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Elementary school children's perceptions of geometry classroom as a psychosocial learning environment: an analysis of participant-produced drawings

Ana Kuzle[1]

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Abstract

A growing literature points to the importance of classroom social climate as one of the determinants of students' academic performance and motivation, engagement, participation, and attitude towards school and teaching. However, little attention is given to social climate in the context of the mathematics classroom as a learning environment, with studies providing only insights into its specific aspects. The present study addressed these problems by investigating classroom social climate in the context of geometry lessons in Grades 3–6 with the goal of providing comprehensive insight into students' perceptions of their geometry classroom climate by identifying its psychosocial aspects. In total, 114 primary-grade students participated in the qualitative cross-sectional study. To capture students' perceptions of their geometry classroom, participant-produced drawings were used as a research method. These were analyzed using qualitative content analysis. The results reflected a teacher-centered image of a geometry learning environment which was driven by frontal work with a broad spectrum of participatory activities, but with very little student–student communication. Additionally, the lesson goals were transparent which were supported by using different teaching tools and materials. Lastly, the lessons were organized in an orderly manner. The findings offer potential opportunities for educators to plan and implement effective pedagogical strategies at the university that would reflect the teaching practices conducive to geometry learning. Likewise, the research method can be used in classroom learning environments as a tool to promote a dialogue between students and their teachers.

Keywords Classroom Social Climate · Geometry Lessons · Learning Environment · Mathematics Education · Participant-produced drawings

✉ Ana Kuzle
kuzle@uni-potsdam.de

[1] Department of Primary Mathematics Education, University of Potsdam, Karl-Liebknecht-Straße 24-25, 14476 Potsdam, Germany

Introduction

The classroom is a significant learning environment in the multifaceted development of children because they spend an average of 20–30 h a week in it during their first six years of schooling (OECD, 2019). It shapes students' essential perceptions, their cognitive, social, and practical development (Radatz et al., 1991) and the development of both interpersonal and academic skills (Trickett & Moos, 1973), and it allows each student to acquire new concepts and procedures (Ahtee et al., 2016). Learning environments as such are personal but "each individual's constructions are mediated by the actions of others in the social setting and the characteristics of the culture in which learning is situated" (Lorsbach & Jinks, 1999, p. 158). In this regard, the classroom is a significant *social environment* in children's development (Eder, 2002). Here, children's perception of the classroom climate as a pleasant learning environment has a positive effect on their individual attitudes toward school and the learning environment (Rohlfs, 2011). Given that learning environments are constrained by history (Lorsbach & Jinks, 1999), each learning environment develops a distinct social climate with time having certain demand characteristics (Evans et al., 2009; Moos & Moos, 1978; Trickett & Moos, 1973). In a broader sense, the classroom climate also can include physical environments, such as school building and classroom furniture, that likewise affect the learning and teaching opportunities (Fahlström & Sumpter, 2018). However, here the focus is on the psychosocial aspect of the classroom climate.

The construct of *classroom climate* is complex and to date no uniform definition exists, but rather it is described through its fundamental supporting elements (Eder, 2002) which can be reduced to different factors in a variety of ways (Evans et al., 2009). This multifaceted nature of classroom social climate and versatility of diverse models with accompanying psychosocial aspects are likewise reflected in research on classroom learning environments which primarily has been assessed with quantitative instruments based on the work of Harvard Project Physics (Walberg, 1976) and Moos's (Moos & Moos, 1978) social climate scales. Such instruments include the Classroom Environment Scale (CES), Learning Environment Inventory Climate Scales, Questionnaire on Classroom Climate, Linz Questionnaire on School and Classroom Climate, Landau Scales on Social Climate, My Classroom Inventory (Bülter & Meyer, 2015; Fraser & Fisher, 1983; Walberg, 1976). The comparison of the different conceptualizations and instruments has shown that the basic concept of classroom climate is broad but generally homogeneous (Bülter & Meyer, 2015) and provides a rich storehouse of data regarding teachers' and students' perceptions of the psychosocial learning environment (Lorsbach & Jinks, 1999). These include psychosocial factors, such as relationship characteristics (e.g., teacher–student, student–student), as well as instructional characteristics (e.g., choice of instructional methods, internal differentiation, design of the learning environment) (Bülter & Meyer, 2015). Especially, the CES has been widely used with secondary students because – due to its detailed structure – it is possible to capture the essence of the psychosocial classroom environment to obtain systematic data on classroom social climate's different psychosocial aspects such as teachers' behavior, teacher–student interactions, and interactions among students. Also, it is possible to determine and understand the effects of socialization in a wide variety of classrooms as perceived by different individuals in the same setting (Fraser & Fisher, 1983).

To date, however, it has not been possible to make an area-wide statement about the classroom social climate in primary-grade mathematics (Eder, 2002). One reason for this is the lack of a suitable instrument for primary-grade students. My Classroom Inventory was the only instrument developed to measure the perception of an actual environment by elementary-grade students (8 to 12 years of age). It was developed on the basis of the CES but includes five scales only (Bülter & Meyer, 2015; Fraser & Fisher, 1983), and hence was not able to give a comprehensive picture of students' perceptions of the psychosocial learning environment. Furthermore, such quantitative methods have been shown not to be reliable due to participants' young age (Einarsdóttir, 2007; Pehkonen et al., 2016). However, the use of children's drawings as a research tool allows change in the perspective and perceiving the learning environment through students' point of view (Borthwick, 2011). A plethora of research studies (Ahtee et al., 2016; Aronsson & Andersson, 1996; Glasnović Gracin & Kuzle, 2018; Kuzle & Glasnović Gracin, 2019; Laine et al., 2013, 2015; Lodge, 2007; Pehkonen et al., 2016; Rolka & Halverscheid, 2011; Walls, 2007) showed that children provide extensive data through their drawings, thus creating a new opportunity to explore their ideas about teaching and learning. Furthermore, when combined with written or oral words, they can be even more revealing (Ahtee et al., 2016; Kearney & Hyle, 2004). The latter approach – so called participant-produced drawings – is characterized by establishing a rapport between the researcher and the participant as well as by a shift in power in the researcher–participant relationship (Kearney & Hyle, 2004) with drawings functioning as a catalyst for helping participants to articulate their feelings, emotions, and lived experiences.

