International Electronic Journal of Mathematics Education
2023, 18(4), em0757
e-ISSN: 1306-3030
https://www.iejme.com

MODESTUM

Research Article

OPEN ACCESS

Depicting classroom social climate: Using drawings to examine primary students' perceptions of geometry teaching and learning practices

Ana Kuzle [1*], Dubravka Glasnović Gracin [2], Ana Krišto [3]

[1] Department of Primary Mathematics Education, Faculty of Human Sciences, University of Potsdam, Potsdam, GERMANY
[2] Faculty of Teacher Education, University of Zagreb, Zagreb, CROATIA
[3] Petar Preradović Primary School, Zagreb, CROATIA
***Corresponding Author:** kuzle@uni-potsdam.de

Citation: Kuzle, A., Glasnović Gracin, D., & Krišto, A. (2023). Depicting classroom social climate: Using drawings to examine primary students' perceptions of geometry teaching and learning practices. *International Electronic Journal of Mathematics Education, 18*(4), em0757. https://doi.org/10.29333/iejme/13743

ARTICLE INFO

Received: 20 Mar. 2023

Accepted: 12 Sep. 2023

ABSTRACT

Climate conducive to learning is one of criteria of good teaching. Even though current pedagogies argue for contemporary type of instruction, mathematics instruction may still be dominated by traditional type of instruction. The present study examined participant-produced drawings of 250 primary grade students regarding geometry teaching and learning practices. Not only different aspects of traditional type of instruction, such as the teacher standing in front of the classroom and delivering the content while students sit at their desks and passively listen to the teacher with little student-student communication were reported, but also some aspects typical for contemporary type of instruction, such as learning through teacher-student discussions, and the use of teaching materials and tools. Still, the aspects of traditional type of instruction prevailed. The results offer potential opportunities for reconsidering the current teacher education as well as policy that would reflect the teaching practices conducive to contemporary geometry instruction.

Keywords: classroom social climate, drawings, geometry, mathematics classroom, mathematics practices, teaching practices

INTRODUCTION

The school has been constantly changing and developing since its inception (e.g., medieval school, old school, new school, modern school), which is determined amongst other by the development of science and pedagogical theories (Domović, 2003). A most notable change in pedagogical theories occurred in the new school, where a progression from a traditional type of instruction to a contemporary one (i.e., constructivist) was observed. Whereas a traditional type of instruction was characterized by one-way communication (e.g., frontal work with teacher transmitting the knowledge), teaching being reduced to drill, mechanical memorization and reproduction of what was memorized, a contemporary type of instruction was characterized by two-way communication between all members involved in the teaching-learning environment, the teacher's role of the counselor of teaching work (e.g., organizes, supervises and evaluates students' achievements), and teaching that places the student at the center of events by using the content, means, procedures and methods of active learning (e.g., group work). Nowadays, the pedagogical practices of modern school emphasize the importance of teaching practices that emphasize communication, diverse interpersonal relationships, and classroom resources (Domović, 2003).

The construct of teaching practices refers to a broad range of processes, such as planning and organizing lessons, the organization of classroom, teaching resources, assessments, the moment-by-moment actions and activities that teachers engage in during their classroom teaching to facilitate student learning (Organization for Economic Co-operation and Development [OECD], 2010, 2016). Both teaching and learning practices are "complex processes that interact with one another, suggesting that in-depth, context-specific analyses are necessary to fully understand each strategy's role in enhancing student performance" (OECD, 2010, p. 9). The research area on teaching and learning practices is still of importance, even though vast and versatile research provides insights about (good) teaching for teachers, teacher educators, and policy makers from different perspectives (Murphy et al., 2003). Teacher's instructional practices in the classroom can range from strictly teacher-centered to primarily student-centered depending on whether it is the teacher or the student who plays a main role in the teaching-learning process (Gulek, 1999; Segall & Wilson, 1998; Sinclair et al., 2013), respectively. Likewise, these instructional practices apply to mathematics lessons (Bobis et al., 2011; Hatisaru, 2019, 2020; Swan, 2006). Most classrooms do not reflect either extreme end of this continuum but rather fall somewhere in between these polarities (Sinclair et al., 2013)–so called balanced learning classroom–which uses best educational practices from both the traditional and the constructivist type of instruction. Both student-centered teaching strategies (e.g., collaborative group work, practical tasks, problem solving, open-ended tasks, investigation, games, student presentations), and blend of teacher-directed strategies (e.g., worked examples/giving examples, explanation, demonstration, structured questioning/questioning) have been emphasized by (mathematics) educators as well as educational organizations (e.g., Bobis et al., 2011; OECD, 2016; Swan, 2006; Utley & Showalter, 2007; Zemelman et al., 2005) to achieve variety in teaching methods, and in that manner foster individual student's (mathematics) learning preferences (Bobis et al., 2011), and support the development of their reasoning skills (Bietenbeck, 2014). Especially in school mathematics, the teacher should use variety of teaching resources (i.e., materials and tools) that help students model and explore mathematical concepts and processes, and deepen their understanding of these, such as concrete manipulatives, models, multimedia, and outdoor activities (Bobis et al., 2011). In such manner, students gain an even more active role in the learning process (Bobis et al., 2011). The suggested teacher's instructional practices also apply to school geometry, as one of the oldest branches of mathematics (Jones, 2000). Geometry lessons offer versatile instructional possibilities, such as activity-based teaching, discovery learning, action-oriented instruction, social learning (e.g., organizing playful forms, partner and group work), and learning with material. As such, they relate more strongly to the students (Radatz et al., 1991).

OECD (2010) reported that teaching and learning practices vary widely across educational systems and across schools within systems. Later on, Mullis et al. (2016b) as well as OECD (2016) reported that different countries, such as Croatia, take the research on teaching and learning practices to heart and construct their mathematics curriculum to necessitate or strongly suggest the use of a variety of teaching strategies that reflect the principles of constructivism and student-centeredness (e.g., implementing new curriculum) (Ministry of Science and Education [MZO], 2019). Globally, students' mathematics performance in TIMSS assessment has showed improvements, which is also the case in Croatia, where an inclination in mathematics performance of Croatian primary grade students against international benchmarks from 490 score in 2011, 502 score in 2015 and 509 score in 2019 has been reported (Mullis et al., 2012, 2016a, 2020). This improvement in attained mathematics competencies may be due to core change in teaching and learning pedagogies in the Croatian curriculum, which remained relatively unexplored, possibly also due to its complexity (Murphy et al., 2003).

Further, the term, which is closely connected to teacher's instructional practices is the construct of classroom climate, and extent to which classroom atmosphere is conducive to learning. Classroom climate is an environment in which students develop both interpersonal, academic and social skills (Evans et al., 2009; Trickett & Moos, 1973), which is primarily influenced by teacher's behavior and leadership style (Domović, 2003). These factors play a significant role in shaping students' perceptions of school subjects and how new knowledge is created regarding those subjects (Picker & Berry, 2000). Furthermore, classroom climate is one of the determinants of students' academic performance and motivation, engagement, participation, and attitude towards school and teaching (Bülter & Meyer, 2015). Thus, the drive to explore the use of current instructional practices in mathematics classrooms is imperative in providing excellent teaching and learning in mathematics classrooms as a learning environment (Hatisaru, 2019).

The goal of the study presented in this paper is to provide diverse school students' perceptions of teaching and learning in the context of school mathematics by using the classroom social climate model developed specially for primary-grade students' perceptions of it (Kuzle & Glasnović Gracin, 2019, 2021). The students' pictorial and verbal reflections (so called participant-produced drawings (Kearney & Hyle, 2004) provide valuable and rich insights into perceived classroom experiences (e.g., core opinions about mathematics, mathematics teaching and learning, emotions, attitudes) (Glasnović Gracin & Kuzle, 2018; Kuzle, 2022; Kuzle & Glasnović Gracin, 2021; Pehkonen et al., 2016). In the following section, the above-mentioned model of classroom social climate as well as the literature that informed this study are discussed. This is followed by the context of the study, the instruments used and the presentation of the coding procedures. Finally, the results of analysis regarding the teaching and learning practices in geometry lessons seen through the students' eyes are presented and discussed. Finally, implications for both theory and practice are given.

THEORETICAL FRAMEWORK

In this section, we first present the construct of classroom social climate by contemplating its different models, with a special focus on the model of Kuzle and Glasnović Gracin (2019, 2021). This is then followed by research on students' perceptions of mathematics teaching and learning practices. Finally, the section ends with three research questions that were in the focus of the study.

Models of Classroom Social Climate

Climate conducive to learning is one of the ten criteria of good teaching (Meyer, 2016), which describes "the humane quality of teacher-student and student-student relationships" (Meyer, 2016, p. 109). Classroom social climate is a complex construct, which may explain why a uniform definition of it is non-existent. Instead, different models of classroom social climate exist that describe it through its supporting elements (Eder, 2002). Most models emerged from the Classroom Environment Scale questionnaire ([CES]) by Moos and Tricket (1973), which is based on the concept of the *perceived environment* (Eder, 2002; Moos & Moos, 1978; Trickett & Moos, 1973). Such conceptualization underlines the basic idea of environment of a particular setting being defined by the shared perceptions of its members along with several *environmental domains* over a longer period (Moos & Moos, 1978). This was likewise reflected in CES, which measured classroom climate across nine dimensions (i.e., involvement, affiliation, and teacher support, task orientation, and competition, order and organization, rule clarity, teacher control, and innovation), which fell under three general conceptual categories (i.e., relationship, personal development, system maintenance and system change). Due to its conceptualization, CES questionnaire allowed capturing the complexity and the essence of the classroom environment (e.g., teachers' behavior, teacher-student interactions, interactions among students), and to determine and understand the effects of socialization in a wide variety of secondary classrooms as perceived by different individuals in the same setting (Fisher & Fraser, 1983). Other models used CES as a basis to investigate classroom social climate at the middle and secondary school level (for more detail see Bülter & Meyer, 2015; Fraser & Fischer, 1983). One model only, namely My Class Inventory ([MCI]), measured the perception of an actual environment by elementary grade students (8 to 12 years of age) (Fraser & Fischer, 1983), which contained five scales, namely, satisfaction, friction, cohesiveness, competitiveness, and difficulty. Even though MCI was simplified for younger students, it was used mainly with students starting from Grade 4. Furthermore, due to somewhat simplified conceptualization of the classroom social climate, it reflected only the above mentioned five aspects and thus, insufficient in terms of gaining a thorough insight into the classroom social climate.

