

# Online versus Classroom teaching: Differences and Specificities in Teacher-student Interaction Processes

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## Abstract

The introduction of information and communication technologies (ICT) in elementary education has radically changed the way of teaching and learning in recent decades. In addition, the recent acceleration in the use of online learning due to the pandemic period has increased the reliance on these teaching methods. Online learning has become a popular teaching practice in recent years in parallel with traditional teaching, yet there are still few studies in the literature that delve into a comparison between the two learning situations and in particular studies focusing on these methods within the elementary education are scarce. The purpose of this study is to examine the characteristics of student-to-student and student-to-teacher interactions that occur in online learning as compared to typical face-to-face classroom interactions, with a specific focus on the elementary school level. The quality of teacher-student interactions was measured using the Classroom Assessment Scoring System (CLASS; Pianta et al., 2008). Elementary students were selected from 36 classes ranging from second to fifth grade. The total sample included 769 students (48% male). The majority of teachers were female (N = 31, 86%). The study shows that online teaching can have positive or negative effects on the quality of interaction between teachers and students, depending on the dimensions considered and the age of the participants. This study helps to highlight the differences and specificities of interaction and learning processes in the two situations (online and face-to-face): online teaching seems to improve positive climate, behavior management, and didactic learning formats, while face-to-face teaching seems to provide greater teacher sensitivity and better-quality feedback.

*Keywords:* Student-teacher relationship; COVID-19; online learning; face-to-face teaching; school climate

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## Introduction

### *Digital Learning Environment*

In recent decades, information and communication technologies (ICT) used in education have drastically changed the way of teaching and learning (Li & Zheng, 2018; Wu et al., 2017), and this evolving familiarity has become an everyday act for students. Furthermore, UNESCO also advocates the use of ICT as a means to improve education systems in terms of dissemination of and access to knowledge (UNESCO, 2017). The use of ICT can also play a formative role in promoting basic digital skills, especially in primary education. Digital learning environments can provide a wealth of opportunities for interaction on multiple levels: Student-student, student-teacher, student-content, and different types of structures such as collaborative groups and/or communities. The adoption of digital learning environments has traditionally been practiced primarily in secondary and higher education (Greenhow et al., 2020; Redpath, 2012), but emerging trends also point to the relevance and possibilities of digital learning environments in primary education. In this context, it has been shown that the use of digital environments can also contribute to achieving the Sustainable Development Goals (Ahel & Schirmer, 2023).

The variety and availability of digital devices not only allow students to be constantly connected to the Internet, but can also promote student motivation and engagement in learning (Chen & Wang, 2015; Nygren & Vikström, 2013), an engagement that is linked to creativity and metacognition, possibly due to components of gamification-inspired teaching (game-based learning) (Braad et al., 2020). These findings are significant for elementary school as the practices associated with engagement are related to long-term outcomes and digital literacy development. The characteristics of online learning have also been associated with the forms of final assessment of learning (Thomas et al., 2018): There is evidence of positive effects of blended learning and formative assessment in digital spaces. Some research reports make interesting comparisons between learning in digital environments and more traditional face-to-face learning: in this case, Pirlott (2022) suggests that online learning represents greater accessibility to learning opportunities and/or content that can be used anywhere, anytime, e.g., through videos or other learning outcomes. Although synchronous virtual teaching is still fundamentally different from face-to-face teaching, the motivation and interaction problems that occur in asynchronous online learning are reduced. The authors found no significant differences in terms of grade point average (GPA), ethnicity, or age. However, interactions in primary education have unique aspects when considering the learning characteristics associated with learners' developmental levels. Petchamé et al. (2021) also provide additional details about the comparison between face-to-face (F2F) and online learning contexts: While students certainly prefer relationship building in F2F contexts, they see relationship building in digital contexts as less problematic. At the same time, they associate online didactics with a greater potential for distraction. Comparisons between F2F and online learning contexts also indicate that students in F2F courses perceive their relationship with instructors as more conflictual (Vagos & Carvalhais, 2022), suggesting that there are subtle contexts in the classroom dynamics between modalities.