Despite several decades of research (Bülter & Meyer, 2015; Evans et al., 2009; Fraser, 1989, 1998; Moos & Moos, 1978) concerning students' perceptions of their classroom learning environments, research on social aspects of the classroom environment such as communication, interaction, social working structures, and norms still are considered a fruitful and interesting research area (Hannula, 2012). Firstly, a growing literature (Evans et al., 2009) points to the importance of classroom social climate as one of the determinants of students' academic performance and motivation, engagement, participation, and attitude towards school and teaching. In this regard, it is important to understand how young children perceive their mathematics classroom. Moreover, given that past research (Bülter & Meyer, 2015; Eder, 2002) has focused more on the secondary level, primary-level research in this area is needed. Secondly, only recently has attention turned to mathematics classroom climate, and more research is needed in this context. Existing studies (Ahtee et al., 2016; Pehkonen et al., 2016), on the one hand, do not comprehensively assess the classroom social climate. Rather they focus on its few aspects and, thus, neither give a comprehensive picture of what is happening in the mathematics classroom nor give credit to the multifaceted construct of classroom social climate. On the other hand, they do not differentiate the classroom climate between different mathematical content areas. Given specific features of geometry lessons[1], namely alternative instructional concepts such as distinct possibilities for activity-based teaching, discovery learning, action-oriented instruction that relate more strongly to the students (Radatz et al., 1991), these could also influence the social climate or make its investigation interesting.

Having these considerations in mind, the main goal of the inquiry presented in this paper was to gain expressive and rich insight of the classroom social climate in Grades 3–6 geometry lessons using participant-produced drawings. To achieve these, students' data were analyzed using a model and an analysis instrument of the classroom social climate for primary-grade students (Kuzle & Glasnović Gracin, 2019, 2021) which were adapted

[1] Geometry lessons refer to two content standards: 'Space and shape', and 'Measurements and measuring'.

from the CES (Trickett & Moos, 1973). Given the fine structure of the model including domains, dimensions, and subdimensions with accompanying scales it enables researchers "to precisely capture the classroom social climate reflecting versatile behaviors, actions, situations, and experiences" (Kuzle & Glasnović Gracin, 2021, p. 769). This article provides an adapted conceptualization of the construct of classroom social climate, the purpose of the research, and findings regarding students' perceptions of their geometry classroom as a psychosocial learning environment, as well as implications for both theory and practice.

Theoretical framework

In this section, I first contemplate on the construct of the classroom social climate before introducing the classroom climate model of Kuzle and Glasnović Gracin (2019, 2021). The section ends with a research question that guided the study.

Classroom social climate: different models

Based on empirical educational research from the last decades, Meyer (2016) outlined ten criteria of good teaching which also include a climate conducive to learning. Under this construct, Meyer (2016) understands "the humane quality of teacher–student and student–student relationships" characterized by:

. . mutual respect, reliably observed rules, jointly shared responsibility, justice on the part of the teacher toward each individual and the learning association as a whole, and caring on the part of the teacher for the students and the students for each other. (p. 109)

A uniform definition of the construct is non-existent but rather is described through its supporting elements that are fundamentally contained in its various conceptualizations (Eder, 2002). One often-pursued approach to the conceptualization and assessment of environments is based on the concept of the *perceived environment* (Eder, 2002; Moos & Moos, 1978; Trickett & Moos, 1973). This approach is based on the contention that the environment of a particular setting is defined by the shared perceptions of its members along with several *environmental domains* over a longer period (Moos & Moos, 1978). Most models emerged from the CES questionnaire (Moos & Trickett, 1973) which measures classroom climate across nine dimensions. These fall under three general conceptual domains or categories: (1) relationship, the degree to which individuals in the environment help and support each other, and to which they are involved in the class and its activities; (2) personal development, the degree to which self-enhancement can occur; and (3) system maintenance and system change, the degree to which the environment is orderly, clear in expectations, maintains control, and can change (Moos, 1974; Moos & Moos, 1978; Trickett & Quinlan, 1979). The first category of Relationship is described by involvement, affiliation, and teacher support dimensions. The second category of Personal development is described by task orientation, and competition dimensions. The third category of System maintenance and system change is described by order and organization, rule clarity, teacher control, and innovation dimensions. Such approach has "the dual advantage of seeing the classroom through the eyes of the actual participants and allowing one to solicit information about long-standing attributes of the classroom in a manner more parsimonious than observational methods" (Trickett & Moos, 1973, p. 94). Thus, CES allows understanding the effects of the social climate of different classrooms and different teaching styles, and it captures the complexity of the construct.

Kuzle and Glasnović Gracin (2019, 2021) proposed a possible further development of existing classroom climate models to better understand structure, functions, and processes in a mathematics classroom. This process was guided by three principles. Firstly, there should be consistency with literature describing psychosocial characteristics of the mathematics classroom as a learning environment (Ahtee et al., 2016; Bobis et al., 2011; Gulek, 1999; Swan, 2006). Secondly, individual insider characterization of the classroom is through students' eyes by using participant-produced drawings. Thus, the amount of researcher-imposed structure was minimal so that the portrayed aspects of the classroom climate emerged from the data to reveal students' perceptions of the learning environment. Thirdly, the model was age-appropriate without sacrificing its depth. The above-mentioned model represents both a refinement and expansion of Moos' (1974) model of classroom social climate on the basis of the data produced, and it is suitable for investigating the classroom social climate in different mathematics lessons using participant-produced drawings. Kuzle and Glasnović Gracin (2021) conceptualized classroom social climate as a function of three conceptual categories, namely, *Interpersonal Relationship*, *Personal Growth*, and *Order*, each being described through different dimensions, subdimensions, and scales (Kuzle & Glasnović Gracin, 2019, 2021).

The category *Interpersonal Relationship* refers to the nature and intensity of personal relationships, and the mutual influences of the teacher and the students within the classroom, including social, pedagogical, and mathematical aspects. The *Verbal and non-verbal communication of the teacher*, *Verbal and non-verbal communication of the students*, and *Organization* are conceptualized as interpersonal relationship dimensions (see Table 1). Given that teachers play a significant role in shaping students' perceptions of school subjects and how new knowledge is created regarding those subjects in a classroom learning environment (Picker & Berry, 2000), the first dimension focused on the role of the teacher. Moreover, in a classroom over which the teacher has responsibility, the teacher directs, and guides classroom activities and related learning processes (Ahtee et al., 2016). The first dimension is specified by two subdimensions: the teacher's position in the classroom and teacher's support. The subdimension *Teacher's position in the classroom* refers to the physical location of the teacher which reflects the mode of instruction, namely, teacher-directed or student-directed (Gulek, 1999), and hence how learning is organized. The subdimension *Support by the teacher* refers to the extent to which the teacher takes a personal interest in the students and supports them in the classroom through teacher-directed methods and actions such as providing positive feedback, assisting or observing students' work (Ahtee et al., 2016). Here, naturally, different actions are connected; for instance, by observing how a student is progressing on a given assignment, a teacher can provide positive feedback or assist the student by pointing him or her in the right direction. The second dimension is specified by three subdimensions: the students' position in the classroom, participation, and affiliation. The subdimension of *Students' position in the classroom* refers to the physical location of the students which reflects the mode of instruction, namely, teacher-directed or student-directed (Gulek, 1999), and hence how learning is organized. The subdimension of *Participation* refers to the extent of student attention and interest in classroom activities which can be reflected by diverse learning opportunities typical for a mathematics classroom such as asking a question, working on an assignment or responding (Ahtee et al., 2016; Gulek, 1999; Swan, 2006). The subdimension of *Affiliation* refers to the extent to which students cooperate and communicate with one another in the classroom. Here, different modes of communication such as student–student communication or student–student support, reflect how students support each other during the learning process (Ahtee et al., 2016). The third dimension is specified by two subdimensions:

