematics concerning students' emotional feelings (Kuzle, 2021). In the field of arithmetic, Schmude (2005) conducted a study with children from the beginning of Grade 2 to the start of Grade 4. The study utilized a questionnaire that addressed the joy of learning arithmetic (i.e., computation). The data reflected an extremely stable, very positive affective attitude of the students in arithmetic. Other studies, which mostly employed students' drawings as a means of reporting on the emotional classroom climate in mathematics, showed that most students primarily think about arithmetic-related content when engaged in learning mathematics (Borthwick, 2011; Dahlgren Johansson & Sumpter, 2010; Laine et al., 2013, 2015). Consequently, a proportion of these studies have been incorporated here. The first findings, which outlined a decline in enthusiasm for mathematics among students in their initial school years, accompanied by an increase in negative emotions, were reported by Dahlgren Johansson and Sumpter (2010). A comparison between Grades 2 and 5 revealed that Grade 2 students exhibited positive emotions more frequently than Grade 5 students (Dahlgren Johansson & Sumpter, 2010). The most frequently occurring emotion in the drawings of Grade 2 students was happiness, whereas in the drawings of Grade 5 students, calmness and frustration were dominant (Dahlgren Johansson & Sumpter, 2010). Subsequent studies by Laine et al. (2013, 2015) yielded analogous results. Here, a negative trend in the emotional classroom climate in mathematics lessons was

established over school years (Laine et al., 2013, 2015). Concretely, the results showed that drawings characterized by an exclusively positive atmosphere increased from 47% (Grade 3) to 58% (Grade 5). Conversely, the proportion of exclusively negative drawings decreased from 11% (Grade 3) to 0% (Grade 5). Yet, ambivalent drawings, in which both positive and negative emotions were depicted, exhibited no alteration (42% in each case).

Geometry lessons presumably offer a wide range of opportunities to promote a positive attitude towards mathematics. Especially students who encounter difficulties in arithmetic lessons can often experience success in geometry lessons due to the high level of activity-orientation in these lessons, which in turn has been shown to increase their sense of competence (Krauthausen, 2018). The often-playful learning content can also increase enjoyment of mathematics as a subject (Astleitner, 2000). Furthermore, geometry facilitates a vivid approach to arithmetic problems, thereby ensuring an experience of competence and an enhancement in the enjoyment of learning and performance (Krauthausen, 2018). Studies that dealt explicitly with emotions experienced in geometry lessons are currently rare. For example, Kuzle (2021) investigated the emotional classroom climate of 114 German students in Grades 3 to 6, using participant-produced drawings. The drawings were interpreted according to the representations they contained and categorized into five distinct categories, namely, positive, ambivalent, negative, neutral, and unidentifiable. The findings indicated that the emotional classroom climate was consistently positive and relatively stable across all grades. However, a positive emotional classroom climate was observed to be a dominant feature in Grade 3 geometry lessons, with negative classroom climates being elicited in very few cases. Nevertheless, an ambivalent classroom climate increased from the lower into the higher grades, warranting particular attention.

Research Questions

Based on the aforementioned theoretical perspective and empirical results, this study aimed to contribute to the research on mathematics-related affect by examining the emotional classroom climate across two distinct mathematical domains (i.e., arithmetic and geometry) within the context of primary school mathematics, as well as its development over time. The exact research questions are:

1. What kind of emotional classroom climate in mathematics lessons can be seen in Grades 3–6 participant-produced drawings?
2. How does emotional classroom climate differ between arithmetic and geometry lessons in Grades 3–6 participant-produced drawings?

Method

Research Design and Subjects

An exploratory, cross-sectional, qualitative research design (Patton, 2002) was employed in this study, utilizing participant-produced drawings (Kearney & Hyle, 2004). The participants were 114 primary school students in Grades 3 to 6. This age group was considered optimal because they had already gained sufficient experience in school mathematics. According to Lucquet's theory of developmental stages in drawing (1913, 1923, in Anning & Ring, 2004), the quality of their drawings was sufficiently high to provide valuable insights into the emotional classroom climate. The distribution of students was as follows: 25 students from Grade 3, 33 students from Grade 4, 28 students from Grade 5, and 28 students from Grade 6. The study involved several urban schools from two German

federal states (i.e., Berlin and Brandenburg) that met the following criteria: they were not high- or low-performing schools, students had at least one geometry lesson per week, and, according to the teachers, could reflect the variety of emotional states experienced during distinct mathematics lessons. A maximum of two average students were randomly selected from each school. Typical case sampling, a form of purposive sampling, was employed to collect rich and in-depth data, allowing for comparison with other similar samples (Patton, 2002).

Data Collection Instruments and Procedures

Similar to previous studies (Ahtee et al., 2016; Glasnović Gracin & Kuzle, 2018; Kuzle, 2019, 2021; Laine et al., 2013, 2015; Tuohilampi et al., 2016) investigating the emotional classroom climate in primary school, the research data consisted of (a) document review and (b) audio recordings collected in one-to-one settings between students and the author of the paper. Regarding (a), each student was given a blank A4 sheet of paper and received instructions in the form of an Anna letter (Dohrmann & Kuzle, 2014), which presented the following drawing assignment:

> "Dear _____, I am Anna and new to your class. I would like to get to know your class better. Draw two pictures of your mathematics lessons. The first drawing should show what your arithmetic lessons are like and how you view them. The second drawing should show what your geometry lessons are like and how you view them. In each drawing, include your teaching group, the teacher, and the pupils. Use speech bubbles and thought bubbles to describe conversations and thoughts. Mark the pupil that represents you in the drawing by writing "ME". Thank you and see you soon! Yours, Anna." (Glasnović Gracin & Kuzle, 2018; Kuzle, 2019, 2021)