Recently, Tsai et al. (2023) suggest that peer-supported learning and the positive

outcomes of peer-supported learning are important for learning motivation in elementary school, where peer dynamics have a significant impact on the learning experience of the students being taught. To date, a literature review provides sufficient evidence of the modal experience/impact of online instruction on student learning outcomes and the quality of interactions between participants and faculty, but most studies focus only on higher education. New studies are now beginning to document hopeful pedagogical outcomes of increased online teaching and learning practice, particularly in the context of elementary school (Greenhow et al., 2022). Recent studies provide interesting insights into the quality of classroom climate in the social context of online education: Gherghel et al. (2023) discuss that social interactions in online contexts have an indirect positive impact on autonomy in managing learning time, mediated by emotional and behavioral engagement related to online learning. Cole et al. (2021) talk about the relationship between students' perceived classroom climate in an online learning environment and academic performance, suggesting that perceived classroom climate could be a strong predictor of academic performance. Harris et al. (2020) mention the importance of building positive relationships as an important strategy that teachers use to increase learner engagement in online courses. Despite the increasing interest in classroom climate among individuals studying in online education contexts, a systematic approach to classroom climate is lacking in the literature, meaning that there is still much to learn and many important issues to consider (Goagoses et al., 2023).

### ***Online Teaching and Learning***

The literature has primarily examined the impact of distance learning on learning outcomes and related cognitive aspects: For learners with ADHD, difficulties resulting from the experience of online are associated with worsening symptoms of inattention and hyperactivity, as well as the expression of oppositional behavior and emotional problems; executive functions are also severely impaired (He et al., 2021).

Online learning is associated with poorer scores on disciplinary assessment tests: In the elementary context, Skar and colleagues (2021) report lower writing skills among first graders who learned writing through distance learning compared to students who learned the skill in face-to-face classes instead. Tomasik and colleagues (2021) suggest that individual differences in learning rates and outcomes increase significantly during distance learning, especially for elementary students.

However, recent studies have also shown various positive effects of digital learning environments on educational outcomes. Maryani et al. (2022) found that targeted online training significantly improved students' reasoning and metacognitive skills. Choy and Cheung (2022) emphasized the positive impact of digital learning environments on peer collaboration and improving self-directed learning skills. In addition, the integration of ICT has been positively associated with increased motivation (Sahlin et al., 2017; Siddiq et al., 2017) and improved academic performance (Genlott & Grönlund, 2016).

Heo and Han (2018) investigated whether motivation, academic stress and age influence students' readiness for self-directed learning (SDLR) in online contexts. Their findings highlight that motivation and academic stress significantly influence SDLR, while age does not appear to have a significant impact. In addition, the literature highlights the importance of considering contextual variables such as the digital divide, teachers' ICT skills

and infrastructure, all of which can have a significant impact on the effectiveness of online teaching and student outcomes, particularly in the context of primary education.

### *The Italian Context*

In Italy, the education sector has experienced a gradual digitalization push since the 1990s, which intensified in the 2000s with ministerial initiatives for digital transformation. The first national plan for digital schools implemented by the Ministry of Education dates back to 2007 and promotes digital innovation and improved digital skills, which are particularly important for early childhood education. In 2008, the Ministry launched the “LIM” action to facilitate the widespread introduction of interactive multimedia whiteboards with the aim of making teachers and students more familiar with multimedia technologies ([www.miur.gov.it](http://www.miur.gov.it)).

The subsequent introduction of Law 107/2015 (The Good School, 2015) produced a new national plan for digital schools, aligned with the European Commission’s broader vision for education in the digital age and addressing modern educational challenges such as lifelong and lifewide learning.

The current National Plan for Digital Schools includes measures in several important areas. First, the connectivity initiatives target structural improvements to enhance institutional connectivity and create innovative digital learning environments. In addition, the measures aimed at cultural change focus on improving students’ digital skills, developing high-quality digital teaching materials and providing comprehensive training and coaching for school staff.