Table 1 Description of the Interpersonal Relationship category

Dimension	1. Category: Interpersonal Relationship	
	Subdimension	Scale
Verbal and non-verbal communication of the teacher	Position in the classroom	In front of the blackboard, Amongst students, At the desk, Somewhere in the classroom
	Support by the teacher	Assistance, Positive feedback, Negative feedback, Mathematics-related question, Mathematics-related statement, Observation, Non-mathematical comment, Passive
Verbal and non-verbal communication of the students	Position in the classroom	At the blackboard, At the table, Next to the teacher, In front of the blackboard, Amongst other students, Somewhere in the classroom
	Participation	Working on assignments at the table, Working on assignments on the blackboard, Listening, Responding, Asking a question, Asking for assistance, Reviewing, Discussion, Positive expression, Negative expression, Non-mathematical comment, Passive
	Affiliation	No communication with other students, Student-student communication, Student-student encouragement, Student-student help request, Student-student support, Negative comments towards other students
Organization	Working method	Teacher-centered instruction (frontal), Individual work, Group work, Working with a partner, Work/discussion while sitting in a circle/half-circle
	Classroom seating arrangement	Traditional classroom arrangement, U-shaped arrangement, Mixed arrangement, Circle/Half circle arrangement, Group tables

the working method, and classroom seating arrangement. The subdimension of *Working methods* refers to the extent of different working methods during teaching such as partner or group work (Meyer, 2016). The subdimension of *Classroom seating arrangement* refers to the extent of different seating arrangements. Both dimensions are connected to one another; for instance, group work is possible only when classroom seating arrangements permits it, such as when tables are arranged in groups. Thus, classroom seating arrangement can influence how learning practices are organized and vice versa (Meyer, 2016). Different scales for each subdimension can be seen in Table 1.

The category *Personal Growth* refers to concrete opportunities for mathematics learning with respect to the goals and clarity of the lesson objective, and teaching resources. *Goal orientation* and *Teaching materials and tools* are conceptualized as personal growth dimen-

Table 2 Description of the Personal Growth category

Dimension	2. Category: Personal Growth
	Scale
Goal orientation	Goal of the lesson, Presence of mathematical content, Teacher's identification of the mathematical content, Students working on the assignment
Teaching materials and tools	Geometry: 2D-shapes and models, 3D-solids and models, geometric tools (e.g., ruler, protractor, compass), poster Arithmetic: number line, place value board, poster

Table 3 Description of the Order category

Dimension	3. Category
	Scale
Keeping order	Student led, teacher led

sions (see Table 2). *Goal orientation* refers to the extent to which classroom activities are directed toward achieving specific academic goals. Here, a lesson goal can be clearly represented by mathematical content or an assignment on the blackboard, the teacher identifying the goal of the lesson, or students working on their assignment (Meyer, 2016). The latter reflects to what extent classroom activities are centered around the achievement of specified academic objectives or aligned with them. *Teaching materials and tools* refer to the extent to which materials and tools are used to achieve specific academic goals, and hence accommodate a range of students' learning preferences (Bobis et al., 2011). Moreover, utilizing different materials and tools supports learners in exploring different mathematical concepts and processes by manipulating them (Bobis et al., 2011). As such, they help students to develop and acquire new and essential perception of mathematical concepts, as well as helping existing ones to unfold (Ahtee et al., 2016). Such resources include different teaching materials and tools, such as concrete manipulatives, models, geometry tools, multimedia, outdoor activities (Bobis et al., 2011) which can be utilized by class protagonists, namely, teacher and students. Different scales for both dimensions can be seen in Table 2.

The category *Order* refers to the social norms and maintenance of order in the classroom. According to Meyer (2016), these are important for the quality of teacher–student and student–student relationships. Furthermore, Gulek (1999) argued that a teacher's activities are not only limited to practices such as instructing or giving feedback, but also involve disciplining or asking students to be quiet or to behave (Gulek, 1999). Because social norms are shared principles of behavior that are considered acceptable in a group, not only the teacher, but also the students, are responsible for proper conduct, keeping order, and behaving properly to create a positive learning environment (see Table 3). Whether behavioral prompts need to be made by the teacher or the students suggests the extent to which rules are established, order and behavior prevail in the classroom, and the teacher is in control of the class. Other than in the CES model in which four dimensions describe the category, the qualitatively-obtained data (Kuzle & Glasnović Gracin, 2021) revealed only the one dimension of who is in charge of *keeping order*, which can conceptually be understood as a combination of Moos' first three dimensions.

Research questions

In order to gain insight into young students' perceptions of the of geometry classroom as a psychosocial learning environment, coherent and viable models and techniques are paramount. Kuzle and Glasnović Gracin (2019, 2021) developed a model of classroom social climate using participant-produced drawings that has proven to be theoretically coherent, and appropriate for young students' ages, to capture their perceptions of the psychosocial attributes of a mathematics learning environment. In this study, I aimed to contribute to the research on classroom social climate by using their model to address the question of primary-grade students' images of geometry by addressing the following research question with corresponding subquestions:

What are Grade 3–6 students' perceptions of a geometry classroom through the lens of classroom social climate revealed by participant-produced drawings?

- What psychosocial aspects of geometry classroom environment can be seen in the participant-produced drawings?
- What are the distributions of psychosocial aspects of geometry classroom environment measured through the examinees' participant-produced drawings?

Method

Research design and subjects

For this study, an explorative cross-sectional qualitative research design (Patton, 2002) using participant-produced drawings (Kearney & Hyle, 2004) was chosen. Typical case sampling as a type of purposive sampling was utilized as a way of collecting rich and in-depth data (Patton, 2002). In total, 114 students from Grades 3–6 from multiple urban schools in the federal states of Berlin and Brandenburg (Germany) participated in the project. From the same school, a maximum of two students were randomly selected. The distribution of students among the grades was as follows: 25 students from Grade 3, 33 students from Grade 4, 28 students from Grade 5, and 28 students from Grade 6. This age group was optimal because students have already gathered enough experience in school mathematics and, according to Lucquet's developmental-stage theory (1913, 1923, in Anning & Ring, 2004), their drawing skills are already solid to high enough to allow rich insights into the classroom social climate.