Depending on their age, students either read the assignment themselves or had it read to them by the researcher. Thought and speech bubbles presented the children's thoughts as an additional visual representation, facilitating their description of these thoughts (Wellman et al., 1996). Students were given a sufficient amount of time to complete the drawing assignment, typically ranging from 10 to 15 minutes for each of the two drawings. After completing the drawing assignments, the students were interviewed using a semi-structured approach, as suggested by Kearney and Hyle (2004) (b). During the semi-structured interview, both a free description of the drawing on the part of the student were given (e.g., "Describe your picture to me.") and specific questions based on the child's description were posed (e.g., "How does the child 1, 2, etc. feel in the first/second drawing?", "What is the reason for that?"). Such a procedure allowed each student to interpret and contextualize their own experiences and drawings.

Data Analysis

As outlined by Patton (2002), the analysis proceeded through multiple stages, encompassing the following steps: (a) transcription of audio data, (b) conducting a qualitative content analysis of the drawings (Patton, 2002), and (c) verifying or refining the interpretation of the drawings through a content analysis of data obtained from the semi-structured interviews. Specifically, the author transcribed the audio data (a) and independently analysed the drawings (b) in collaboration with an additional coder. Each drawing was examined sequentially according to predefined content categories. To achieve a holistic evaluation of the emotional classroom climate, the evaluation focused on the

emotional expressions of both the students and the teacher (Laine et al., 2013, 2015), which were inferred based on Koike's (1997, as cited in Gramel, 2008, p. 36) classification of emotional expressions, namely facial expression, gestures, the facial schema, the representation of situations triggering emotions, and symbols. As in Kuzle (2021, 2024), the facial features, as well as the content of the speech and thought bubbles, were analysed using Zambo's (2006) coding manual, which was further extended to include physical gestures (e.g., body posture, arm position), as proposed by Koike (1997, as cited in Gramel, 2008), and Kuzle (2021, 2024), to allow for a more nuanced analysis. To support the interpretation of the drawings, the semi-structured interviews were analysed (c) using the same methodological approach, treating them as participant-produced data. The interview data generally corroborated the coders' interpretations of the drawings but also provided additional insights (e.g., the emotions of non-depicted classroom protagonists or those depicted from behind), and, in rare cases, revealed contrasting perceptions of the emotional classroom climate. By triangulating these two data sources, the internal consistency of the findings was evaluated, thereby strengthening the validity of the results, as was suggested in similar studies (e.g., Einarsdóttir, 2007; Kearney & Hyle, 2004; Kuzle, 2021, 2024).

Following the individual ratings of the children depicted in each drawing, a holistic evaluation of the emotional classroom climate was conducted by integrating Zambo's (2006) rating system with the emotional classroom climate categories developed by Laine et al. (2013, 2015). Here, a positive counter (+1) was assigned if a child's depiction in a specific category was assessed as emotionally positive. Conversely, a negative assessment received a score of -1, and a neutral assessment was marked as 0. In cases where no relevant emotional features were illustrated, the category was coded as unidentifiable and denoted with a dash (–). This system permitted an aggregate score to be calculated for each drawing, ranging from +2 to -2. After rating all relevant features, the cumulative score was calculated to determine the overall emotional tone of each child's depiction. A total score of zero indicated a neutral emotional state, while a positive or negative score reflected a positive or negative emotional tone, respectively. If a child's depiction contained both positive and negative emotional elements, the overall emotional expression was classified as ambivalent.

A slightly modified version of the emotional classroom climate categories developed by Laine et al. (2013, 2015) was subsequently applied to enable a holistic assessment, as previously demonstrated in Kuzle (2021, 2024). The emotional categories were as follows: positive (i.e., persons smile, think or behave positively, with the possibility of some neutral expressions); ambivalent (i.e., both positive and negative facial or body language expressions or thoughts); negative (i.e., persons are sad or angry or have negative thoughts or behaviour, with the possibility of some neutral expressions); neutral (i.e., all facial or body language expressions or other thoughts are neutral); and unidentifiable (i.e., no discernible emotional expressions or thoughts). In instances where both identifiable and non-identifiable individuals were present in a drawing, only the non-identifiable figures were considered in the overall analysis. Still, a neutral score was assigned to them for consistency. Figure 1 provides an overview of the coding process.

Three students (two on the left side and one on the right side of the drawing) are smiling, and their eyes are open wide (positive).
One child is illustrated from behind (neutral).
The teacher is smiling with eyes open wide (positive).
All of the children's arms are positioned downward (neutral).
The student described the teacher as usually being in a good mood and laughing a lot (positive).
The student describes herself as always being in a good mood and having fun in an arithmetic lesson.

Figure 1. Exemplary coding of a drawing depicting a positive classroom climate in a Grade 4 arithmetic lesson.

To ensure objectivity in the analysis, two researchers independently coded the students' data. Initial inter-rater reliability was high, with an agreement rate of 87%. Nevertheless, discrepancies in coding were subsequently reviewed and discussed in light of the students' visual and verbal data. These discussions also served to refine the coding manual, particularly concerning drawings in which the protagonists were depicted from behind, or in a highly simplified or abstract manner. Further disagreements emerged regarding the interpretation of certain thought features, such as ambiguous phrases like "good" or "okay", which were most prevalent in drawings produced by Grade 3 students. To address these cases, the researchers agreed that the final decision on the emotional categorization of a given physical or cognitive feature would be guided by the corresponding data from the semi-structured interview. Through the process of analyst triangulation, coding discrepancies were resolved, resulting in 100% interrater agreement. This iterative process not only enhanced the reliability of the analysis but also contributed to the verification and validation of the qualitative findings. Following finalized coding, descriptive statistics were computed to determine the overall emotional classroom climate.