Kuzle and Glasnović Gracin (2019, 2021) developed a new model of classroom social climate based on the existing classroom climate models with the goal of better understanding structure, functions, and processes in a mathematics classroom. The model has proven to be viable when using participant-produced drawings, and appropriate to characterize different aspects of classroom social climate already when working with young students (8 years of age and older) (Kuzle, 2022). The above-mentioned model represents both a refinement and expansion of Moos' (1974) model of classroom social climate on the basis of produced data by providing a deeper insight into different students' and teachers' behaviors, actions, practices, situations, and experiences due to its structure, namely categories, which are divided into dimensions, and subdimensions with accompanying scales. As shown in **Figure 1**, Kuzle and Glasnović Gracin (2021) conceptualized classroom social climate as a function of three conceptual categories, namely *Interpersonal Relationship, Personal Growth, and Order*. A concise description of the model is given in the following (for more detail see Kuzle & Glasnović Gracin, 2019, 2021).

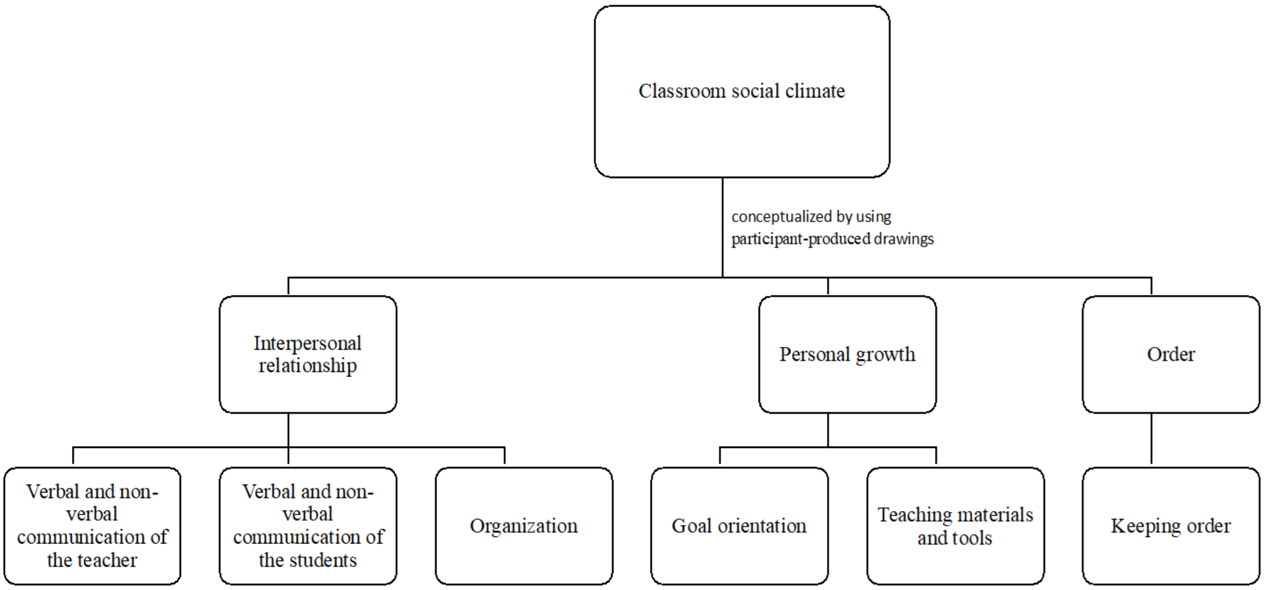

Figure 1. Conceptualization of classroom social climate by using participant-produced drawings (Kuzle & Glasnović Gracin, 2021)

The category "Interpersonal Relationship" refers to nature, the intensity of personal relationships, and the mutual influences of the teacher and the students within the classroom by focusing on social, pedagogical, and mathematical aspects. This category is conceptualized through three dimensions, namely *Verbal and non-verbal communication of the teacher*, *Verbal and non-verbal communication of the students*, and *Organization*, which focus on the role of the teacher in the classroom. The dimension *Verbal and non-verbal communication of the teacher* is specified by two subdimensions: the teacher's position in the classroom and teacher's support. The former refers to the physical location of the teacher, which reflects the mode of instruction, namely teacher-directed or student-directed mode (Gulek, 1999), and, hence how learning is organized. The latter 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 by providing positive feedback, assisting or observing students' work. The dimension *Verbal and non-verbal communication of the students* is specified by three subdimensions: the students' position in the classroom, participation, and affiliation, which focus on the role of the students in the classroom. The first subdimension refers to the physical location of the students, which reflects the mode of instruction, namely teacher-directed or student-directed mode (Gulek, 1999), and, hence how learning is organized. The second subdimension refers to the extent of student attention and interest in classroom activities through student-directed learning methods and actions, such as asking a question, asking for assistance, discussing, working on an assignment or responding. The third subdimension refers to the extent to which students cooperate and communicate with one another in the classroom (e.g., student-student encouragement, student-student support, negative comments towards other students) in order to support the learning process of the group. The dimension *Organization* is specified by two subdimensions: working method, and classroom seating arrangement. The former refers to the extent of different working methods during teaching (e.g., teacher-centered instruction (frontal), individual work, group work), whereas the latter refers to the extent of different seating arrangements (e.g., traditional classroom arrangement and group tables).

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. This category is conceptualized through two dimensions, namely *Goal orientation*, and *Teaching materials and tools.* The former refers to the extent to which classroom activities are directed toward achieving specific academic goals. The latter refer to the extent to which materials and tools are used to achieve specific academic goals in order to accommodate a range of students’ learning preferences. Such resources include different teaching materials and tools, such as concrete manipulatives, models, different visualization tools, which can be utilized by both the teacher as well as the students.

The category “Order” refers to the social norms and maintenance of order in the classroom, which is described through one dimension, namely *Keeping order*. Taken that social norms are shared principles of behavior that are considered acceptable in a group, both the teacher as well as the students are responsible for proper conduct, keeping order, and behaving properly to create a positive learning environment.

Previous Research Findings on Students’ Perceptions of Mathematics Teaching and Learning Practices Using Drawings

Hatisaru (2019) investigated 1284 Turkish Grade 6 students’ images of mathematicians and their work. The students’ drawings illustrated their actual mathematics teachers and classrooms that offered an insight into the mode of instruction (Gulek, 1999). The analysis revealed that 40.48% of students depicted moderately teacher-directed mathematics classroom, which is characterized by tables arranged in rows with students sitting in rows, and the teacher being at a distance (i.e., at blackboard, at desk) and lecturing (Gulek, 1999). The most common mode of instruction was highly teacher-directed (Gulek, 1999) with more than half of the participating students (55.58%) depicting such mode of instruction. The teacher was mostly illustrated on the blackboard or smartboard or standing in front of the class explaining mathematics or disciplining. None of the drawings revealed a strongly student-centered classroom (e.g., group work, clustered seating arrangements, discussions, active learning). Most commonly depicted teaching resource was a whiteboard (23.4%). Other teaching and learning material resources, namely textbooks and concrete materials, were minimally present. Similar results were reported by Hatisaru (2020) with a sample of 120 students from Grade 6 to Grade 8 (11 to 14 years of age). In the study, the students were instructed to draw a picture illustrating their mathematics classroom (i.e., teaching and learning practices). The research again showed that mathematics lessons are mostly perceived as being led by the teacher. The teacher explained and demonstrated the content and was at the center of the lesson. The students sat at desks and passively listened to the teacher who stood in front of the class. Situations such as students working in pairs or groups and engaging in open-ended tasks or questioning were not available. The interaction between the teacher and the students was limited to questions and answers, and a whiteboard and textbooks were commonly illustrated as mathematics teaching and learning materials (Hatisaru, 2021). Thus, both studies revealed students’ perceptions of mathematics teaching as instruction and practicing with teacher standing in front of the classroom, and explaining and demonstrating the subject or tasks, and themselves as passive protagonists in classroom by sitting at desks and listening to the teacher.

Glasnović Gracin and Kuzle (2018) conducted a multiple case study with four high-achieving students from Grade 2 to Grade 5 from Croatia. The study focused on specific social aspects (i.e., social interaction and communication) in the context of geometry lessons. The participants were instructed to illustrate their mathematics classroom when dealing with arithmetic content and when dealing with geometric content. The drawings again revealed a similar picture: the teacher lectured in front of the blackboard, the students set in their seats and worked individually in all four cases. These findings were in line with Pehkonen et al. (2016), where, in their illustrations of mathematics lessons, a significant proportion of Finnish Grade 3-Grade 5 students drew expository teaching and the teacher posing questions. Thus, students generally perceived the mathematics classroom as a learning environment, where they individually solved tasks from textbooks, or the tasks given by the teacher whilst the teacher taught the whole class. Nevertheless, despite the frontal teaching, the social aspects in the four drawings differed and reflected different practices of the teachers (e.g., posing questions, giving tasks, giving instructions, teaching, giving feedback, and observing students while working) as well as those of the students (e.g., answering the teacher’s question, posing a question, solving a task, and working quietly on a given task). Thus, the participating students viewed geometry lesson as frontal teaching with limited communication between the students. Similarly, the analysis of Grade 2 and Grade 5-Grade 6 Swedish students’ drawings showed that they perceived learning of mathematics as an individual activity (Dahlgren Johansson & Sumpter, 2010).