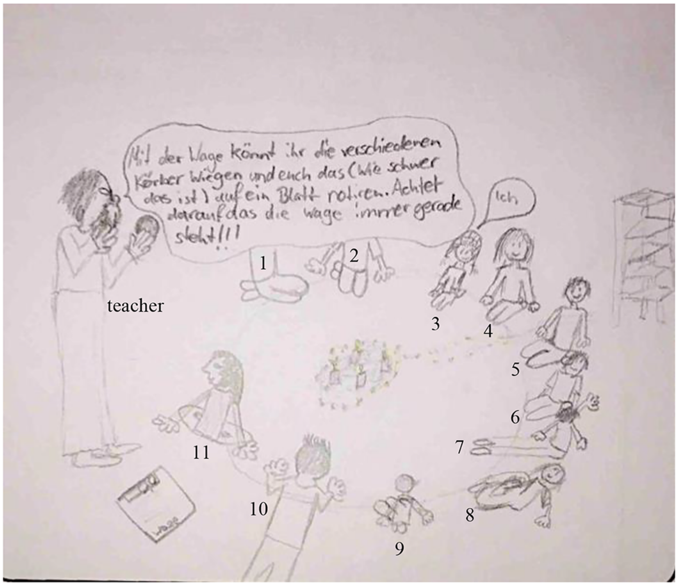
Data collection instruments and procedure

The research data consisted of (1) audio data, (2) document review, and (3) a semi-structured interview which were collected in a one-to-one setting between a student and the author. (1) The audio data consisted of the students' unprompted verbal reports during the drawing process and prompted verbal reports after the drawing process (see (3)). (2) The document review consisted of students' drawings. An adaptation of the instrument from the work of Ahtee et al. (2016), and Laine et al. (2013, 2015) was used that involved drawing an individual image of a geometry lesson. Concretely, each student received instructions in the form of an Anna letter (Dohrmann & Kuzle, 2014) on a piece of A4-paper with an assignment given by a fictional 12-years old bright girl by the name of Anna: "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. Include in each drawing your teaching group, the teacher, and the pupils. Use speech bubbles and thought bubbles to describe conversation and thinking. Mark the pupil that represents you in the drawing by writing "ME". Thank you and see you soon! Your Anna." Here, only the second drawing is of relevance. The students took as much time as needed, usually about 10–15 min. Furthermore, thought and speech bubbles were used to present children's thoughts as an additional visual representation and to facilitate children's description of their thoughts (Wellman et al., 1996).

After the students had finished drawing, the drawings were used as a catalyst for a semi-structured interview (3) as suggested by Kearney and Hyle (2004). Most importantly, they avoid adults interpreting children's drawings other than as intended by the child (Einarsdóttir, 2007). During the interview, a free description of the drawing on the part of the child was given (e.g., "Describe your picture to me.") and specific questions based on the child's description were posed (e.g., "You told/drew that your teacher stands at the blackboard/sits at the table a lot. How does this change in the course of the lesson?", "Can you tell me what you did during the lesson?", "What do the students say when another child is not paying attention?"). This procedure gave students the opportunity to frame their own experiences which lasted about 10 min in total. Data triangulation was used to assess the consistency of the results and to increase their validity, as suggested by Einarsdóttir (2007) when employing visual research methods.

Data analysis

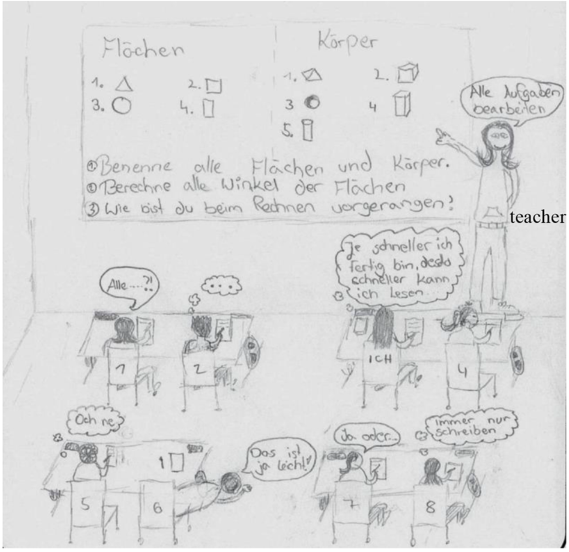
Data analysis was based on the comprehensive evaluation of the classroom social climate in the context of the geometry lessons. The drawings were analyzed after all the data had been collected to interpret the meanings that the students had given to the situations and objects that they had presented (Blumer, 1969). As suggested by Patton (2002), multiple stages of the analysis using a deductive approach were performed. This process contained the following steps: transcribing audio data, analysis of drawings with respect to the conceptualization of classroom social climate by Kuzle and Glasnović Gracin (2019, 2021), confirming the interpretation by content analysis of the data from the semi-structured interview and extending it based on aspect that were only revealed in the interview, and coding of dimensions and respective subdimensions with accompanying scales included in the students' data. Concretely, the author transcribed the audio data and analyzed the drawings separately with another researcher using a deductively created coding manual that provided descriptions of each component of the classroom social climate model, namely, domains, dimensions, and subdimensions. Afterwards, the author and another research expert first assigned one of Kuzle and Glasnović Gracin's (2019, 2021) domains to each item based on both the drawing and interview to achieve 100% agreement. Then, both researchers assigned the remaining codes for dimensions, subdimensions, and scales to a randomly-chosen drawing separately using the inventory to calculate the degree of agreement between the two



Description and coding of 1st domain "Interpersonal relationship": The teacher is standing amongst students who are sitting in a circle (Teacher's position in the classroom: amongst students). The teacher is explaining the task and at the same time providing help by giving hints for better handling of the task: "Make sure that the (balance) scale is always straight!" (Support by the teacher: assistance). The teacher is making a mathematical statement: "With the (balance) scale you can weigh different objects (how heavy they are) and write it down on a sheet of paper." (Support by the teacher: mathematics-related statement). The students are sitting on the classroom floor in a circle (Students' position in the classroom: somewhere in the classroom; Working method: work/discussion while sitting in a circle; Classroom seating arrangement: circle arrangement). Students 3-5 and 8-11 are listening to the teacher (Participation: listening). The pairs of students 1 and 2, and 6 and 7 are talking to each other about non-mathematical topics while the teacher is explaining the task (Participation: non-mathematical comment; Affiliation: student-student communication). Students 6 and 7 have their faces directed towards each other. Students 1 and 2 have no faces to be seen but the legs are directed towards each other, whereupon one can assume that they are talking to each. The content of their discussion is not known.
Description and coding of 2nd domain "Personal growth": The teacher is explaining the work assignment (Goal orientation: the goal of the lesson is clear). In the sitting circle, there are different objects that the children are supposed to weigh by using a balance scale (Goal orientation: the teacher identifies the mathematical content; Teaching materials and tools: 3D-models). The teacher is holding two objects in her hands (Teaching materials and tools: 3D-models).
Description and coding of 3rd domain "Order": There are no behavioral demands on the part of the students or the teacher in the drawing or the interview (Keeping order: unavailable).