The educational landscape has thus undergone significant changes, which can already be observed in the international context (Dhawan, 2020) and have been dramatically accelerated by the COVID-19 pandemic. The need to maintain uninterrupted teaching during school closures accelerated the digitalization process and increased the reliance on online teaching and virtual learning environments.

Italy was one of the first European countries to be severely affected by the pandemic and quickly introduced strict containment measures. The emergency measures issued on February 23, 2020 led to the suspension of face-to-face teaching in severely affected regions (DPCM 23/2/2020). The abrupt switch to distance learning was initially a major challenge, particularly for primary school students who reported greater effort in completing learning tasks, difficulty understanding lesson feedback, increased stress and anxiety (Petillion & McNeil, 2020). Teachers similarly faced increased anxiety (Li et al., 2020), depression (Cormier et al., 2022), and burnout (Sokal et al., 2020).

In recent years, online teaching has become increasingly established in the Italian primary school system and has developed from an emergency solution to a regular teaching method (Alon et al., 2023). After the initial lockdown in 2020, “distance learning” became “integrated digital teaching,” where face-to-face and online learning phases are blended or online teaching is used selectively based on specific student needs. In addition, video teaching was increasingly used for supporting activities in the classroom, embedding digital practices even more into the standard educational framework.

### ***Online Teaching and Emotional Support***

The assessment of the impact of distance learning on classroom climate was primarily studied at higher levels of education (secondary and above). The construct of emotional support includes both a positive classroom climate, characterized by enthusiasm and emotional closeness between teachers, students and peers, and a negative climate, characterized by emotions such as anger, aggression, or hostility. Emotional support also includes teacher sensitivity, which reflects attention and responsiveness to the educational and emotional needs of elementary school students (Pianta & Hamre, 2009).

Vaillancourt et al. (2022) reported that elementary students who participated in face-to-face instruction considered face-to-face interactions more important than older students who placed less value on blended online/face-to-face formats. Conversely, primary school students valued certain aspects of distance learning, such as less bullying, less peer pressure, and less social anxiety. The literature emphasizes the critical role of effective student-teacher interactions in promoting the academic success and learning processes of elementary school students (Pianta et al., 2002). Nevertheless, online learning is often criticized by educators because it is difficult to build authentic relationships and effectively monitor student progress (Niemi & Kousa, 2020). Similar challenges were noted in U.S. K–12 teachers' experiences during remote learning, where rebuilding caring relationships with students became a central concern (Miller, 2021).

### ***Online Teaching and Classroom Organization***

Classroom organization refers to teachers' control and flexibility in managing classroom activities, adapting to primary students' interests and schedules, and managing student behavior, productivity and instructional support (Pianta et al., 2012). Instructional support specifically includes strategies that stimulate varied thinking, encourage problem solving and promote active discussions. It also includes structured learning formats, quality feedback, and the language patterns used by teachers that impact students' cognitive development, learning outcomes, and academic achievement (Jamil et al., 2015).

Distance learning can have a negative impact on the communicative quality of feedback. Alawamleh et al. (2020) found that online teaching is associated with lower quality teaching materials, poorer learning outcomes, and less communicative interaction between students and teachers. In contrast, higher level distance learning experiences often showed positive learning outcomes and fewer academic failures. Reyes-Mercado et al. (2023) reported that digital learning environments improve students' ability to complete courses and thus facilitate effective learning processes.

### ***Observational Studies on Digital Learning***

Digital learning environments are inherently different from traditional face-to-face classrooms in terms of content delivery, type of feedback, and type of interaction, which largely depend on the communication channels and learning formats (synchronous or asynchronous). These different characteristics require specialized observation methods to

accurately capture interactions in digital contexts.

Ariffin and Darus (2022) used the Classroom Assessment Scoring System (CLASS) to investigate the teaching strategies used by teachers in online settings. The study found that online instructional leadership was effective with varying levels of teacher seniority, consistently emphasizing positive interactions and appropriate support. The findings confirm the applicability of the CLASS domains—emotional support, classroom organization, and didactic support—when observing online interactions, particularly in foreign language classrooms.