Kuzle (2022) investigated classroom social climate in the context of geometry lessons in Grades 3-Grade 6 (N=114) in Germany with the goal of providing comprehensive insight into students’ perceptions of their geometry classroom climate by identifying its psychosocial aspects. The results reflected a fairly-consistent picture of a geometry learning environment: frontal work with a broad spectrum of participatory activities (e.g., students sat at their desks, listened to the teacher, participated in the discussions, or worked quietly on their assignments at the table), which were organized in an orderly manner, but with very little student-student communication. Nevertheless, social relationships within the classroom were evident in student-teacher communication (e.g., giving feedback, making mathematics-related statements, posing mathematics-related questions, and aiding). The lesson goals were transparent, which were supported by using different teaching materials and tools, which were more versatile than in the studies reported by Hatisaru (2019, 2020).

Research Questions

Despite the strive to contemporary type of instruction, the above-mentioned studies suggest that the traditional type of instruction is still the dominant type of instruction in many mathematics classrooms. Students mostly experience a teacher-directed style of teaching: students sit at desks, and passively listen to the teacher who stands in front of the class and delivers the mathematical content to the students (OECD, 2016; Picker & Berry, 2000), which may lead to students’ negative emotions (e.g., frustration, dissatisfaction) and passive behaviors in the classroom (Boaler, 2015; Smith & Stein, 2011; Swan, 2006). Even though the large-scale assessments (e.g., TIMSS and PISA) identified various aspects of school and classroom climate by using surveys, they did not reveal detailed descriptions of different types of teaching and learning practices (Vieluf et al., 2012), and furthermore, they may not be necessarily understood by school students in the way researchers intended (Ahtee et al., 2016).

For this reason, methods such as surveys have shown not to be always reliable due to the participants' young age (e.g., Einarsdóttir, 2007; Pehkonen et al., 2016). By using drawings, students are given control of the data collection process and can draw freely about their experiences of mathematics (Kearney & Hyle, 2004). Having these considerations in mind, the following research questions guided the study:

What do the drawing characteristics suggest about teaching and learning practices regarding

1. interpersonal relationship
2. personal growth
3. order

in geometry lessons through the students' eyes?

METHOD

Research Design and Subjects

For this study, an explorative cross-sectional qualitative research design (Patton, 2002) using participant-produced drawings (i.e., children's drawings and interviews) (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 250 students from Grade 2-Grade 4 from multiple urban and rural schools from different north-west continental regions of the Republic of Croatia 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: 92 students from Grade 2, 82 students from Grade 3, and 76 students from Grade 4. This age group was chosen for two reasons. Firstly, they have already gathered enough experience in school mathematics. This applies also for Grade 2 students since the data collection occurred during the second school term. Secondly, the drawing skills of students starting from age 8 are already solid to high enough according to Lucquet's developmental-stage theory (1913, 1923 in Anning & Ring, 2004) so that they allow rich insights into the classroom social climate.

Research Context

In Croatia, elementary education is compulsory and consists of eight years. Children begin school at the age of 6 or 7. Mathematics is taught as a mandatory and major subject during all levels of schooling. From Grade 1 to Grade 4, all major subjects are taught by one teacher per class. The Croatian educational system is highly centralized; teaching in schools is regulated by the national curriculum (Ministry of Science and Education [MZO], 2019), which is released by the educational authorities, and applies to all schools and classrooms on the state level (Zakon o odgoju i obrazovanju u osnovnoj i srednjoj školi, 2008). As noted earlier, the learning and teaching practices suggested by the curriculum are similar to those suggested by international research studies and curricula. Concretely, before the thorough educational reform in 2019, the educational plan and program (Ministry of Science, Education and Sports [MZOS], 2006) was implemented in 2006, which was directed only to compulsory education in Croatia (Grade 1-Grade 8) and was structured around topics for each subject and in each grade level, including mathematics. On general terms, the primary education should ensure that students develop certain personality qualities such as independence, initiative, research spirit, creative interest, communicativeness.

The conceptual change in educational and teaching activity in the school was more oriented on teaching than was the case earlier. The curriculum encourages teachers to embrace those teaching practices that are inclusive of students' individual differences in learning and highlights the need for students to be active and independent in their learning by adapting teaching forms, methods and means of work conducive to these aspects (MZOS, 2006). Furthermore, creating a pleasant classroom and school atmosphere based on mutual respect, honesty, understanding and solidarity is emphasized as an important factor contributing to the above listed goals. These fundamental determinants of education and teaching work apply for all subjects–thus, mathematics also. The aim of teaching mathematics is to acquire basic mathematical knowledge necessary for understanding phenomena and laws in nature and society, to acquire basic mathematical literacy, and to develop the ability and skills to solve mathematical problems (MZOS, 2006, p. 238, translation by the authors).

Data Collection Instruments, Research Procedure, and Data Analysis

The research data consisted of students' drawings, and a semi-structured interview, which were collected in a one-to-one setting between a student and the researcher who collected the data. Students' drawings of teacher and student activities of mathematics lessons underpin their "perceptions of their mathematics teaching and learning experiences and consequently their images of mathematics" (Hatisaru, 2020, p. 200). Still, a drawing as a graphic representation is a construction, which cannot be mistaken for the real object, but rather stands for an aspect of reality (Golomb, 1994). The concept of image is multifaceted comprising of, for instance, attitudes, beliefs, emotions, feelings, and self-concepts relating to mathematics and mathematics learning experience (Laine et al., 2013, 2015), built up over the years through various experiences (Kuzle & Glasnović Gracin, 2020). For the purposes of the study, an adaptation of the instrument from the works of Ahtee et al. (2016), and Laine et al. (2013, 2015) was used. 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, as follows:

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.

In this paper, only the second drawing is of relevance, namely students’ drawings of their geometry lessons. The students did not have a time limit for drawing and were not provided with additional drawing instructions. Furthermore, thought and speech bubbles were used as these present children’s thoughts as an additional visual representation, and facilitate children’s description of their thoughts (Wellman et al., 1996). After the students had drawn their typical geometry lesson, the drawings were used as a catalyst for a semi-structured interview as suggested by Kearney and Hyle (2004). In the interview, the students were asked to describe what they had drawn in their drawing (e.g., “Describe your picture to me.”). This procedure served as an additional source of information on what a typical geometry lesson looks like. Data triangulation was used to assess the consistency of the results, and to increase the validity of the results as was suggested by Einarsdóttir (2007) when employing visual research methods. Moreover, it gave each student the opportunity to frame their own experiences.

Data analysis was based on the comprehensive evaluation of the classroom social climate in the context of the geometry lessons. After all the data had been collected, the analysis followed, which was based on the conceptualization of classroom social climate by Kuzle and Glasnović Gracin (2019, 2021) (see **Figure 1**). Thus, a deductive approach was used using multiple stages of the analysis as suggested by Patton (2002). This process contained the following three steps: transcribing audio data, analysis of drawings, confirming the interpretation by content analysis of the data from the semi-structured interviews and extending it based on aspects that were only revealed in the interview, and coding of dimensions and respective subdimensions with accompanying scales included in the students’ data. Through the coding process two additional scales emerged, namely copying from the board (as a Participation subdimension scale) and 1D-objects (as a Personal growth dimension scale).

Figure 2 illustrates the coding of one student’s drawing, which does not represent a prototypical drawing, but rather has been selected based on data richness and versatility.

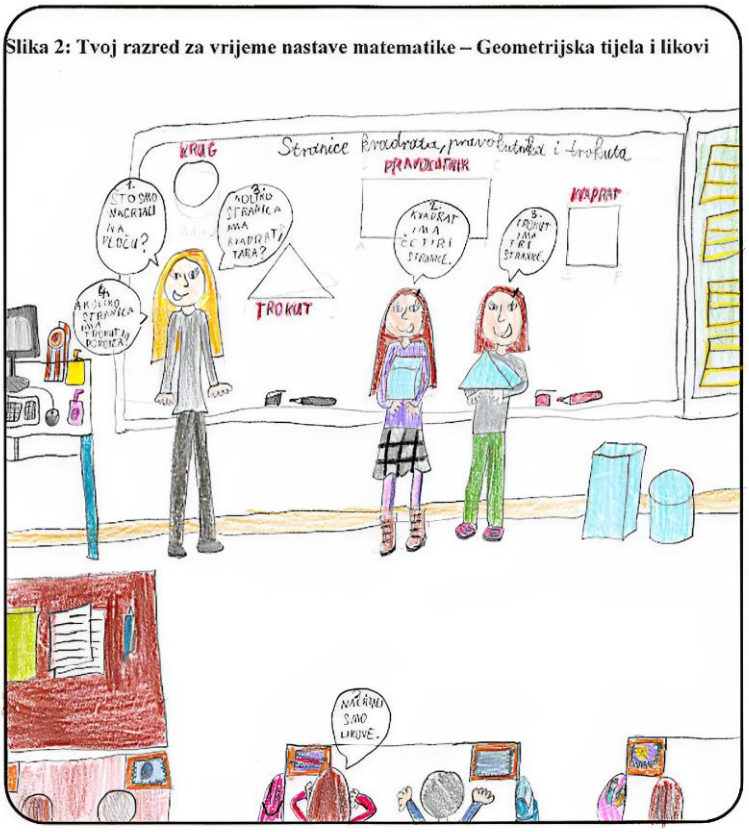

Figure 2. Grade 2 student’s drawing of a geometry classroom (reprinted with permission)

As seen from **Figure 2**, the teacher is standing in front of the blackboard. The teacher is facing the students. The teacher asks the mathematical question: “What have we drawn on the blackboard?”, “How many edges does a triangle have, Dorotea?”, “How many edges does a square have, Tara?" Five students are sitting at the table. Two students are standing in front of the blackboard. The students listen to the teacher. The students answer the teacher's question: "A square has four edges.", "A triangle has three edges.", "We have drawn 2D-shapes." The teacher stands in front of the class and teaches. The lesson is taught frontally. The tables are in front and arranged in one row. The goal of the lesson is clear. There is mathematical content on the blackboard. The teacher brought 3D-models and required from the students to recognize 2D-shapes on their surfaces. 2D-shapes are represented on the blackboard: triangle, square, rectangle, and circle. Two students in front of the board hold a model of a cube and a pyramid, and below the board are models of a rectangular prism and a cylinder. The teacher and the students do not show any behavioral demands.