Fig. 1 Exemplary coding of Grade 5 student's drawing of a geometry classroom dealing with Space and Shape (with examples)

(McHugh, 2012), achieving 92% agreement. We discussed the issues that required further attention for consensus. The discrepancies were due to some descriptions of the scales as well as inconsistencies in the data between the drawing and interview. To resolve the first issue, the scale descriptors were revised. Regarding the latter, both researchers agreed that the final decision about the nature of a code assigned to a particular feature would be based on the data from the semi-structured interview. Thus, we refined the coding manual by providing a more-detailed description of the scales, discussed the differences in coding while taking into consideration both students' products, and subsequently adjusted our coding, after which the interrater reliability was 100%. Here, analyst triangulation contributed to the verification and validation of qualitative analysis (Creswell & Miller, 2000; Patton, 2002). Afterwards, descriptive statistics were calculated. The following Fig. 1 and Fig. 2 illustrate the coding of students' drawings. The drawings do not represent a prototypical drawing, but rather have been selected based on data richness and versatility.



Description and coding of 1st domain "Interpersonal relationship": The teacher is standing in front of the blackboard (Teacher's position in the classroom: in front of the blackboard). She is asking the students to complete the tasks on the board by saying "Complete all tasks". The following tasks are illustrated on the blackboard. 1. Name all surfaces and solids. 2. Calculate all angles of [the given] surfaces. 3. How did you go about calculating? (Support by the teacher: mathematics-related statement). Students are sitting at their desks (Students' position in the classroom: at the table). Two students (i.e., students 2 and 4) are already working on the tasks (Participation: working on assignments at the table). Student 6 is expressing a positive thought by saying "This is easy!" (Participation: positive expression). In total four students (i.e., students 1, 5, 7 and 8) are making a negative comment. Student 1 is uttering "All of them...?!" which is indicating an annoyed reaction that all tasks should be worked on. Student 5 is uttering "Oh no." Student 8 is complaining about always having to write by saying "Always writing." with Student 7 responding by saying "Yes or…" (Participation: negative expression). One student ("Ich" = ME) is thinking more about wanting to read. This is expressed by a thought bubble "The faster I finish, the faster I can read." (Participation: non-mathematical comment). Six students are not communicating with each other (Affiliation: no communication with other students). Students 7 and 8 are talking to each other and making negative comments about the task they have to work on (see above, Affiliation: negative comment towards other students). The students are asked to work on the tasks. Since the teacher does not mention a social form, it can be assumed that they are to work on them individually. Furthermore, the tasks imply that they are to be done individually (Working method: individual work). The desks are arranged in rows (Classroom seating arrangement: traditional classroom arrangement).
Description and coding of 2nd domain "Personal growth": The blackboard shows mathematical content (solids and shapes) and related tasks (Goal orientation: the goal of the lesson is clear). The teacher's gestures (i.e., finger pointing at the board) indicate the mathematical content (Goal orientation: the teacher identifies the mathematical content). The students are given tasks to work on (Goal orientation: students work on their assignment). 2D-shapes are shown on the board (i.e., triangle, square, circle, rectangle) (Teaching materials and tools: 2D-shapes). 3D-solids are shown on the board (i.e., pyramid, cube, sphere, rectangular prism, cylinder) (Teaching materials and tools: 3D-solids).
Description and coding of 3rd domain "Order": There are no behavioral demands on the part of the students or the teacher in the drawing or the interview (Keeping order: unavailable).

Fig. 2 Exemplary coding of Grade 6 student's drawing of a geometry classroom dealing with Measurement and Measuring (with examples)

Results

In order to describe the classroom learning environment in the context of geometry lessons, the results of the participant-produced drawings, namely, drawings and semi-structured interviews, were organized around the three domains which are presented below. The relative frequencies were determined based on the students' data to get a better overview of the results which are shown in Tables 4, 5, 6, 7, 8, 9, 10, 11, 12 and 13.

Table 4 Frequency of verbal and non-verbal communication of the teacher: Position in the classroom

Scale	Grade 3	Grade 4	Grade 5	Grade 6	Total
In front of the blackboard	60%	59.4%	70%	61.5%	62.8%
Amongst students	16%	6.3%	10%	7.7%	9.7%
At the desk	4%	12.5%	13.3%	3.8%	8.8%
Somewhere in the classroom	8%	3.1%	0%	3.8%	3.5%
Unidentifiable	4%	6.3%	0%	3.8%	3.5%
Unavailable	8%	15.6%	6.7%	19.2%	12.4%

Table 5 Frequency of verbal and non-verbal communication of the teacher: Support by the teacher

Scale	Grade 3	Grade 4	Grade 5	Grade 6	Total
Assistance	12%	3.1%	16.7%	26.9%	14.2%
Positive feedback	4%	3.1%	0%	3.8%	2.7%
Negative feedback	0%	0%	0%	3.8%	9%
Mathematics-related question	4%	12.5%	16.7%	15.4%	12.4%
Mathematics-related statement	8%	31.3%	26.7%	19.2%	22.1%
Observation	8%	12.5%	0%	0%	5.3%
Non-mathematical comment	12%	6.3%	3.3%	7.7%	7.1%
Passive	0%	0%	0%	0%	0%
Unavailable/unidentifiable	60%	37.5%	50%	34.6%	45.1%

Table 6 Frequency of verbal and non-verbal communication of the students: Position in the classroom

Scale	Grade 3	Grade 4	Grade 5	Grade 6	Total
Only one student is shown (at the blackboard/at the table)	28%	9.4%	20%	15.4%	17.7%
At the table	44%	43.8%	56.7%	69.2%	53.1%
Next to the teacher	4%	12.5%	3.3%	7.7%	7.1%
In front of the blackboard	0%	12.5%	6.7%	7.7%	7.1%
Amongst other students	0%	0%	0%	0%	0%
Somewhere in the classroom	4%	6.3%	6.7%	0%	4.4%
Unidentifiable	8%	9.4%	10%	0%	7.1%
Unavailable	12%	15.6%	10%	7.7%	11.5%