Results

This section is divided into two parts. The first part focuses on the emotional classroom climate in mathematics lessons across four grade levels (i.e., Grades 3–6). The second part provides a differentiated insight into the similarities and differences in the emotional classroom climate between arithmetic and geometry lessons at these grade levels.

Emotional Classroom Climate in Grades 3–6 Mathematics Lessons

Table 3 presents the results regarding the emotional classroom climate in mathematics lessons across Grades 3–6 without distinguishing between distinct mathematics lessons. The drawings were classified into one of five categories (i.e., positive, negative, ambivalent,

neutral, or unidentifiable) (Laine et al., 2013, 2015) based on the physical features (e.g., face, body), and speech and thought bubbles of the children and teacher in the drawings.

A total of 228 drawings from Grades 3–6 students were analyzed. The results indicated that almost half of the drawings (46.5%) depicted a positive emotional classroom climate in mathematics lessons. As exemplified in Figure 1, in these cases, the visual depictions of students and teachers exhibited a range of positive emotional, physical, facial, and body features. These characteristics included wide-open eyes, broad smiles, and open body language, characterized by extended arms. Furthermore, positive speech and thought bubbles were evident, such as the heart and smiley symbols, as well as verbal expressions such as "That's easy.", "I am in a good mood.", and "I like it." In 27.2% of the drawings, the emotional classroom climate was classified as ambivalent, with positive and negative features being either illustrated or mentioned. The former included positive features such as arms open upwards, smiling faces, affirmations such as "I understand it.", "I can do geometry," and "Easy." The latter included negative features, such as mouth turned downward, eyes in a downward slant, tears on the face, verbal expressions such as "Boring.", "Wake up!", "Oh no, not today." An example of a drawing illustrating an ambivalent emotional classroom climate is presented in Figure 2.

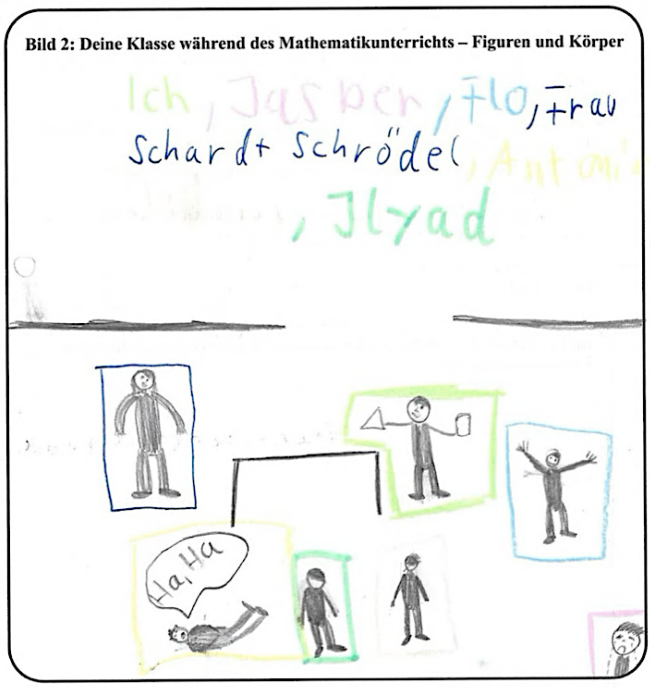

Figure 2. Drawing depicting an ambivalent classroom climate in a Grade 4 geometry lesson.

Approximately one seventh of the students' drawings (14.0%) depicted the emotional classroom climate as negative. In such cases, the visual depictions of students and teachers exhibited a range of negative emotional, physical, facial, and body features, with some neutral ones. The negative characteristics included a mouth turned downward, eyebrows slanted inward, and the teacher's mouth open in a scream-like manner. Furthermore, the presence of negative speech and thought bubbles was evident, including sad smiley symbols, as well as verbal expressions such as "Not again.", "Finally, we get to go home.", "Shut up.", "Always just computing." In 9.2% of the drawings, the emotional classroom climate was classified as neutral, as all emotional physical face and body features (e.g., eyes with no

expression, mouth drawn as a straight line, hands on the table) as well as speech and thought bubbles (e.g., “Do all the tasks.”, “A cube has 6 faces.”, “The answer is 27.”) were neither positive nor negative.

Table 3
Emotional Classroom Climate in Grades 3–6 Mathematics Lessons: Absolute and Relative Frequencies

		Emotional classroom climate categories				
Grade	*N*	positive	ambivalent	negative	neutral	unidentifiable
3	50	31 (62%)	11 (22%)	5 (10%)	2 (4%)	1 (2%)
4	66	31 (47.0%)	17 (25.8%)	8 (12.1%)	7 (10.6%)	3 (4.6%)
5	56	24 (42.9%)	16 (28.6%)	9 (16.1%)	6 (10.7%)	1 (1.8%)
6	56	20 (35.7%)	18 (32.1%)	10 (17.9%)	6 (10.7%)	2 (3.6%)
Total	228	106 (46.5%)	62 (27.2%)	32 (14.0%)	21 (9.2%)	7 (3.1%)

Independent of the grade level, the majority of the students’ drawings reflected a positive emotional classroom climate in mathematics lessons, ranging from 35.7% in Grade 6 to 62% in Grade 3. This was followed by a series of drawings illustrating an ambivalent emotional classroom climate in mathematics lessons, ranging from 22% in Grade 3 to 32.1% in Grade 6. The third most prevalent classroom climate category was that of drawings illustrating a negative emotional classroom climate in mathematics lessons, ranging from 10% in Grade 3 to 17.9% in Grade 6. Drawings portraying a neutral emotional classroom climate were the least frequently coded, ranging from 4% in Grade 3 to 10.7% in Grades 5 and 6. In each grade level, one to three drawings were excluded from the analysis due to an inability to infer the type of emotional classroom climate that they represented.