The same procedure was used for each student's product. Afterward, an analysis of all coded results was conducted to identify the proportions of the individual codes, and finally, the descriptive statistics were calculated.

RESULTS

The students' perceptions of their classroom social climate in the context of geometry lessons using the participant-produced drawings are organized around the three categories: interpersonal relationship, personal growth, and order. The results are presented for each dimension within a specific category separately. The relative frequencies were determined based on the students' data to get a better overview of the results, which are illustrated in the upcoming tables.

Interpersonal Relationship

The first dimension *Verbal and non-verbal communication of the teacher* was represented through its respective subdimensions, namely, Teacher's position in the classroom and Support by the teacher with accompanying scales (see **Table 1**). Concerning the first subdimension *Teacher's position in the classroom*, participant-produced drawings revealed that in almost two-thirds of drawings (66.0%) the teacher is standing in front of the blackboard during geometry lessons. Independent of the grade level, the teacher being illustrated in front of the blackboard dominated in the students' drawings, ranging from 61.0% (Grade 3) to 70.7% (Grade 2). The second most often coded position of the teacher was at the desk (14.8%), which was rarely illustrated in Grade 2 students' drawings (5.4%) as opposed to Grade 3 and Grade 4, where almost every fifth drawing illustrated this situation (18.3% and 22.4%). Furthermore, Grade 3 and Grade 4 students' drawings revealed similar percentages in all aspects (scales) of this subdimension, whereas Grade 2 students mostly drew the teacher only in front of the blackboard but not at the table. Still, the latter was the second most often coded position of the teacher (14.8%). On a few occasions, the teacher was either illustrated being amongst the students (6.0%), which was rather similarly distributed across different grades or being somewhere else in the classroom (1.6%). Thus, 80.8% of the drawings illustrated the teacher's position in the front of the classroom when taking both scales (i.e., in front of the blackboard and at the desk) into consideration. The teacher's position in the classroom was either unidentifiable or unavailable in 11.6% of drawings, with a dropping tendency from lower into higher grades.

Table 1. Frequency of dimension Verbal and non-verbal communication of teacher

Subdimension	Scales	Grade			
		2 (*n*=92)	3 (*n*=82)	4 (*n*=76)	Total (*N*=250)
Teacher's position in classroom	In front of blackboard	70.7%	61.0%	65.8%	66.0%
	Among students	5.4%	7.3%	5.3%	6.0%
	At desk	5.4%	18.3%	22.4%	14.8%
	Somewhere in classroom	2.2%	2.4%	-	1.6%
	Unidentifiable	1.1%	-	1.3%	0.8%
	Unavailable	15.2%	11.0%	5.3%	10.8%
Support by teacher	Assistance	-	2.4%	1.3%	1.2%
	Positive feedback	4.3%	1.2%	9.2%	4.8%
	Negative feedback	-	1.2%	3.9%	1.6%
	Mathematics-related question	27.2%	17.1%	21.1%	22.0%
	Mathematics-related statement	25.0%	35.4%	43.4%	34.0%
	Observation	4.3%	8.5%	10.5%	7.6%
	Non-mathematical comment	2.2%	3.7%	3.9%	3.2%
	Passive	-	-	-	-
	Unavailable/unidentifiable	41.3%	32.9%	13.2%	30.0%

Regarding the second subdimension *Support by the teacher*, the scale 'mathematics-related statement' predominated with 34.0%, which was either the first (Grade 3 and Grade 4) or the second (Grade 2) most often coded type of support in geometry lessons. An increased tendency was observable from lower grades (25.0%) into higher grades (43.4%). Thus, the teacher support is mainly characterized by the teacher explaining the content (mathematics-related statement). Unfortunately, the second most often coded scale was 'unavailable/unidentifiable' with almost one-third of the drawings (30.0%), which was highest in Grade 2 (41.3%) but decreased in Grade 4 to 13.2%. Another aspect of teacher support, namely mathematics-related question, was fairly good represented in the drawings with 22.0%, which was either the first most often illustrated aspect (Grade 2) with 27.2% or the second most often illustrated aspect (Grade 3-Grade 4) with 17.1% and 21.1%, respectively, the third most often coded type of support in general. However, the differences in percentages in some aspects were minimal, such as mathematics-related question (27.2%) and mathematics-related statement (25.0%) in Grade 2. Whereas the scale 'mathematics-related question' ranged from 17.1% in Grade 3 to 27.2% in Grade 2, the scale 'mathematics-related statement' ranged from 25.0% in Grade 2 to 43.4% in Grade

4. Together, these two scales, which are similar in nature, were illustrated in more than 50% of students' drawings independent of the grade level. Other means of teacher support were illustrated or mentioned on a few occasions only (i.e., positive feedback, assistance, observation, non-mathematical comment, negative feedback). Here, positive feedback ("Bravo Ivana!", "Excellent class.", "I am glad you like it.") was reported in all grades and more often than negative feedback ("No! It's wrong, Branka!", "It is not correct!", "They do not know!"), which was only reported in Grade 3 and Grade 4 but to a very small extent. The assistance of the teacher dealt with difficult situations for the students in which the teachers helped the students. Here utterances such as "Come, I will explain. If anyone does not understand, please let me know, and I will explain.", "I can explain." were illustrated. Similarly, this aspect was illustrated to a very small extent in Grade 3 and Grade 4, whilst in Grade 2 not at all. Passive actions of the teachers (i.e., The teacher is a passive person in the classroom. The teacher neither speaks/teaches nor thinks about mathematical content) were not illustrated at all.

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 **Table 2**). Concerning *Students' position in the classroom*, almost two-thirds of the students (64.8%) were illustrated sitting at table during their geometry lessons. This was most often coded students' position in the classroom independent of the grade level, ranging from 60.9% in Grade 2 to 67.1% in Grade 3 and Grade 4. In 24.4% of the cases the drawings portrayed only one to two students at the blackboard or at the table, which was higher in Grade 2 and Grade 4 (29.3% and 25.0%) than in Grade 3 (18.3%). Other positions in the classroom, namely in front of the blackboard (6.8%), somewhere in the classroom (6.4%) or next to the teacher (2.0%) were reported only occasionally, whereas amongst other students not at all. The position of the students could either not be identified or was not available in only 6.4% of the participant-produced drawings.

Table 2. Frequency of dimension Verbal and non-verbal communication of students

Subdimension	Scales	Grade			
		2 (*n*=92)	3 (*n*=82)	4 (*n*=76)	Total (*N*=250)
Students' position in classroom	Only one or two students shown (at blackboard/table)	29.3%	18.3%	25.0%	24.4%
	At table	60.9%	67.1%	67.1%	64.8%
	Next to teacher	1.1%	4.9%	-	2.0%
	In front of blackboard	6.5%	7.3%	6.6%	6.8%
	Amongst other students	-	-	-	-
	Somewhere in classroom	6.5%	8.5%	3.9%	6.4%
	Unidentifiable	4.3%	4.9%	3.9%	4.4%
	Unavailable	2.2%	3.7%	-	2.0%
Participation	Working on assignment(s) at table	8.7%	18.3%	19.7%	15.2%
	Working on assignment on blackboard	4.3%	7.3%	6.6%	6.0%
	Listening	25.0%	37.8%	30.3%	30.8%
	Responding	32.6%	13.4%	22.4%	23.2%
	Questioning	10.9%	6.1%	5.3%	7.6%
	Asking for assistance	-	4.9%	6.6%	3.6%
	Review	-	1.2%	2.6%	1.2%
	Discussion	13.0%	8.5%	21.1%	14.0%
	Positive expression	7.6%	7.3%	9.2%	8.0%
	Negative expression	5.4%	4.9%	5.3%	5.2%
	Non-mathematical comment	8.7%	7.3%	11.8%	9.2%
	Passive	-	3.7%	1.3%	1.6%
	Copying from the board	14.1%	14.6%	6.6%	12.0%
	Unidentifiable	31.5%	19.5%	15.8%	22.8%
	Unavailable	2.2%	3.7%	-	2.0%
Affiliation	No communication with other students (while working on assignment(s))	8.7%	15.9%	21.1%	14.8%
	Student-student communication	2.2%	2.4%	1.3%	2.0%
	Student-student encouragement	-	1.2%	1.3%	0.8%
	Student-student help request	-	-	-	-
	Student-student support	-	-	1.3%	0.4%
	Negative comments towards other students	-	2.4%	2.6%	1.6%
	Unidentifiable/unavailable	92.4%	84.1%	76.3%	84.8%