Interpersonal relationship

The first dimension *Verbal and non-verbal communication of the teacher* was represented through its respective subdimensions of Teacher's position in the classroom and Support by the teacher with accompanying scales (see Tables 4 and 5). Concerning the first subdimension *Teacher's position in the classroom*, participant-produced drawings revealed that, in 62.8% of cases, the teacher is standing in front of the blackboard. Independent of the grade level, the teacher being in front of the blackboard dominated in the students' drawings. On a few occasions, the teacher was illustrated as being amongst the students (9.7%), which was the second most-frequently coded position in Grades 3 and 6, at the desk (8.8%), which was the second most-often coded position in Grades 4 and 5, or somewhere in the classroom (3.5%). The interviews revealed that, in such cases, the teacher either explained the geometry content or provided assistance to the students. In Grades 4 and 6, this aspect was either unidentifiable or unavailable in more than 20% of drawings.

Table 7 Frequency of verbal and non-verbal communication of the students: Participation

Scale	Grade 3	Grade 4	Grade 5	Grade 6	Total
Working on assignments at the table	20%	9.4%	26.7%	30.8%	21.2%
Working on assignment on the backboard	12%	15.6%	16.7%	0%	11.5%
Listening	8%	18.8%	10%	19.2%	14.2%
Responding	8%	9.4%	6.7%	30.8%	13.3%
Asking a question	0%	3.1%	0%	15.4%	4.4%
Asking for assistance	0%	0%	0%	0%	0%
Reviewing	8%	9.4%	6.7%	0%	6.2%
Discussion	0%	0%	6.7%	0%	1.8%
Positive expression	4%	15.6%	10%	7.7%	9.7%
Negative expression	8%	15.6%	0%	23.1%	11.5%
Non-mathematical comment	8%	21.9%	30%	19.2%	20.4%
Passive	0%	6.3%	3.3%	11.5%	5.3%
Unidentifiable	24%	18.8%	13.3%	3.8%	15%
Unavailable	20%	18.8%	20%	15.4%	18.6%

Table 8 Frequency of verbal and non-verbal communication of the students: Affiliation

Scale	Grade 3	Grade 4	Grade 5	Grade 6	Total
No communication with other students	20%	21.9%	23.3%	38.5%	25.7%
Student-student communication	4%	0%	6.7%	3.8%	3.5%
Student-student encouragement	0%	0%	0%	0%	0%
Student-student help request	0%	3.1%	0%	0%	0.9%
Student-student support	4%	0%	3.3%	0%	1.8%
Negative comments towards other students	8%	6.3%	6.7%	15.4%	8.8%
Unidentifiable/ unavailable	64%	68.8%	60%	50%	61.2%

The second subdimension *Support by the teacher* was either not reported or was not identifiable in almost half of the drawings (45.1%), with the highest percentage in Grade 3 (60%). Otherwise, the scale 'mathematics-related statement' predominated with 22.1% which, was either the first and the second most-often coded type of support independent of the grade level, followed by the scales 'assistance' (14.2%) and 'mathematics-related question' (12.4%). The teacher's assistance was either the first or the second most-often coded type of support in all grades and ranged from 12% in Grade 3 to 26.9% in Grade 6 besides in Grade 4 (3.1%). Other means of teacher support were illustrated or mentioned on a few occasions (positive feedback), with those reflecting a lack of support to a limited extent, such as negative feedback, observation, or non-mathematical comment, if at all (i.e., passive). Negative feedback was only reported by one Grade 6 student who illustrated in the drawing a teacher giving negative feedback: "That's too imprecise for me!" This was also discussed again in the interview: "Yes, we are always supposed to draw with a sharpened pencil and if we don't do that, she grumbles at us. And actually, she always says that it's too imprecise."

The second dimension *Verbal and non-verbal communication of the students* was represented through its respective subdimensions, namely, Students' position in the classroom, Participation, and Affiliation with accompanying scales (see Tables 6, 7 and 8). Concerning *Students' position in the classroom*, slightly more than half of the students (53.1%) sat at

Table 9 Frequency of organization: Working method

Scale	Grade 3	Grade 4	Grade 5	Grade 6	Total
Teacher-centered instruction	32%	46.9%	50%	38.5%	42.5%
Individual work	4%	3.1%	13.3%	15.4%	8.8%
Group work	0%	0%	3.3%	0%	0.9%
Working with a partner	8%	0%	0%	0%	1.8%
Work/discussion while working in a circle/halfcircle	12%	9.4%	6.7%	11.5%	9.7%
Unidentifiable/Unavailable	44%	40.6%	26.7%	34.6%	36.3%

Table 10 Frequency of organization: Classroom seating arrangement

Scale	Grade 3	Grade 4	Grade 5	Grade 6	Total
Frontal arrangement	44%	40.6%	43.3%	53.8%	45.1%
U-shaped arrangement	8%	3.1%	3.3%	0%	3.5%
Mixed arrangement	0%	0%	10%	11.5%	5.3%
Circle/Halfcircle arrangement	4%	6.3%	3.3%	0%	3.5%
Group tables	8%	3.1%	10%	11.5%	8%
Unidentifiable	20%	12.5%	20%	11.5%	16%
Unavailable	20%	34.4%	10%	11.5%	19.5%

their tables and worked on their assignments (21.2%) during their geometry lessons. The former was the most-often coded student position in the classroom independent of the grade level, ranging from 43.8% in Grade 4 to 69.2% in Grade 6. Other positions in the classroom, namely, next to the teacher, in front of the blackboard and, somewhere in the classroom were reported only occasionally, whereas amongst other students was not reported at all. The position of the students could not be identified or was not available in nearly 20% of the participant-produced drawings, with the lowest percentage in Grade 6 (7.7%).

Besides working on the assignments at the table (21.2%), various other *Participation* forms were illustrated in the drawings or mentioned in the interviews to a limited extent, such as listening, responding, asking a question, review, and discussion. The latter was illustrated by two Grade 5 students only. Nevertheless, every fifth drawing (20.4%) did not reflect any mathematical thoughts, but included statements such as "I'm tired", or "What's for lunch?", with slightly more than one-tenth (11.5%) of expressions being negative, such as "That's difficult", "That's boring" or "I am bad at math". The former was the most-often coded aspect in the drawings of Grade 4 (21.9%) and Grade 5 students (30%). The latter was the second most-often illustrated type of participation in Grade 6 students' drawings (23.1%). Asking questions such as "What is that?" and "How was that again?" was reported by 15.4% of Grade 6 students in the interviews. Positive expressions in all cases were connected to the activity-based nature of geometry lessons: "We are all happy because we can craft in the lesson." Or "I am happy that I can make something together with my friend […"]. Students' data did not reveal any elements pertaining to asking for assistance. In 33.6% of the participant-produced drawings, participation of the students was either not shown or was unidentifiable which was higher in Grades 3 and 4 than in Grades 5 and 6.