Regarding the emotional classroom climate type, several trends were identified across Grades 3–6. The data showed a decline in positive emotions from Grade 3 to Grade 6 concerning the positive emotional classroom climate category. Whereas almost two-thirds of the drawings in Grade 3 (62%) illustrated a positive emotional classroom climate in mathematics lessons, this was true for only a bit more than one-third of the Grade 6 drawings (35.7%). The analysis revealed a negative trend in the prevalence of drawings depicting ambivalent and negative emotional classroom climates in mathematics lessons from Grade 3 to Grade 6, indicating an increase in drawings depicting ambivalent and negative emotional classroom climates in mathematics lessons from Grade 3 to Grade 6. In Grade 3, approximately every fifth drawing (22%) illustrated an ambivalent emotional classroom climate, whereas in Grade 4 this figure increased to almost every fourth drawing (25.8%). Notably, in Grades 5 and 6, almost every third drawing (28.6% and 32.1%, respectively) depicted an ambivalent emotional classroom climate. Similarly, negative emotions exhibited an increase from 10% in Grade 3 to 17.9% in Grade 6, although this figure remained comparatively low, reflecting an ambivalent emotional classroom climate. Conversely, the neutral emotional classroom climate category demonstrated stability across Grades 4–6.

Emotional Classroom Climate in Grades 3–6 Arithmetic and Geometry Lessons

Table 4 provides an in-depth analysis of the emotional classroom climate of mathematics lessons across Grades 3–6. Here, the distinction between arithmetic and geometry lessons is highlighted to explicate the trends documented in Table 3.

Table 4
Emotional Classroom Climate in Grades 3–6 Arithmetic and Geometry Lessons: Absolute and Relative Frequencies

	Emotional classroom climate categories									
	positive		ambivalent		negative		neutral		unidentifiable	
Content area	Ari	Geo	Ari	Geo	Ari	Geo	Ari	Geo	Ari	Geo
Gr. 3	16	15	5	6	4	1	0	2	0	1
$N = 25$	64%	60%	20%	24%	16%	4%	0%	8%	0%	4%
Gr. 4	17	14	8	9	5	3	2	5	1	2
$N = 33$	51.5%	42.4%	24.2%	27.3%	15.2%	9.1%	6.1%	15.2%	3.0%	6.1%
Gr. 5	11	13	6	10	7	2	4	2	0	1
$N = 28$	39.3%	46.4%	21.4%	35.7%	25%	7.1%	14.3%	7.1%	0%	3.6%
Gr. 6	7	13	6	12	10	0	4	2	1	1
$N = 28$	25%	46.4%	21.4%	42.9%	35.7%	0%	14.3%	7.1%	3.6%	3.6%
Total	51	55	25	37	26	6	10	11	2	5
$N = 114$	44.7%	48.2%	21.9%	32.5%	22.8%	5.3%	8.8%	9.7%	1.8%	4.4%

An examination of Grades 3 and 4 revealed minimal differences in positive and ambivalent emotional classroom climate categories between the two lessons. Specifically, just one drawing more of an arithmetic lesson compared to drawings of a geometry lesson was illustrated as positive, and one drawing more of a geometry lesson compared to drawings of an arithmetic lesson was illustrated as ambivalent in Grade 3. In Grade 4, the findings indicated a similar state regarding the ambivalent emotional classroom climate. In the context of the positive emotional classroom climate category, three additional drawings pertaining to an arithmetic lesson were coded in comparison to those derived from geometry lessons. The discrepancy between the two lessons regarding the negative emotional classroom climate category was found to be notably higher in Grade 3. Here, only one Grade 3 geometry drawing (4%) elicited a negative emotional classroom climate, whereas four Grade 3 arithmetic drawings (16%) did so. In Grade 4, an increase in the number of drawings was observed, with one additional arithmetic drawing and two additional geometry drawings.

As was the case in Grades 3 and 4, a minimal difference was observed in the positive emotional classroom climate category between the two lessons. However, in this case, the drawings from the geometry lesson ($n = 13$) were slightly more positive (7.1%) compared to the arithmetic lesson ($n = 11$). That geometry lessons more often depicted an ambivalent emotional classroom climate ($n = 10$) than arithmetic lessons ($n = 6$) was also the case in Grade 5. However, the variance was found to be higher in Grade 5 than in Grades 3 and 4. A total of ten geometry drawings (35.7%) and six arithmetic drawings (21.4%) were assigned to the ambivalent emotional classroom climate category. The trend pertaining to negative emotional classroom climate, as previously observed in Grades 3–4, remained consistent. Once more, a greater proportion of students ($n = 7$, 25%) illustrated a negative emotional classroom climate in arithmetic lessons than in geometry lessons ($n = 2$, 7.1%). Furthermore, the observed variance increased to 17.9%. The trends observed in Grade 5 were also evident in Grade 6, but they became even more pronounced. Again, a greater number

of geometry drawings (n = 13) elicited positive emotional classroom climate than arithmetic drawings (n = 7). Furthermore, a greater number of geometry drawings (n = 12) depicted an ambivalent emotional classroom climate in comparison to arithmetic drawings (n = 6), with a variance of 21.5%. The negative emotional classroom climate was illustrated in drawings of an arithmetic lesson only (n = 10%).