Regarding *Participation*, various situations were illustrated in the participants' drawings, where students were most often illustrated listening to the teacher (30.8%) and/or responding to the teacher's question (23.2%) (e.g., "Square has four edges. The triangle has three edges. We have drawn 2D-shapes.", "These are geometric solids, and we can touch them."). These two scales were the most often illustrated aspects of *Participation* during a geometry lesson. The former was most often illustrated in Grade 3 and Grade 4 (37.8% and 30.3%), whereas the latter was most often illustrated in Grade 2 (32.6%). These aspects of participation are in line with support by the teacher (see **Table 1** and **Table 2**): teacher making a mathematics-related statement (34.0%) and the students listening to the teacher (30.8%), and teacher posing a mathematics-related question (22.0%), and the students responding (23.2%). The questions posed by the teacher were routine ones, such as asking students to identify or describe a given geometric object. Some similarities in students' participatory forms are observable when looking at the most often illustrated scales in each grade; in Grade 2 responding, listening, copying from the board and discussion; in Grade 3 listening, working on the assignment, copying from the board and responding; in Grade 4 listening, responding, discussion, and working on the assignment. Thus, the depicted geometry lessons reveal participatory forms, which are both typical for a teacher- and student-centered geometry instruction, with former occurring more often than the latter. Some other *Participation* forms were illustrated in more than 10.0% of drawings, such as students working on assignments at the table, discussing, and copying from the board. Whereas working on assignments at the table was the second most often coded participatory activity in Grade 3 and Grade 4 (18.3% and 19.7%, respectively), this was not so prominent in Grade 2 students' drawings (8.7%). On the other hand, copying from the board–which was illustrated in almost every eighth drawing (12.0%)–was more often seen in Grade 2 and Grade 3 students' drawings (14.1% and 14.6%) than in Grade 4 students' drawings (6.6%). Other participatory activities during a geometry lesson (i.e., making non-mathematical comments or positive comments, posing questions, working on the blackboard, making negative comments, asking for assistance) were illustrated to a very limited extent. The students asked for help when they did not understand the content or the task (e.g., "Teacher, can you help me?", "I do not understand. Can you clarify it for me?"). Students' positive expressions were shown the most in Grade 4 drawings (9.2%). Positive comments reflected students' perception of the task or geometry or teacher appreciation (e.g., "Easy, easy.", "Thanks for explaining it to me, teacher.", "This is good.", "This is better than counting.", "The geometry is fascinating.", "This is cool!", and "Yes! It is fun!"). A small percentage of negative expressions (5.2%) dealt with the perception of the geometry lesson ("Boring!"). In 24.8% of the drawings, participation of the students was either not shown or was unidentifiable, which decreased from higher grades into lower grades (33.7% to 15.8%). *Student affiliation* was not shown or not possible to identify in 84.8% of the drawings. However, when this aspect was identified, the students did not discuss the assignment with other students during a geometry lesson but rather worked quietly on the assignment(s) (14.8%). This aspect increased from lower into higher grades (8.7% in Grade 2, 15.9% in Grade 3, and 21.1% in Grade 4). Other aspects of *Affiliation* were illustrated to an extremely limited extent, namely student-student communication, negative comments towards other students, student-student encouragement, and student-student support, with one to two drawings per grade level. Student-student help request was not illustrated at all.

Table 3 gives an overview of the *Organization* dimension, which is described by two subdimensions, namely, Working method and Classroom seating arrangement with accompanying scales. With respect to *Working method*, the teacher standing in front of the classroom and teaching (teacher-centered geometry instruction), was present in more than half of the drawings (58.8%), followed by working individually (12.8%). In all grades, teacher-centered geometry instruction was the most often coded working method ranging from 54.9% in Grade 3 to 63.0% in Grade 2. The percentage of drawings illustrating students' individual work during geometry lessons increased from lower grades (5.4%) into higher grades (18.4%). Other working forms, namely group work, working/discussing in a (half)circle, and working with a partner were illustrated in a few instances only, if at all. Whereas the group work was represented in all three grades by only one participant per grade level, working with a partner was only shown in one Grade 3 student drawing. Nevertheless, in one-fourth of the drawings (25.5%), working method was either not shown/not reported or was not identifiable with the highest percentage in Grade 2 with 29.3% of drawings, and the lowest in Grade 4 with 19.7% of drawings. In summary, teacher-centered instruction dominated in the students' drawings of their geometry lessons. The chosen working method was associated with *Classroom seating arrangement*. More than two-thirds of the participant-produced drawings (67.2%) reflected a traditional classroom arrangement of a geometry lesson with tables in rows ranging from 63.4% in Grade 3 to 72.4% in Grade 4. Only a few participant-produced drawings reported seating arrangements typical for student-centered geometry instruction, namely tables being arranged in groups, in U-shape or their mixture. No drawing illustrated a circle/halfcircle arrangement in geometry lessons. However, in almost one-fourth of the drawings (23.2%) (see **Table 3**) either one table or none were drawn so that classroom seating arrangement could not be identified, which was more often the case in Grade 2 than in Grade 3 and Grade 4. In summary, traditional seating arrangement dominated in the students' drawings, which also reflects a teacher-centered geometry instruction.

Table 3. Frequency of dimension Organization

Subdimension	Scales	Grade			
		2 (*n*=92)	3 (*n*=82)	4 (*n*=76)	Total (*N*=250)
Working method	Teacher-centered instruction	63.0%	54.9%	57.9%	58.8%
	Individual work	5.4%	15.9%	18.4%	12.8%
	Group work	1.1%	1.2%	2.6%	1.6%
	Working with a partner	-	1.2%	-	0.4%
	Work/discussion while sitting in a circle (half circle)	1.1%	1.2%	1.3%	1.2%
	Unidentifiable/unavailable	29.3%	25.6%	19.7%	25.5%
Classroom seating arrangement	Traditional classroom arrangement	66.3%	63.4%	72.4%	67.2%
	U-shaped arrangement	1.1%	6.1%	2.6%	3.2%
	Mixed arrangement	2.2%	3.7%	1.3%	2.4%
	Circle/half circle arrangement	-	-	-	-
	Group tables	3.3%	2.4%	6.6%	4.0%
	Unidentifiable	17.4%	12.2%	9.2%	13.2%
	Unavailable	9.8%	12.2%	7.9%	10.0%

Personal Growth

The second category *Personal growth* gives indications of the *Goal orientation* and *Teaching materials and tools* in the geometry lessons (see **Table 4**). The students' data revealed that in 98.40% of the drawings the students perceived the goal of the lesson as being clear. Already in Grade 2, the highest percentage of drawings (100%) revealed this aspect, which in subsequent grades also remained high with about 97%. Just two drawings from Grade 3 and Grade 4 each did not reflect any mathematical content. In these cases, the blackboard was empty, or the drawer illustrated the geometry lesson from the side. In 11.2% of cases, the mathematical content was indicated by the teacher. These included for instance the teacher informing the students about the lesson plan (e.g., "Today we are learning the perimeter of the triangle."), identifying the content on the blackboard (e.g., "This is a broken line.") or demonstrating (e.g., "This is the way how to draw the circle."). To achieve the lesson goals, the participants illustrated or mentioned various teaching materials specific to geometry, such as 2D-shapes (e.g., triangle, square) (76.0%), 3D-solids (e.g., cube, prism) (22.0%), and line segment (20.8%) (see **Table 4**). 2D-shapes dominated in all grades ranging from 65.9% in Grade 3 to 82.9% in Grade 4. Both the teacher (12.4%) as well as the students (10.8%) were illustrated working with geometric tools, such as ruler, protractor, compass. Concrete physical manipulatives for 2D-shapes and 3D-solids, such as tangram (i.e., 2D-model) wooden model of a cube (i.e., 3D-models), or posters were illustrated only occasionally. In 10 instances only no teaching materials or tools were illustrated.

Table 4. Frequency of category Personal growth

Subdimension	Scales	Grade			
		2 (*n*=92)	3 (*n*=82)	4 (*n*=76)	Total (*N*=250)
Goal orientation	Goal of lesson is clear	100%	97.6%	97.4%	98.4%
	No mathematical content	-	2.4%	2.6%	1.7%
	Teacher identifies/shows mathematical content	8.7%	11.0%	14.5%	11.2%
	Students work on their assignment	5.4%	12.2%	6.6%	8.0%
Teaching materials and tools	2D-shapes	79.3%	65.9%	82.9%	76.0%
	3D-solids	25.0%	23.2%	17.1%	22.0%
	2D-models	3.3%	6.1%	2.6%	4.0%
	3D-models	6.5%	9.8%	13.2%	9.6%
	Poster	1.1%	1.2%	2.6%	1.6%
	Geometric tools (teacher)	9.8%	9.8%	18.4%	12.4%
	Geometric tools (students)	7.6%	7.3%	18.4%	10.8%
	Line segment	21.7%	28.0%	10.5%	20.8%
	Unavailable	1.1%	11.0%	1.3%	4.0%

Order

Concerning the third category *Order*, behavioral prompts on the part of the teacher and of the students were not present in almost all drawings (94.8%, *n*=237), which was independent of the grade level (see **Table 5**). Thus, behavioral prompts were illustrated in 13 drawings only. Whereas the behavioral prompts on the part of the students were evident in two drawings only (0.8%), the ones on the part of the teacher were present in 11 drawings (4.4%). The former was only illustrated by two Grade 3 students by uttering "Then I told them to be quieter.", "Shhhhhh!". The latter was illustrated by seven Grade 2 students, and by two Grade 3 and Grade 4 students. Here, the teachers needed to quite the class (e.g., "Silence!", "Stop talking!" "Listen up!", and "Everybody calm down!"). Thus, there were only 13 instances in 13 drawings, where either the student or the teacher instructed the students how to behave.

Table 5. Frequency of category Order

Scales	Grade			
	2 (*n*=92)	3 (*n*=82)	4 (*n*=76)	Total (*N*=250)
Led by students	0%	2.4%	0%	0.8%
Led by teacher	7.6%	2.4%	2.6%	4.4%
Unavailable	92.4%	95.1%	97.4%	94.8%

DISCUSSION

In the last section, diverse school students' perceptions of teaching and learning in context of primary grade geometry lessons are discussed with regard to traditional and contemporary teaching practices, and the limitations of the study are considered.