In 61.2% of the drawings, *Student affiliation* was either not shown or not possible to identify. However, when this aspect was identified, the students did not discuss the assignment with other students but rather worked quietly on the assignment(s) (25.7%). This aspect was most often coded ranging from 20% in Grade 3 to 38.5% in Grade 6. Other aspects of affilia-

Table 11 Frequency of Personal Growth: Goal orientation

Scale	Grade 3	Grade 4	Grade 5	Grade 6	Total
The goal of the lesson is clear.	84%	87.5%	93.3%	92.3%	89.4%
No mathematical content.	16%	12.5%	6.7%	7.7%	10.6%
The teacher identifies/shows the mathematical content.	28%	25%	33.3%	38.5%	31%
The students work on their assignment.	36%	34.4%	43.3%	38.5%	38.1%

tion were illustrated to a limited extent, namely, negative comments towards other students, student–student communication, student–student support, requests for student–student help, and student–student encouragement. An interesting aspect emerged in the interview regarding student–student support, namely, that a student explained that the tables are arranged in groups "because then we can help each other better with the drawing".

The third dimension *Organization* is described by two subdimensions, namely, Working method and Classroom seating arrangement with accompanying scales (see Tables 9 and 10). With respect to the *Working method*, the teacher standing in front of the classroom and teaching, with students taking notes (teacher-centered instruction), was present in almost half of the drawings (42.5%), followed by working in a (half-)circle (9.7%), and working individually (8.8%), which was also confirmed by the interview data. In all grades, teacher-centered instruction was the most-often coded working method ranging from 32% in Grade 3 to 50% in Grade 5. Other working forms, namely, working with a partner and group work, were present in two Grade 3 students' drawings and one Grade 5 student's drawing. In these cases, the students reported enjoying working with another student such as "I am happy that I can craft something together with my friend […]". Nevertheless, in more than one-third of the drawings (36.3%), the working method was not shown/reported or not identifiable, with the highest percentage being 44% of drawings in Grade 3.

The chosen working method was associated with *Classroom seating arrangement*. Nearly half of the participant-produced drawings (45.1%) reflected a traditional classroom arrangement with tables in rows, ranging from 40.6% in Grade 4 to 53.8% in Grade 6. Only a few participant-produced drawings reported tables being arranged in a U-shape, groups, a circle/half-circle or their mixture. One Grade 5 student explained that the working method in his classroom is dependent of the mathematical content: "Yes, the tables are moved around because, in geometry, we always work in groups of 4." However, in one-third of the drawings (35.5%), either one table or none was drawn, which was more often the case in Grades 3 and 4 than in Grades 5 and 6; therefore, the classroom seating arrangement could not be identified.

Personal growth

The second domain *Personal growth* gives indications of the *Goal orientation* and *Teaching materials and tools* in the geometry lessons. The students' data revealed that in 89.4% of the drawings, the students perceived the goal of the lesson as being clear (see Table 11). Already in Grade 3, a high percentage of drawings (84%) revealed this aspect. In a few cases when there was no mathematical content presented on the board, it was defined by the interview: "The students should look for figures in their environment, so […]". Just a small percentage of the participant-produced drawings for each grade level (6.7–16%) did not reflect any mathematical content. Here mathematical content or assignments were illus-

Table 12 Frequency of Personal Growth: Teaching materials and tools

Scale	Grade 3	Grade 4	Grade 5	Grade 6	Total
2D-shapes	56%	68.8%	66.7%	38.5%	58.4%
3D-solids	16%	25%	26.6%	65.4%	32.7%
2D-models	4%	9.4%	6.7%	7.7%	7.1%
3D-models	20%	12.5%	16.7%	23.1%	17.7%
Poster	0%	0%	3.3%	0%	0.9%
Geometric tools-teacher	12%	3.1%	10%	7.7%	8%
Geometric tools-students	8%	6.3%	3.3%	11.5%	7.1%
Unavailable	20%	6.3%	6.7%	11.5%	10.6%

Table 13 Frequency of Order: Keeping order

Scale	Grade 3	Grade 4	Grade 5	Grade 6	Total
Led by the students	0%	0%	10%	0%	2.7%
Led by the teacher	4%	3.1%	6.7%	3.8%	4.4%
Unavailable	96%	96.9%	86.7%	96.2%	93.8%

trated on the blackboard (see Fig. 2). Furthermore, in almost every third drawing (31%), the mathematical content was indicated by the teacher. For instance, these included the teacher explaining how to solve a mathematical problem or informing the students about the lesson plan. More than one-third of students at each grade level were illustrated as working on their assignments.

To achieve the lesson goals, the students illustrated or mentioned various teaching materials specific to geometry, such as 2D-shapes (58.4%), 3D-solids (32.7%), and 3D-models (17.7%) (see Table 12). Different teaching materials were used for different purposes, such as explaining the mathematical content (e.g. "My math teacher has a cube in his hand that he uses to explain things to us"). Whereas 2D-shapes dominated in the drawings of Grades 3–5 students, 3D-solids dominated in the drawing of Grade 6 students. Other materials, such as 2D- and 3D-models, posters, and tools such as ruler and protractor, were illustrated only occasionally.

Order

Concerning the third domain *Order*, behavioral prompts on the part of the teacher and students were not present in almost all drawings (93.8%) and this was independent of the grade level (see Table 13). In contrast, behavioral prompts were evident in the drawings of 2.7% of students and 4.4% for the teacher. The former was only illustrated by three Grade 5 students by uttering "Stop it.", "Shut your mouth." and "Wake up.". The latter was illustrated by one to two students from Grades 3–6 which reflected admonishment by uttering phrases such as "Pay attention." or words such as "Silence." which was confirmed in the interviews. Altogether there were only eight instances in seven drawings for which either the student or the teacher instructed students how to behave.

Discussion and conclusions

Characteristics of learning environments are powerful predictors of students' academic success, constructive learning processes, positive self-concept, school satisfaction, and psychological distress (Evans et al., 2009; Fraser, 1989; Fraser & Fisher, 1983; Grewe, 2017; Gruehn, 2000; Haertel et al., 1981; Walberg, 1976). Thus, classroom social climate represents an important component of teaching that should not be underestimated for both the learners and the teachers (Meyer, 2016).