Concerning the emotional classroom climate type in each lesson, several trends were identified across Grades 3–6. In the drawings of arithmetic lessons, the data indicated a decline in positive emotions from lower into higher grades, ranging from 64% in Grade 3 to 25% in Grade 6. Furthermore, the data reflected a growing tendency in negative emotions from lower into higher grades, ranging from 16% in Grade 3 to 35.7% in Grade 6. The drawings assigned to the ambivalent emotional classroom climate category, which encompassed both positive and negative emotions and/or emotional expressions, remained relatively stable across all grades. Two prototypical drawings of the negative emotional classroom climate in an arithmetic lesson in Grades 3 and 6 are presented in Figures 3 and 4, respectively.

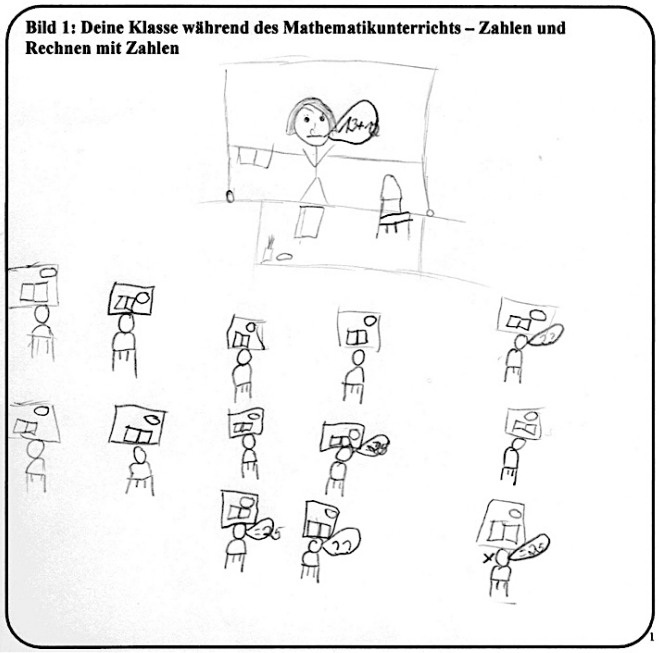

Figure 3. Drawing depicting a negative classroom climate in a Grade 3 arithmetic lesson.

As illustrated in Figure 3, the teacher is represented by a facial expression that conveys a negative emotional state. Concurrently, the thought bubbles of two children are depicted with the iconic question mark symbol. The drawer described the teacher as being extremely demotivated, a state that was customary for her. Furthermore, she elaborated that the teacher's demeanour can be characterized as irritable and unfriendly, particularly towards students who demonstrate a slower pace of learning, which was often accompanied by reprimands for their inability to solve the assigned problems. The drawer herself stated, "Math lessons are no fun." She added that the class often felt overwhelmed. Statements and explanations of a similar nature were also given by other students, irrespective of their grade level. A student from Grade 5 stated, "Well, some students find the tasks too difficult because there are so many numbers. And they don't feel like doing the calculation tasks again." In a similar vein, another student asserted, "So the mood is rather bad because most of the

students don't feel like doing math or can't do the maths and then don't pay attention." Especially the latter was often reported by the students. On many occasions, the students also described the lessons as being boring, a perception that became increasingly pronounced as students progressed into higher grades.

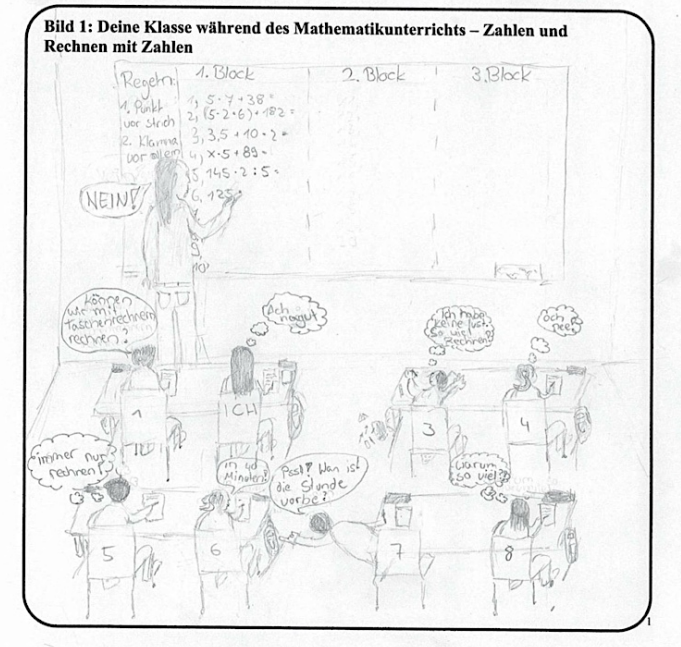

Figure 4. Drawing depicting a negative classroom climate in a Grade 6 arithmetic lesson.