Primary Grade Students' Perceptions of Geometry Teaching and Learning Practices

The analysis of participant-produced drawings regarding students' perceptions of the teaching and learning in the context of primary grade school mathematics in Croatia showed a fairly consistent picture of geometry lessons in Grade 2-Grade 4. The students perceived their geometry lessons as follows: the teacher was in the center of instruction–he/she stood in front of the classroom (66.0%) (*Teacher's position in the classroom*), made mathematics-related statements (i.e., explained, delivered, demonstrated the geometrical content, gave students an assignment and/or solved routine problems) (34.0%), and posed mathematics-related questions (22.0%) (*Support by the teacher*). In 14.8% of instances, the teacher was at the desk. The teacher's positions in the classroom implies that the teacher mainly (two-thirds of drawings) explains the mathematics content in front of the blackboard, which reflects a traditional type of instruction (Domović, 2003). In occasions, where the teacher was portrayed being at the desk (14.8%) implies that students meanwhile work individually on their assignments. This is consistent with the results of Finnish Grade 3-Grade 5 students (Pehkonen et al., 2016), of Turkish Grade 6-Grade 9 students (Hatisaru, 2019, 2020) and German Grade 3-Grade 6 students (Kuzle, 2022). However, delivering the content was more dominant in this study. Only rarely, the teachers' position changed (e.g., amongst the students, somewhere in the classroom), which is rather worrying. Such teaching practice reflects minimal assistance by the teacher (1.2%), which was also supported by the data. According to Moos and Moos (1978), teacher assistance is of essence since it can counteract student inattention in the classroom. The fact that every third drawing portrayed mathematics-related statements may imply that no problematic situations are given during a geometry lesson but rather the content being merely delivered. Interestingly, the percentage of mathematics-related statements increased from the lower into higher grades (25.0% in Grade 2, 35.4% in Grade 3, 43.4% in Grade 4). This may be another indicator of traditional type of instruction in which learning is achieved through passive instead of active students' behavior (Domović, 2003). Thus, the results regarding *Support by the teacher* demonstrate that the teacher's primarily role is to explain the content. Nevertheless, since every fifth drawing reflected mathematics-related questions it seems that the teacher still expects geometry being learnt through discussions and questioning, which is supported by different students' participation scales. This practice reflects indeed aspects of contemporary type of instruction (Domović, 2003), which are also strongly emphasized by mathematics educators (e.g., Bobis et al., 2011; Swan, 2006; Utley & Showalter, 2007; Zemelman et al., 2005) but on a smaller scale in comparison to the reported aspects typical for the traditional type of instruction.

During their geometry lessons, the students in drawings sat in tables (64.8%) (*Students' position in the classroom*), listened to the teacher (30.8%), responded to teacher questions (23.2%), worked on assignments at the table (15.2%), and copied from the board (12.0%) (*Participation*). The interaction between the teacher and the students in the classroom was limited to asking and answering (routine) mathematics questions (23.2%), and classroom discussions (14.0%) (*Participation*) with almost no occurrences of content-related interactions among students (14.8%) (*Affiliation*). Thus, similar to findings of Hatisaru (2019), this study results pertaining to participation demonstrate that the students mainly listen to the teacher (30.8%) followed by responding to teachers' questions (23.2%). This is aligned with *Support by the teacher* regarding teacher making mathematics-related statements (34.0%) and posing mathematics-related questions (22.0%). Thus, regarding these aspects the students' perception of their role as well of that of the teacher is unanimous. This somewhat confirms the results of Kuzle (2022) regarding the students' position in the classroom; whereas listening and responding were almost twice less reported in the study of Kuzle (2022), discussions took more often place in the context of this study. The students' passive role in the geometry lessons is furthermore supported by students copying the geometrical content from the blackboard (12.0%), which, however, decreased from lower into higher grades (14.1% to 6.6%). As in the studies of Kuzle (2022), Dahlgren Johansson and Sumpter (2010), and Pehkonen et al. (2016), the students generally perceived the geometry classroom as a learning environment, where they individually solved tasks from textbooks or solved the tasks given by the teacher, while the teacher taught the whole class. Similar to study of Kuzle (2022), a broad spectrum of participation in geometry lessons was reported in this study; whereas in Kuzle (2022) none of the scales prevailed, here mathematics-related statements (34.0%) dominated in the students' drawings. Still, classroom discussions took place (14.0%), which was most often reported in Grade 4 (21.1%). This type of two-way communication (teacher-student) is an indicator of contemporary type of instruction (Domović, 2003), even though *Affiliation* with an extreme low percentage of different student-student interactions more strongly argue for a traditional type of instruction in geometry lessons. As in the study of Kuzle (2022), the students communicated with each other or helped and supported each other only to a limited extent. Despite little communication between the students, the existing communication with the teacher was positive, constructive and conducive to instruction, which is important for developing students' positive attitudes towards the subject and learning motivation, and consequently influencing student achievement (Cohen, 2006; Picker & Berry, 2000).

Improved school performance is a favoring factor of a positive classroom climate (Evans et al., 2009; Gruehn, 2000). Even though, this indicator was not explicitly found in the data, in 98.4% 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 may guide students in the direction of increased performance, and the formation of interest in the subject (Meyer, 2016). Both *Working method* as well as *Classroom seating arrangement* reflected a teacher-centered mode of instruction with frontal work (i.e., teacher standing in front of the classroom, and teaching meanwhile students write in their notebooks) (58.8%), and with the classroom tables being arranged in rows (67.2%). Active geometry learning methods (e.g., group work, working with a partner)–which reflect a student-centered mode of instruction (Gulek, 1999; Sinclair et al., 2013)–were just present in a few drawings. These findings are consistent with the research of Kuzle (2022), Hatisaru (2019, 2020), and Picker and Berry (2000), where many students associated mathematics with routine procedures and viewed learning as an individual activity. On a positive side, the instructional practices of contemporary type of instruction also emphasize the importance of classroom resources (Bobis et al., 2011; Domović, 2003), which were clearly illustrated in the students' drawings. Not only a blackboard and students' notebooks were used as teaching and learning materials but also other resources that are typical for geometry instruction were portrayed in the students' drawings. Almost all students' drawings illustrated *Teaching materials and tools*, which mainly referred to 2D-shapes (76.0%), and 3D-solids (22.0%), which was followed by different geometric tools used by either the teacher (12.4%) or the students (10.8%), and models of 2D- (4.0%) or 3D-objects (9.6%), which are crucial for both exploring mathematical concepts and deepening students' knowledge about these (Bobis et al., 2011). Thus, geometry concepts were represented through both iconic as well as enactive representations, which is similar to results of Kuzle (2022), where, however, concrete manipulatives played a larger role. It is probable that such teaching resources were unavailable to the participating teachers or lacked knowledge about incorporating these in their classroom teaching. Similar to Kuzle (2022), disciplinary incentives were present only minimally (5.2%), which indicates that the students perceived their geometry lessons being orderly regulated with very little disciplining occurrences.

In summary, the results showed a rather unanimous picture of teaching and learning of geometry in primary school in Croatia, where differences between the three grade levels were minimal. Furthermore, the students' drawings of their typical geometry lessons did not only reflect either extreme of teacher- or student-centered classroom but a mixture of practices from both types of classrooms. Nevertheless, the practices typical for teacher-centered instruction were more often illustrated than those reflecting student-centered instruction, which is not entirely aligned with Croatian curriculum guidelines (MZOS, 2006). This is rather worrying for several reasons. Firstly, research (e.g., Boaler, 2015; Smith & Stein, 2011; Swan, 2006) showed that traditional type of teaching (i.e., frontal teaching with students memorizing, and applying facts and procedures) can negatively impact students' attitudes towards mathematics, and thus, may have long term implications for students' mathematics learning. Furthermore, uniformity of teaching methods is not conducive to fostering student's individual learning preferences but rather a variety of teaching methods is needed (Bobis et al., 2011). Even though, such instruction may help students gain factual knowledge and increase their skills in solving routine problems, it may have no significant effect on students' reasoning skills (Bietenbeck, 2014; Swan, 2006; Vincent-Lancrin et al., 2019).

In this study, purposive sampling was used but if the reported practices are typical of the population, it would imply that Croatian primary students primarily gain opportunities to practice procedures to become fluent in them, and few opportunities in developing these through discussions of more open-ended problem-solving tasks, and in that manner build their mathematical understanding. Secondly, students' perceptions of classroom learning environments are associated with aspects, such as mathematics learning outcomes (Fraser, 2014; Wong et al., 2002), and interest in (Latterell & Wilson, 2012), and attitudes about mathematics (Hatisaru & Murphy, 2019; Picker & Berry, 2000). Thus, students who perceive mathematics classroom as boring, criticize teacher's lecturing style of teaching or do not feel supported in the learning process can negatively impact their future classroom experiences. Thus, teachers play a central role in both students' perceptions of the school subject(s) as well as how and what type of knowledge is created (Picker & Berry, 2000; Tsai, 2000). Last but not least, teaching tools and materials are strongly suggested when introducing new concepts, and solving open-ended tasks (Bobis et al., 2011), especially in geometry (Radatz et al., 1991). Even though almost each student's drawing reflected their use–but mainly using iconic representations–, it may be that physical manipulatives (e.g., 2D- and/or 3-models) were not regular classroom experiences of participating students, which may inhibit the learning for understanding.

Limitations of the Study and Future Research Directions

This study was an exploratory cross-sectional qualitative study using typical case sampling as a type of purposive sampling with a sample of 250 cases from both urban and rural schools. The drawings and associated texts, however, represent student responses at that point in time and within these classroom contexts. Other geometry practices may exist but were not mentioned by the students and for that reason cannot be excluded. As such, the results may be limited to specific cultural and contextual characteristics as well as specific characteristics of schools, which participated in this study and may not be representative of a general trend in the population from which the sample has been drawn but is rather illustrative of other similar samples. These limitations suggest a possible next step in research, namely, to conduct a study with a larger data sample in a wider variety of settings (e.g., counties or countries) and using alternative sampling strategies (e.g., maximum variation sampling, probability sampling). In that manner, a researcher could create a less-biased and more thorough description of students' perceptions of teaching and learning practices in primary school geometry lessons, which can then be generalizable to a population. In addition, drawings from entire classrooms across different grades and schools would not only allow a more holistic insight into the collective classroom social climate in primary grade geometry lessons but would allow for comparisons between different grades and schools as well as an insight into school climate. The research could also be extended to other grade levels (middle school, high school) to provide a sense of trends regarding the classroom social climate from lower into higher grades.