The results regarding the primary-grade students' perceptions of the classroom social climate showed a fairly-consistent picture of geometry learning environment in the grades studied. Here the students perceived their geometry classrooms as follows: a teacher-centered geometry classroom was illustrated, with work being predominantly frontal, as was reported in the study of Pehkonen et al. (2016) during which the teacher made mathematics-related statements. When the teacher assisted, his or her position changed to being amongst the students or somewhere in the classroom. This aspect of the classroom social climate is essential because the teacher's assistance can counteract student inattention in the classroom (Moos & Moos, 1978). Students sat at their desks, listened to the teacher, participated in the discussions, or worked quietly on their assignments at the table. These findings are also consistent with studies that reported that many students associate mathematics with routine procedures and view learning as an individual activity (e.g., Picker & Berry, 2000). Students generally perceive the mathematics classroom as a learning environment where they individually solve tasks from textbooks or from the teacher, while the teacher teaches the whole class (Pehkonen et al., 2016). They communicated with each other or helped and supported each other only to a limited extent. The teachers were also perceived as providing them with help. Such occasions were explicitly illustrated or mentioned which indicates that already young students have a perception of support. Social relationships within the classroom were more evident in student–teacher communication than in student–student communication. Although there was little communication between the students, the existing communication was positive and reflected many social aspects. Individual aspects of partner or group work rounded out the classroom situation. The teacher's support was rarely shown but, when illustrated, was constructive and conducive to instruction.

Bülter and Meyer (2015), and Evans et al. (2009) also argued that, in classes with a positive classroom climate, increased engagement and participation can be observed. Students' data revealed that they were largely in place in the classroom situation working on their assignments, which indicates focused work. Other than in the study of Pehkonen et al. (2006), students perceived a variation in teaching and learning practices and in teaching resources used in the classroom. Because the students' data revealed a broad spectrum of *Participation* in geometry lessons and none of the scales dominated (see Table 7), the divergent results do not allow any conclusive statements about this aspect of the classroom social climate. According to Evans et al. (2009), and Gruehn (2000), improved school performance is a factor favoring a positive classroom climate. This indicator was not explicitly found in the data but, in 89.4% of the drawings, the goal of the lesson was identified by the students. This indicates that, in geometry lessons, a specific teaching goal is being pursued, which can guide the students in the direction of increased performance and the formation of interest in the subject. The teaching was illustrated as being very action-oriented with a plethora of teaching resources, which is consistent with good geometry teaching practices (Radatz et al., 1991).

The study reflected a high proportion of behavioral demands that were not drawn on the part of the students and teachers (93.8%) in the category *Order*. Thus, the students perceived their geometry lessons as being orderly regulated with very little disciplining occurrences. Given that all of the classrooms established a predominantly positive emotional classroom climate with very few instances of negative features (Kuzle, 2021), the lack of disciplining was not due to the teachers' character or students being afraid of their teachers. Rather, this is a further positive indicator of classroom social climate. If rule clarity was unclear and teaching discipline was explicitly lacking, the share of behavioral cues would have been higher. There were only a few classroom disruptions and behavioral challenges. Negative communications rarely occurred. A small percentage (7.1%) of behavioral demands on the part of both teachers and students can be an indication that social behavior or discipline is insufficient, and thus would represent a negative teaching climate (Evans et al., 2009). Accordingly, the proportion of violent acts, performance anxiety, and school disenchantment must be quite low (Maschke & Stecher, 2010). Nonetheless, the lack of behavioral demands is an indication of well-designed lessons with good teaching discipline and social behavior of the students (Bülter & Meyer, 2015) and, hence, a positive classroom climate (Maschke & Stecher, 2010). Nevertheless, the study calls for attention for several reasons. Not only can traditional teaching practices negatively impact students' attitudes towards mathematics (Swan, 2006), but students' perceptions of classroom learning environments are associated with their learning outcomes involving mathematics performance, interest and attitudes (Picker & Berry, 2000; Wong et al., 2002).

This research was an exploratory qualitative study using purposive sampling with a sample of 114 cases. As such, the results could be limited to specific cultural and contextual characteristics and, for that reason, might not be widely generalizable. Also, one cannot assume that the drawings offered a comprehensive and objective picture of the classroom social climate as some drawbacks occurred, such as difficulties while drawing, limited expressiveness of some aspects using drawings, and unfamiliarity with the term 'geometry'. These subsequently led to relatively high frequencies of "unavailable" and "unidentifiable" codes of some scales, especially in the lower primary grades. Also, the data sources provide just one perspective, namely, that of students. According to Maturana (1988), one can only make an objective sense of an environment when investigating the phenomenon with all individuals who take part of the realm in which the phenomenon takes place. Thus, the whole "truth" – in this case – of the classroom social climate can be reached when three perspectives are taken in focus: the perspective of a teacher, the students, and the researcher. These limitations suggest a possible next step in research process, namely, to expand the study methodologically as well as to refine the tools used in the study. Future studies could then involve a larger sample in a wider variety of cultural and contextual settings, as well as alternative sampling methods. Despite these drawbacks, participant-produced drawings have opened up a new way of gaining insight into students' perceptions of psychosocial classroom learning environment in elementary-school geometry.

By relating the study results to educational practice, some implications of a practical nature can be drawn. On the one hand, the findings raise issues pertaining to teacher training. The data did not identify teaching practices conducive to geometry learning such as student-centered approaches, activity-based teaching, or discovery learning (Radatz et al., 1991). Thus, solid teacher training needs to better prepare future mathematics teachers to play the roles and to reflect the teaching practices conducive to geometry learning that have been emphasized in the literature as well as ongoing developments. On the other hand, an important implication of this research in relation to teaching practice is that the drawings might be used as a classroom tool to promote a dialogue between students and their teachers (Anning, 1997), as well as a rich way to explore and understand students' views of the classroom climate (Kuzle & Glasnović Gracin, 2021). Trickett and Moos (1973) already emphasized that teachers can learn a lot about their teaching through classroom climate instruments. Drawings offer even greater potential for teachers to capture children's thoughts and perceptions (Anning, 1997; Anning & Ring, 2004). For instance, the aspects of the classroom social climate that occurred less frequently might have played a subordinate role in classroom instruction. Thus, they could provide teachers with feedback about how their lessons are perceived by students, and therefore help them to plan and implement changes for future lessons (Anning, 1997). This is paramount because teachers are the most-significant factor influencing students' learning (Hattie, 2013) and characteristics of learning environments are powerful predictors of students' academic success (Evans et al., 2009).

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