In Figure 4, the teacher is depicted from behind with a speech bubble containing a negative statement, "No". The drawer explained that the teacher was irritated, which was further accentuated by the remark, "She invariably is, in fact." Whereas only child 1's thought bubble contained a neutral statement ("May we use the calculator?"), the remaining thought bubbles contained negative statements such as "I don't feel like doing so much maths." (child 3), "Oh no." (me), "Always doing the maths." (child 5), "Psst! When is the lesson over?" (child 7), "In 40 minutes." (child 6) and "Why so many?" (8). The interview with the student further intensified the depiction of the situation. She asserted, "None of the students want to do maths. The teacher writes far too many maths problems on the board. Many classmates don't feel like doing maths and hope the lesson is over quickly. Some are also quite angry because the material is so difficult and there's so much of it." Many Grade 6 students disclosed a similar emotion of demotivation and boredom in their interviews, as supported by the following statement: "The class is annoyed. They don't want to do all the tasks on the pieces of paper. It's always the same. Everyone does the same thing. The way the teacher does maths is boring. I don't feel so good ... unmotivated."

In the geometry lesson drawings, the data indicated a decline in positive emotions from Grade 3 (60%) to Grade 4 (42.4%), with a relatively stable level in Grades 5 and 6 (46.4%). Other than in the case of drawings portraying an arithmetic lesson, the drawings portraying a geometry lesson elicited a decreasing tendency of negative emotions from lower into higher grades, ranging from 4% in Grade 3 to 0% in Grade 6, though in Grades 4–5, being a bit higher, but remained stable. However, drawings assigned to the ambivalent emotional classroom climate category showed a growing tendency from lower to higher grades, ranging from 24% in Grade 3 to 42.9% in Grade 6. Figure 5 provides a prototypical drawing of the

ambivalent emotional classroom climate in a geometry lesson. The teacher is depicted with a positive emotional expression, smiling as she points to the board and assigns the task using a neutral assertion, “Do all the tasks.” Positive emotions were expressed by two children, namely child 4 and child 6. Child 4 is smiling, and child 6 raises his arm, accompanied by a speech bubble that reads, “That is easy.” Two children, namely child 2 and child 7, exhibit a neutral emotional state, as their thought bubbles contain neutral statements such as “...” and “Yes or ...”. The remaining four children display negative emotional responses to the classroom environment. The speech bubble of child 1 (“All... [of them]?!”) indicates a state of frustration. In contrast, the thought bubble of child 3 (“Ich = me”; “The faster I finish, the faster I can read.”), implies a desire to conclude the activity promptly to engage in other activities. The thought bubbles of child 5 (“Oh no.”) and child 8 (“Always just writing.”) both serve to convey a sense of dissatisfaction with the tasks at hand, thereby reflecting negative emotions towards the lesson. In two drawings only, the negative emotions and/or emotional expressions (“So we’re always supposed to draw with a sharpened pencil and if we don’t do it, then we’re criticized.”) of the teacher contributed additionally to the coding of drawings as ambivalent. Statements such as “I like geometry the most because it’s more relaxed and we don’t write so many tests.”, “… topic in the second picture interests the class more overall, with the figures and bodies and everything.” and “It’s fun and easier.” were not uncommon.

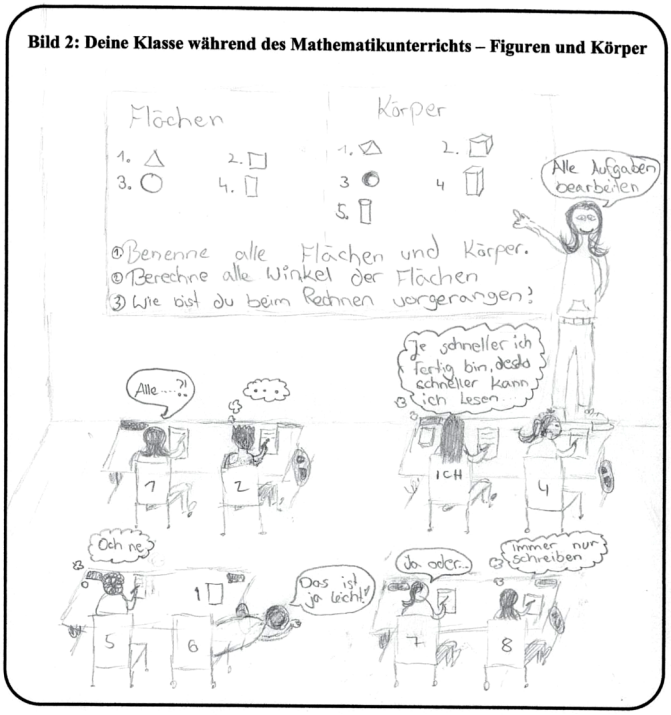

Figure 5. Drawing depicting an ambivalent classroom climate in a Grade 6 geometry lesson.

Discussion and Conclusion

In the last section, a differentiated insight into the emotional classroom climate in distinct school mathematics lessons in Grades 3–6 is discussed. Lastly, the study’s limitations are considered, and some possible future research directions and practical implications are discussed.

A Differentiated Insight into the Emotional Classroom Climate in Distinct School Mathematics Lessons in Grades 3–6

The present study utilized participant-produced drawings as a data source for researching primary-grade students' perceptions of distinct mathematics lessons, specifically arithmetic and geometry lessons, from an emotional perspective (Evans et al., 2009). To express different aspects of the psychological dimension of affect (e.g., emotions and emotional reactions, thoughts, attitudes, beliefs) (Hannula, 2012), students in Grades 3–6 used various physical face and body features (i.e., eyes/eyebrows, mouth, arm posture) and thoughts (i.e., symbols, signs, words) (Kuzle, 2021, 2024; Zambo, 2006), which were the assigned to one of five emotional classroom climate categories as suggested by Laine et al. (2013, 2015, 2020).