Rif et al. (2023) used observation methods to evaluate digital foreign language teaching practices and emphasized the effectiveness of debriefing techniques to promote critical thinking and linguistic fluency. Similarly, Shakina et al. (2022) investigated the effectiveness of co-operative learning and discovery learning strategies used by English teachers in online environments. Moon et al. (2023) presented the System for Observing Virtual Real-Time Lessons in Physical Education (SOVRTL-PE), a tool specifically designed to assess pedagogical practices and instructional quality in online physical education, providing a comprehensive framework for observational assessments.

Online learning thus represents both a complex educational context and a unique opportunity to systematically analyze formative and relational processes. Comparison with established face-to-face teaching practices reveal important insights into relational, emotional and organizational dynamics. Despite extensive public debate, exemplified by articles in prominent media outlets such as the New York Times (Marcus, 2022), there remains a notable lack of rigorous empirical research. As a result, policy decisions on online education have often been made without a thorough assessment of the potential consequences.

## *Aims*

Given this discrepancy and the heated public debate, there is a need to examine the characteristics of online learning from a scientific perspective and compare them with those of face-to-face learning. Despite this, there is a dearth of studies in the literature that organically and systematically compare the processes related to the two learning situations (face-to-face vs. online) and several research questions also remain open about how online interactions influence fundamental features of the educational setting, that in turn have been recognized as relevant for the educational outcomes. In this we considered in particular the dimensions that have been proposed by Pianta and colleagues (2008) and for the measurement of which a standardized observational instrument is available (Pianta et al., 2008). These dimensions are “emotional support,” a measure of teachers’ responsiveness and creation of a warm atmosphere in the classroom, “classroom organization,” a measure of effective behavior management and structuring of learning activities, and “instructional support” that refers to teachers’ facilitation of cognitive development and their ability to provide constructive feedback.

In this study in particular we aim to compare the two experiences (face-to-face vs. online learning) in the elementary school context to answer the following research questions:

1. How do online and face-to-face learning environments differentially impact the dimensions of Emotional Support, Classroom Organization, and Instructional Support in

elementary education?

2. Is the age of the children related to the quality of interactions between pupils and teachers in the two different educational settings? That is, are older students more likely to experience higher (or lower) quality interactions in the online environment?

With respect to the first research question, we hypothesized that online learning would be positively related to positive characteristics of classroom climate, because group management is facilitated by the online mode. We also hypothesized that online instruction would be positively related to classroom organization, because the online context would facilitate the processes of organizational management of behaviors (especially with reference to disruptive and problem behaviors) and instructional formats. Lastly, we hypothesize that face-to-face instruction would facilitate the expression of teacher sensitivity and the ability to provide targeted feedback to learners, as the face-to-face teaching situation would facilitate the activation of multiple interactions between teacher and students, as already found in recent studies on the topic. With regard to the associations with age, we have no a priori hypotheses, as there are hardly any studies comparing the quality of student-teacher interaction in face-to-face and online settings with children of this age (7–10 years).

## Method

### *Research Model and Procedure*

The study used an observational procedure to collect data on the quality of teacher-student interactions in second-to-fifth grade classes. Observations were carried out in two different contexts: during face-to-face and online lessons. For the face-to-face context, observers conducted in-class observations, while for lessons conducted online (via Zoom or Teams) observers were included as guests during the online lessons. Six 20-minute observation sessions were conducted for each class (three in the online setting and three in the face-to-face setting), during which notes were taken on the specific aspects of each dimension, which formed the basis for the coding that took place in the 10 minutes following the observation. Observations were conducted at different times of the day to capture the teacher's various activities with the students. Observations were conducted as planned in all participating classes and no data were missing. On the whole the observers conducted classroom observations in two different days for each class. This within-subjects design served as the main methodological control to reduce variability across classes, teachers, and student composition.