Teachers are the most significant influencing factor in students' learning (Hattie, 2013). The teacher's role in the context of teaching-learning situations has a long tradition that is based on the search for and investigation of influencing factors that can determine successful teaching (Voss et al., 2015). Thus, the particular role of the teacher can be further explored in future research. On the one hand, teacher's interpersonal characteristics such as teaching experience, professional background, and teacher attitudes could be researched in connection to specific teaching practices in geometry lessons. On the other hand, the study design did not allow the making of direct inferences between the students' perceptions of geometry teaching and learning practices and those of the teacher by using additional data sources, such as the teacher's drawing of a geometry lesson, researcher's observations of a geometry lesson. Perceptions of phenomena are likely to differ according to participants consulted within an environment (Beswick, 2007), and classroom protagonists may all have different conceptions of what happens in the same learning environment (Kalyon, 2020), which would be another interesting research perspective. Such research design would provide an objective sense of an environment by taking into the account the perspective of all protagonists who take part of the realm in which the phenomenon takes place. Also, future studies on how students' classroom experiences regarding teaching and learning practices correlate with their performance on large scale studies would contribute to understanding of possible factors behind students' performance in mathematics, which were, thus far, not possible to research in detail (Vieluf et al., 2012).

The results have also provided evidence of possible methodological biases, such as difficulties while drawing, student motivation and limited expressiveness of some aspects using drawings although students took task seriously and put considerable amount of effort and thought into completing it. These led consequently to relatively high frequencies of "unavailable" and "unidentifiable" codes of some scales for subdimension of *Support by the teacher*, *Participation*, *Affiliation*, *Working method* and *Classroom seating arrangement*, which was especially dominant in Grade 2. Due to the heterogeneous development in childhood, it is important to ensure that the children in the lowest grades are able to do what is required of them in terms of drawing (Billmann-Mahecha & Drexler, 2010). Also, it may be useful to see if this type of research matches the interests of the students. By talking to participants before they begin the actual task, it could be established whether the respective child likes to draw, or whether more specific instructions are needed or alternatively incentives could be given. Thus, a re-design of semi-structured interview placing a higher value on the aspects is another possible research direction. Just as importantly, students' drawings of their perceptions of teaching and learning practices do not only give researchers a better insight into current educational practices in geometry but may also provide practitioners a window into their students' thinking and learning (e.g., Anning, 1997; Kuzle & Glasnović Gracin, 2021; Pehkonen et al., 2016). Future studies could, thus, evaluate possibilities for classroom implementation, and practicability of it as a classroom-tool for discussing students' perceptions of teaching and learning practices.

CONCLUSIONS

Despite the above-mentioned limitations, the findings presented here provide valid and valuable insight into geometry teaching and learning practices and bring several implications of practical nature. On the one hand, the findings raise issues pertaining to teacher training. The data did not reveal the teaching practices conducive to geometry learning, such as student-centered approaches, activity-based teaching, discovery learning (Radatz et al., 1991). Adequate and solid teacher training as well as supplementary training should not be underestimated. Both are essential 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.

The drawing assignment and its coding schema have been developed based on an extensive literature review. Both instruments not only provide a basis for further study of students' perceptions of teaching and learning practices but may also impact educational classroom practices in school geometry. With the help of the inventory, also practitioners have the possibility of identifying practices in geometry as seen through their students' lenses. Thus, the inventory may be used as a classroom tool for discussing students' learning in the context of geometry lessons. "For instance, the aspects of the classroom social climate model that occur less frequently may have played a subordinate role in classroom instruction" (Kuzle & Glasnović Gracin, 2021, p. 771), which may promote constructive dialogue about teaching and learning between students and their teachers, and in that sense help them reflect on their own practices, and then plan and implement changes for future lessons (Anning, 1997; Anning & Ring, 2004; Hatisaru, 2019). This is paramount since teachers are the most significant influencing factor in students' learning (Hattie, 2013) and characteristics of classroom climate are powerful predictors of students' academic success (Evans et al., 2009). On a greater scope, students' drawings as well as research on school or classroom social climate may inform policy makers about the impact of curriculum as well as possible necessary revisions on classroom teaching. Consequently, if the goal of teaching mathematics is to help students understand mathematical concepts, use them in daily-life situations, and to express mathematical reasoning in problem solving processes–as outlined in Croatian curriculum (MZOS, 2006)–, then students should be supported in developing these skills. At last, the findings are useful to understand future development of mathematics provision in Croatia as well as in other countries with a centralized educational system in regard to taking measures to improve current curricula that would reflect teaching and learning practices conducive to contemporary mathematics instruction.

Author contributions: All authors have sufficiently contributed to the study and agreed with the results and conclusions.

Funding: No funding source is reported for this study.

Ethical statement: The authors stated that ethical review and approval was not required for the study on participants in accordance with the local legislation and institutional requirements.

Declaration of interest: No conflict of interest is declared by authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

REFERENCES

Ahtee, M., Pehkonen, E., Laine, A., Näveri, L., Hannula, M. S., & Tikkanen, P. (2016). Developing a method to determine teachers' and pupils' activities during a mathematics lesson. *Teaching Mathematics and Computer Science, 14*(1), 25-43. https://doi.org/10.5485/tmcs.2016.0414

Anning, A. (1997). Drawing out ideas: Graphicacy and young children. *International Journal of Technology and Design Education, 7*, 219-239. https://doi.org/10.1023/a:1008824921210

Anning, A., & Ring, K. (2004). *Making sense of children's drawings*. Open University Press.

Beswick, K. (2007). Teachers' beliefs that matter in secondary mathematics classrooms. *Educational Studies in Mathematics, 65*(1), 95-120. https://doi.org/10.1007/s10649-006-9035-3

Bietenbeck, J. (2014). Teaching practices and cognitive skills. *Labour Economics, 30*, 143-153. https://doi.org/10.1016/j.labeco.2014.03.002

Billmann-Mahecha, E. (2010). Auswertung von Zeichnungen [Evaluation of drawings]. In G. Mey & K. Mruck (Eds.), *Handbuch Qualitative Forschung in der Psychologie* (pp. 707-722). VS Verlag für Sozialwissenschaften. https://doi.org/10.1007/978-3-531-92052-8_49

Boaler, J. (2015). *What's math got to do with it?* Penguin Press.

Bobis, J., Anderson, J., Martin, A., & Way, J. (2011). A model for mathematics instruction to enhance student motivation and engagement. In D. J. Brahier & W. R. Speer (Eds.), *Motivation and disposition: Pathways to learning. 73rd yearbook of the National Council of Teachers of Mathematics* (pp. 1-12). NCTM.

Bülter, H., & Meyer, H. (2015). Unterrichtsklima als Determinante des Lernerfolgs [Teaching climate as a determinant of learning success]. In I. Leitz (Ed.), *Motivation durch Beziehung* (pp. 25-67). Springer. https://doi.org/10.1007/978-3-658-07416-6

Cohen, J. (2006). Social, emotional, ethical, and academic education: Creating a climate for learning, participation and democracy, and well-being. *Harvard Educational Review, 76*, 201-237. https://doi.org/10.17763/haer.76.2.j44854x1524644vn

Dahlgren Johansson, A., & Sumpter, L. (2010). Children's conceptions about mathematics and mathematics education. In K. Kislenko (Ed.), *Current state of research on mathematical beliefs XVI* (pp. 77-88). Institute of Mathematics and Natural Sciences, Tallinn University.

Dohrmann, C., & Kuzle, A. (2014). Unpacking children's angle "Grundvorstellungen": The case of distance Grundvorstellung of 1° angle. In P. Liljedahl, C. Nicol, S. Oesterkle, & D. Allan (Eds.), *Proceedings of the 38th Conference of the International Group for the Psychology of Mathematics Education and the 36th Conference of the North American Chapter of the Psychology of Mathematics Education* (Vol. 2, pp. 409-416). PME.

Domović, V. (2003). *Školsko ozračje i učinkovitost škole* [*School atmosphere and school efficiency*]. Naklada Slap.

Eder, F. (2002). Unterrichtsklima und Unterrichtsqualität [Teaching climate and teaching quality]. *Unterrichtswissenschaft: Zeitschrift für Lernforschung, 30*(3), 213-229.

Einarsdóttir, J. (2007). Research with children: Methodological and ethical challenges. *European Early Childhood Education Research Journal, 15*(2), 197-211. https://doi.org/10.1080/13502930701321477

Evans, I. M., Harvey, S. T., Buckley, L., & Yan, E. (2009). Differentiating classroom climate concepts: Academic, management, and emotional environments. *Kotuitui: New Zealand Journal of Social Sciences Online, 4*(2), 131-146. https://doi.org/10.1080/1177083x.2009.9522449

Fey, J. T., Hollenbeck, R. M., & Wray, J. A. (2010). Technology and the mathematics curriculum. In B. J. Reys, R. E. Reys, & R. Rubenstein (Eds.), *Mathematics curriculum: Issues, trends, and future directions* (pp. 41-49). National Council of Teachers of Mathematics.

Fisher, D. L., & Fraser B. J. (1983). Validity and use of the classroom environment scale. *Educational Evaluation and Policy Analysis, 5*(3), 261-271. https://doi.org/10.3102/01623737005003261

Fraser, B. (2014). Classroom learning environments: Historical and contemporary perspectives. In N. Lederman & S. Abell (Eds.), *Handbook of research on science education* (pp. 104-119). Routledge.