The analysis of participant-produced drawings from Grades 3 to 6 revealed a prevailing positive emotional classroom climate in the context of mathematics lessons. However, in Grade 3, such an emotional classroom climate predominated (62% of drawings), followed by a decline from lower to higher grades, reaching 35.7% of drawings portraying a positive emotional classroom climate in Grade 6. Furthermore, an incline in drawings illustrating an ambivalent and negative emotional classroom climate, from lower to higher grades, accompanied by a lower percentage of positive ones, emerged from the data. Similar results were reported in a cross-sectional study by Dahlgren Johansson and Sumpter (2010), where the majority of Grade 2 students expressed positive attitudes towards mathematics, associated with a positive feeling of joy. Conversely, a decrease in positive emotions was observed among Grade 5 students compared to Grade 2 students, a finding consistent with the results of Laine et al. (2013, 2015), which involved Grade 3 and Grade 5 students. Likewise, in a longitudinal study, Reindl and Hascher (2013) reported a negative trend in the emotional experience during the primary grade school years.

Consequently, the theory posits that the students' positive emotions decrease throughout primary school, with ambivalent emotions becoming more prevalent (Dahlgren Johansson & Sumpter, 2010; Reindl & Hascher, 2013; Laine et al., 2013, 2015). The students exhibited positive activating emotions, specifically joy, which were reported more frequently in the lower grades and decreased throughout the primary school grades, as previously reported in the literature (Hascher & Reindl, 2013, 2015; Pekrun et al., 2006). However, negative activating emotions, such as anger and fear, as well as negative deactivating emotions, including boredom (Pekrun, 2006), were also reported. The prevalence of negative emotions was observed in drawings depicting arithmetic lessons, particularly those that portrayed a negative emotional classroom climate, and in drawings of geometry lessons, particularly those that depicted an ambivalent emotional classroom climate. Regarding negative emotions, a discernible trend emerged. This finding aligns with previous research (Haag & Götz, 2012; Hascher & Hagenauer, 2018; Mata et al., 2022; Pekrun et al., 2006; Schiefer et al., 2018) that has documented an increase in negative emotions throughout students' school years.

This decline in positive emotions was particularly evident in arithmetic lessons throughout the primary grades. The study's results indicated that drawings of a positive emotional classroom climate in arithmetic lessons were predominantly observed in Grades 3 to 5, with percentages ranging from 39.3% in Grade 5 to 64% in Grade 3. In Grade 6, only 25% of drawings portraying an arithmetic lesson reflected a positive emotional classroom climate. Consequently, it can be inferred that a favourable emotional classroom climate was present in Grades 3–4, as was also reported in the study by Schmude (2005), which explicitly focused on the joy of learning arithmetic (i.e., computation). Notably, the proportion of

positive drawings decreased in Grades 4 and 5. This phenomenon can be attributed to the concurrent increase in negative drawings, which ranged from 15.2% of drawings in Grade 4 to 35.7% of drawings in Grade 6. A decline in positive emotions was evident, although these remained above 50% in Grade 4. This decline in the proportion of positively rated drawings, accompanied by an increase in the number of negatively rated drawings in Grade 6 compared to Grade 5, indicates a negative trend in the positive emotional classroom climate in arithmetic lessons. This negative phenomenon can be attributed to the increasing abstract nature of arithmetic lessons, which students find challenging to comprehend, and a less focused approach to learning arithmetic content using manipulatives, as reported by several students. Yet, the drawings reflecting ambivalent emotional classroom climate demonstrated stability across Grades 3–6. As previously noted, similar trends were identified by Dahlgren Johansson and Sumpter (2010), Reindl and Hascher (2013), and Laine et al. (2013, 2015, 2020). Although these studies reported on the emotional classroom climate in mathematics lessons, the majority of students primarily associated arithmetic-related content with mathematics lessons. Consequently, it can be hypothesized that as the grade level increases, the proportion of positively rated/drawn pictures decreases, thereby confirming a negative trend in the positive emotional classroom climate in arithmetic lessons.

As Kuzle (2021) previously reported, positive emotions predominated in geometry lessons across all four grades. However, when comparing perceptions of arithmetic and geometry lessons among students in Grades 5 and 6, geometry lessons were more frequently perceived as positive compared to arithmetic lessons, and were rarely characterized as purely negative. Thus, it can be assumed that positive emotions predominated in geometry lessons. This phenomenon can presumably be explained by the fact that geometry lessons generally have a high level of relevance to the real world and a strong focus on practical activities (Krauthausen, 2018). These factors enable students to experience a wide range of competencies, in addition to the presentation of both present and future significance. According to the control-value theory (Pekrun, 2006) and the basic-needs theory (Ryan & Deci, 2004), this can lead to the development of positive emotions. This assumption was emphasized by comparing geometry with art in the study by Hascher and Reindl (2015). This school subject, characterized by autonomy and communication, generally receives a more consistently positive response from students than mathematics lessons (Hascher & Reindl, 2015), supporting the basic needs theory (Ryan & Deci, 2004). It can therefore be concluded that geometry lessons have the fundamental potential to facilitate the realization of autonomy, competence, and social interaction, thereby promoting positive emotions. However, a decline in positive emotions has also been observed in geometry lessons, as evidenced by comparing the drawings of students in Grades 3 to 4, but remained relatively stable in Grades 5 and 6. A notable finding is the increasing prevalence of drawings depicting an ambivalent emotional classroom climate in geometry lessons, reaching 42.9% in Grade 6. One possible explanation for this finding may be the optimism exhibited by children, which is more pronounced in younger students than in older ones (Hasselhorn, 2005), particularly in hands-on activities characteristic of geometry lessons. However, it is possible that negative trends in the positive emotional classroom climate are driving this phase of schooling in general, independent of the subject or subject-specific area.