The period in which the observations were conducted lasted 3 months. Each class consisted of approximately 21 students. A total of 108 observation cycles for each educational setting were performed (total: 216 cycles). One of the observers was the certified CLASS observer, while the other observer was trained by the certified CLASS coder. The training included four sessions (8 hour, 2 hour/time) and two practice sessions (4 hour, 2 hour/time). The training was conducted both on the online and the face-to-face context. The ethical code of the Italian Association of Psychology (AIP) was followed in this study and it was approved by the ethical review board of the university.

### *Research Context and Sample*

The study was conducted during the pandemic period characterized in Italy by repeated

lockdowns that led schools to provide students with the opportunity during certain periods to do online teaching, by means of tools such as Zoom and Microsoft Teams. The observations analyzed in this study were made in a period (spring 2021) during which teaching was delivered in a mixed mode, alternating days of online and face-to-face teaching.

Students from 36 primary school classes, ranging from second to fifth grade, took part in the study. To recruit teachers to participate in the research, invitation letters were sent to principals of 5 public ( $n = 3$ ) and private ( $n = 2$ ) elementary schools located in Northern Italy. The principals agreed to forward the request for participation to teachers in their respective schools. Teachers who agreed to participate were asked to hold informational meetings with students' parents in which the researchers presented the research project and subsequently collected informed consents from parents. The 36 classes in the final sample were those with respect to which informed consent was obtained from all students' families (both parents). The teachers involved in the research were all Italian nationals, the majority of whom were women ( $N = 31$ , 86%). Adherence to participation in the research was total from students in the classes involved, from whom we collected parental consent. The total sample size was 769 students: about half of the student sample was male (48%), and 7% of the sample were first- or second-generation immigrants.

## **Instrument Used and Its Validation**

### ***Classroom Assessment Scoring System***

The quality of teacher-student interactions was measured using the Classroom Assessment Scoring System (CLASS; Pianta et al., 2008). The CLASS is an observational instrument with three domains (emotional support, classroom organization, and instructional support) and 10 dimensions (positive climate, negative climate, teacher sensitivity, consideration of student perspective, behavior management, productivity, instructional learning format, concept development, quality of feedback, and language modelling). Each dimension was assigned a score from 1 to 7 (low = 1, 2; medium = 3, 4, 5; high = 6, 7). Observers were required to follow the dimension descriptions for the low, medium, and high domains in the manual CLASS when scoring each dimension. Scores for the domains were then calculated by adding the scores for the dimensions and dividing by the number of dimensions (Pianta et al., 2008). The CLASS framework delineates three domains: "Emotional Support," which evaluates the depth and affective quality of teacher-student interactions, reflecting the teacher's capacity to offer a responsive and emotionally conducive learning milieu; "Classroom Organization," which appraises the teacher's efficacy in orchestrating a structured and goal-oriented learning environment conducive to educational engagement; and "Instructional Support," which quantifies the teacher's role in fostering cognitive development and articulating constructive feedback to support students' academic progression.

The instrument CLASS has been internationally validated to observe the dynamics of interaction and classroom management in face-to-face lectures (Kirk et al., 2022; Pakarinen et al., 2010; Stuck et al., 2016). In this study, we adapted the instrument to apply the observation protocol to online lectures. In this context, the study conducted by Ariffin and Darus (2022) demonstrates the applicability of CLASS to observe interaction and learning processes in an

online context. Recent studies also highlight the feasibility of applying observation techniques in online teaching (Salekdeh & Hassaskhah, 2023). For example, Khlaif et al. (2021) used an observation protocol developed based on checklists designed for observing face-to-face learning processes (Wheeler et al., 2019; Topçu et al., 2018).

To assess the applicability of the instrument in an online context, experienced psychological researchers skilled in the use of CLASS conducted pre-observations. They found that all dimensions captured by CLASS could be effectively observed in online interactions between students and between teachers and students. Reliability analyses were also conducted to ensure the validity of the instrument. Inter-observer agreement was calculated separately for online and face-to-face instruction using intraclass correlations. The interrater reliabilities of the domains from CLASS were 0.81 and 0.86 for emotional support, respectively for face-to-face and online observations, 0.80 (face-to-face) and 0.83 (online) for classroom organization, and 0.78 (face-to-face) and 0.83 (online) for instructional support.