Fraser, B. J., & Fisher, D. L. (1983). Development and validation of short forms of some instruments measuring student perceptions of actual and preferred classroom learning environment. *Science Education Assessment Instruction, 11*, 115-131. https://doi.org/10.1002/sce.3730670114

Glasnović Gracin, D., & Kuzle, A. (2018). Drawings as external representations of children's mathematical ideas and emotions in geometry lessons. *Center for Educational Policy Studies Journal, 8*(2), 31-53.

Golomb, C. (1994). Drawing as representation: The child's acquisition of a meaningful graphic language. *Visual Arts Research, 20*(2), 14-28.

Gruehn, S. (2000). *Unterricht und schulisches Lernen* [*Teaching and school learning*]. Waxmann Verlag.

Gulek, C. (1999). *Using multiple means of inquiry to gain insight into classrooms: A multi-trait multi-method approach* [Unpublished doctoral dissertation]. Boston College.

Hatisaru, V. (2019). Putting the spotlight on mathematics classrooms. In J. Novotná & H. Moraová (Eds.), *Proceedings of the International Symposium Elementary Mathematics Teaching: Opportunities in Learning and Teaching Elementary Mathematics* (pp. 182-192). Charles University, Faculty of Education, Prague.

Hatisaru, V. (2020). School students' depictions of mathematics teaching and learning practices. *International Electronic Journal of Elementary Education, 13*(2), 199-214. https://doi.org/10.26822/iejee.2021.184

Hatisaru, V., & Murphy, C. (2019). "Creature" teachers "monster" mathematicians: Students' views about mathematicians and their stated attitudes to mathematics. *International Journal of Education in Mathematics, Science and Technology, 7*(3), 215-221. https://doi.org/10.31129/LUMAT.7.2.355

Hattie, J. (2013). *Lernen sichtbar machen* [*Making learning visible*]. Schneider Verlag Hohengehren.

James, W. (1977). The principles of psychology. In J. J. McDermott (Ed.), *The writings of William James: A comprehensive edition* (pp. 21-74). University of Chicago Press.

Kalyon, D. S. (2020). Primary teachers' and students' images of teachers and learning environments. *International Electronic Journal of Elementary Education, 13*(1), 155-167. https://doi.org/10.26822/iejee.2020.180

Kearney, K., & Hyle, A. (2004). Drawing out emotions: The use of participant-produced drawings in qualitative inquiry. *Qualitative Research, 4*(3), 361-383. https://doi.org/10.1177/1468794104047234

Kuzle, A. (2022). Elementary and middle school children's perceptions of psychosocial classroom learning milieu in the context of school geometry: An analysis of participant-produced drawings. *Learning Environments Research, 26,* 379-399. https://doi.org/10.1007/s10984-022-09430-0

Kuzle, A., & Glasnović Gracin, D. (2019). Classroom social climate in the context of middle school geometry. In M. Graven, H. Venkat, A. Essien, & P. Vale (Eds.), *Proceedings of the 43rd Conference of the International Group for the Psychology of Mathematics Education* (Vol. 2, pp. 511-518). PME.

Kuzle, A., & Glasnović Gracin, D. (2021). Drawing out classroom social climate: the use of participant-produced drawings in research on psychosocial classroom learning environment in the context of school mathematics. *LUMAT: International Journal on Math, Science and Technology Education, 9*(1), 748-773. https://doi.org/10.31129/LUMAT.9.1.1624

Laine, A., Ahtee, M., Näveri, L., Pehkonen, E., Koivisto, P. P., & Tuohilampi, L. (2015). Collective emotional atmosphere in mathematics lessons based on Finnish fifth graders' drawings. *LUMAT: International Journal on Math, Science and Technology Education, 3*(1), 87-100. https://doi.org/10.31129/lumat.v3i1.1053

Laine, A., Näveri, L., Ahtee, M., Hannula, M. S., & Pehkonen, E. (2013). Emotional atmosphere in third-graders' mathematics classroom–an analysis of pupils' drawings. *Nordic Studies in Mathematics Education, 17*(3-4), 101-116.

Latterell, C. M., & Wilson, J. L. (2012). Students' perceptions of what mathematicians do. *Mathematics Educator, 13*(2), 73-84.

Meyer, H. (2016). *Was ist guter Unterricht?* [*What is good teaching?*]. Cornelsen Verlag.

Ministry of Science, Education, and Sports [MZOS] (2006). *Nastavni plan i program za osnovnu školu* [The educational plan and programme for elementary school]. Narodne Novine, Službeni List Republike Hrvatske. https://narodne-novine.nn.hr/clanci/sluzbeni/2006_09_102_2319.html

Ministry of Science and Education [MZO] (2019). Kurikulum nastavnog predmeta matematika za osnovne škole i gimnazije [Curriculum for mathematics for elementary schools and gymnasia]. Narodne Novine, Službeni List Republike Hrvatske. https://narodne-novine.nn.hr/clanci/sluzbeni/2019_01_7_146.html

Moos, R. H. (1974). *The social climate scales: An overview*. Consulting Psychologists Press.

Moos, R. H., & Moos, B. S. (1978). Classroom social climate and student absences and grades. *Journal of Educational Psychology, 70*(2), 263-269. https://doi.org/10.1037/0022-0663.70.2.263

Mullis, I. V. S., Martin, M. O., & Loveless, T. (2016b). *20 years of TIMSS. International trends in mathematics and science achievement, curriculum, and instruction*. TIMSS & PIRLS International Study Center.

Mullis, I. V. S., Martin, M. O., Foy, P., & Arora, A. (2012). *TIMSS 2011 international results in mathematics*. TIMSS & PIRLS International Study Center.

Mullis, I. V. S., Martin, M. O., Foy, P., & Hooper, M. (2016a). *TIMSS 2015 international results in mathematics.* TIMSS & PIRLS International Study Center.

Mullis, I. V. S., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. (2020). *TIMSS 2019 international results in mathematics*. TIMSS & PIRLS International Study Center.

Murphy, P. K., Delli, L. A. M., & Edwards, M. N. (2004). The good teacher and good teaching: Comparing beliefs of second-grade students, preservice teachers, and inservice teachers. *Journal of Experimental Education, 72*(2), 69-92. https://doi.org/10.3200/jexe.72.2.69-92

OECD. (2010). *Mathematics teaching and learning strategies in PISA*. OECD Publishing. https://doi.org/10.1787/9789264039520-en

OECD. (2016). *Ten questions for mathematics teachers … and how PISA can help answer them.* OECD Publishing. https://doi.org/10.1787/9789264265387-en

Patton, M. Q. (2002). *Qualitative research and evaluation methods*. SAGE.

Pehkonen, E., Ahtee, M., & Laine, A. (2016). Pupils' drawings as a research tool in mathematical problem-solving lessons. In P. Felmer, E. Pehkonen, & J. Kilpatrick (Eds.), *Posing and solving mathematical problems. Advances and new perspectives* (pp. 167-188). Springer. https://doi.org/10.1007/978-3-319-28023-3

Picker, S., & Berry, J., (2000). Investigating pupils' images of mathematicians. *Educational Studies in Mathematics, 43*, 65-94. https://doi.org/10.1023/A:1017523230758

Radatz, H., Rickmeyer, K., & Freitag, W. (1991). *Handbuch für den Geometrieunterricht an Grundschulen* [*Handbook for teaching geometry in elementary schools*]. Schroedel.

Schoenfeld, A. H. (1992). Learning to think mathematically: Problem solving, metacognition, and sense-making in mathematics. In D. Grouws, (Ed.), *Handbook for research on mathematics teaching and learning: A project of the National Council of Teachers of Mathematics* (pp. 334-370). MacMillan.

Segall, W., & Wilson, A. (1998). *Introduction to education: Teaching in a diverse society*. Prentice Hall.

Smith, M. S., & Stein, M. K. (2011). *Five practices for orchestrating productive mathematics discussions.* NCTM.

Swan, M. (2006). Learning GCSE mathematics through discussion: What are the effects on students? *Journal of Further and Higher Education, 30*(3), 229-241. https://doi.org/10.1080/03098770600802263

Trickett, E. J., & Moos R. H. (1973). Social environment of junior high and high school classrooms. *Journal of Educational Psychology, 65*(1), 93-102. https://doi.org/10.1037/h0034823

Tsai, C. C. (2000). Relationships between student scientific epistemological beliefs and perceptions of constructivist learning environments. *Educational Research, 42*(2), 193-205. https://doi.org/10.1080/001318800363836

Utley, J., & Showalter, B. (2007). Pre-service elementary teachers' visual images of themselves as mathematics teachers. *Focus on Learning Problems in Mathematics, 29*(3), 1-14.

Vieluf, S., Kaplan, D., Klieme, E., & Bayer, S. (2012). *Teaching practices and pedagogical innovation: Evidence from TALIS.* OECD Publishing. https://doi.org/10.1787/9789264123540-en

Vincent-Lancrin, S., Urgel, J., Kar, S., & Jacotin, G. (2019). *Measuring innovation in education 2019: What has changed in the classroom?* OECD Publishing. https://doi.org/10.1787/9789264311671-en

Voss, T., Kunina-Habenicht, O., Hoehne, V., & Kunter, M. (2015). Stichwort Pädagogisches Wissen von Lehrkräften: Empirische Zugänge und Befunde [Keyword pedagogical knowledge of teachers: Empirical approaches and findings]. *Zeitschrift für Erziehungswissenschaft, 18*(2), 187-223. https://doi.org/10.1007/s11618-015-0626-6

Wellman, H. M., Hollander, M., & Schult, C. A. (1996). Young children's understanding of thought bubbles and of thoughts. *Child Development, 67*(3), 768-788. https://doi.org/10.2307/1131860

Wong, N. Y., Marton, F., Wong, K. M., & Lam, C. C. (2002). The lived space of mathematics learning. *Journal of Mathematical Behavior, 21*, 25-47. https://doi.org/10.1016/S0732-3123(02)00101-3

Zemelman, S., Daniels, H., & Hyde, A. (2005). *Best practice: New standards for teaching and learning in American's schools*. Heinemann Publishing.