Limitations of the Study, Future Research Directions, and Practical Implications

This study employed a qualitative, exploratory cross-sectional design, using purposive sampling, with a total of 114 students from two federal states in Germany. Consequently, the findings cannot be assumed to be generalizable to the broader population; instead, they

serve as illustrative insights for analogous groups. These limitations indicate a potential direction for future studies: conducting research with a larger and more diverse sample across various contexts (e.g., multiple federal states or countries) and using different sampling methods, such as maximum variation or probability sampling. Such an approach has the potential to yield a more comprehensive understanding of students' perceptions of the emotional classroom climate in distinct mathematics lessons, with results that are also more broadly applicable. Furthermore, drawings from entire classrooms encompassing diverse grades and schools could provide a more holistic picture of the shared emotional classroom climate in primary school and allow comparisons across different grades and schools, as evidenced by the research conducted by Laine et al. (2013, 2015, 2020) and Tuohilampi et al. (2016). The cross-sectional nature of this study did not allow the examination of the development of emotional classroom climate over time. A longitudinal study following specific groups from the start of primary school through the transition to secondary school would be valuable. Moreover, the data suggested that the teacher's actions influenced the students' perceptions of the emotional classroom climate. Future research focusing on the factors in teachers' actions that could explain differences in the emotional classroom climate in primary school mathematics, as suggested by Laine et al. (2020), as well as focusing on how the factors of autonomy, experience of competence, and social exchanges are addressed in the lessons, may be of relevance.

The use of visual representations, specifically participant-produced drawings, enabled the gain of insights into the emotional classroom climate from the students' perspective. Nevertheless, it is notable that this method has its limitations. The quality of the drawings was both dependent on the age of the students and their level of motivation to draw. The interpretation of some students' drawings, due to their frequently minimalist nature, often required additional data from the interviews. To minimize the impact of researcher bias, it is necessary to employ both analyst and methodological triangulation. One possible method for achieving this objective is to have students describe their drawings. Such an approach fosters a more profound and precise comprehension of their experiences and emotional perspectives (Anning & Ring, 2004). Additionally, prior to executing the task, engaging students in conversation can help ascertain their level of enjoyment regarding drawing and whether further guidance or motivation is required.

By relating the study results to teaching practice, some implications for mathematics lessons can be drawn. The study results revealed that students experience a range of emotions during their mathematics lessons, including both positive and negative ones. Following a comprehensive examination of the development of positive emotions, the underlying causes of these emotions, and the factors that influence them, the Emo-Math Project intervention program demonstrated how positive influence can be used to change emotions. The program aimed to promote self-regulation, establish effective learning methods and strategies for emotion regulation, and apply these in practical examples of tasks (Sutter & Hascher, 2022). This approach was further enriched by the incorporation of reflective activities, which aimed to emphasize the practical relevance of mathematical concepts for students' daily lives and future careers (Sutter & Hascher, 2022). Similar content was also taught in workshops for teachers. Here, too, the factors described in Pekrun's (2006) control-value theory and Ryan and Deci's (2004) basic needs theory, such as autonomy, the experience of competence, and the relevance of the content, ensure that the enjoyment of learning is maintained or increased. The study demonstrated that, upon receiving teacher training and adapting their pedagogical approach, teachers played a key role in the development of positive emotions. Even though the study was conducted with Grade 7 students, it can be assumed that the intervention

measure can also be implemented in other grades, such as primary school. A longitudinal study in a primary school would be interesting in this respect. It would provide an insight into whether the decline in positive emotions throughout schooling, which has been documented on multiple occasions, could be slowed down or even halted by such an intervention measure.

The increase in students' competencies is closely linked to the emotions they experience (Pekrun et al., 2006). Emotions represent a fundamental component of motivation in lessons and, as such, should be given appropriate consideration by teachers (Schiepe-Tiska & Schmidtner, 2013). In addition to teaching, all planning efforts should also be carried out with appropriate consideration of the students' emotions. The promotion of autonomy, experience of competence, and social learning can serve as the basis for this. Additionally, it is imperative to demonstrate the relevance of the learning content to students' everyday life situations, as supported by the control-value theory (Pekrun, 2006) and the basic-needs theory (Ryan & Deci, 2004). To respond to the constantly evolving interests of students, teachers need to adjust their approaches to counteract the decline in interest that is continually occurring (Eccles et al., 1993). Here, regular and transparent feedback can be constructive (Astleitner, 2000), among other benefits. In addition to the individual performance of the students, it is therefore essential to constantly recognize the emotional well-being of the children and take this into account when designing the lesson.

The ability to recognize and manage one's own emotions is a pivotal developmental milestone for students. Teachers must recognize the crucial role emotions play in students' learning motivation, academic performance, and attitude toward the subject, and incorporate this understanding into their teaching practices. The present study provided a differentiated insight into the emotional classroom climate in distinct mathematics lessons across Grades 3–6 and its development over the primary school years. Further evidence should be provided for subject-specific or even topic-specific differences, as well as intervention measures influencing the growth of positive emotions, to counteract a distant attitude towards mathematics due to (possible) development of negative emotions.

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