The internal consistency reliabilities for the three domains were emotional support (face-to-face:  $\alpha = 0.90$ ; online:  $\alpha = 0.86$ ), classroom organization (face-to-face:  $\alpha = 0.93$ ; online:  $\alpha = 0.96$ ), and classroom support (face-to-face:  $\alpha = 0.88$ ; online:  $\alpha = 0.93$ ).

### **Data Analysis**

Data analysis was performed as follows: Descriptive statistics on the dimensions measured by CLASS were compiled in advance, distinguishing between face-to-face and online contexts. To answer to the first research question, we performed paired sample t-tests to identify possible significant differences between the average scores of CLASS results obtained in the two different educational settings. Then, in order to explore the association between age and CLASS dimensions we calculated Pearson correlations between the sub-dimensions of CLASS and the age of the students.

## **Results**

Table 1 shows the descriptive statistics for the class dimensions measured for each of the online and face-to-face interactions.

**Table 1**

*Means, Standard Deviations, and Paired Sample T-Tests of the Variables*

	Online		Face-to-face		t-test	p	d
	M	SD	M	SD			
<i>Emotional support</i>							
Positive climate*	6.42	0.27	5.96	0.49	5.932	<.001	0.99
Negative climate	2.97	0.53	3.18	0.69	-1.867	.07	-0.31
Teacher sensitivity*	6.26	0.27	6.56	0.26	-3.803	.001	-0.63
Regard for student perspectives	4.67	0.67	4.83	0.77	-1.261	.22	-0.21
<i>Classroom organization</i>							
Behavior management*	6.01	0.43	5.69	0.59	3.077	.004	0.51

Productivity	3.33	0.63	3.53	0.76	-1.061	.30	-0.18
Instructional learning formats*	5.93	0.40	5.71	0.46	2.515	.02	0.42
<i>Instructional support</i>							
Concept development	4.83	0.86	4.67	0.63	1.206	.24	0.20
Quality of feedback*	5.89	0.44	6.19	0.42	-3.064	.004	-0.51
Language modelling	6.26	0.25	6.28	0.26	-0.206	.84	-0.03

Note. \*Statistically significant difference

In order to answer to the first research questions, we conducted paired sample t-tests comparing the average scores obtained by the classrooms on the 10 subdimensions of the CLASS in the online vs. face-to-face setting. As can be seen from the table, there are statistically significant differences in all three domains examined by CLASS. In particular, with respect to the domain of emotional support, it appears that the classroom climate seems to be more positive in the online context than in the face-to-face context. The dimensions of teacher sensitivity are also more pronounced in the face-to-face context than in the online context. As regards Classroom organization, the online context is characterized by significantly higher values for the dimensions of behavior management and instructional formats. Finally, in the area of instructional support, only a significant difference was found with respect to the Quality of feedback dimension, which reached higher average values in the face-to-face context. According to the d-cutoff values proposed by Cohen (1988), the effect sizes for the significant differences are: low for Instructional learning formats, medium for Teacher sensitivity, Behavior management, and Quality of feedback, and high for Positive climate.

With respect to the second research question, we examined the Pearson's correlations between the average scores obtained by the classrooms in the two settings and age. Table 2 reports these correlations. It emerges that regarding Emotional Support, a negative correlation is observed between Teacher Sensitivity and Age in Face-to-face Context (-.63\*). For the area domain of classroom organization, a negative correlation is observed between productivity and age (-.69\*) in the online context. Regarding the area of instructional support, a positive correlation is observed between concept development and age in the face-to-face context (.35\*) and between language modelling and age (.52\*) in the online context.

**Table 2**  
*Correlations Between CLASS subdimensions and Students' Age*

		Correlations with age	
		Face-to-face	Online
<i>Emotional support</i>	Positive climate	.31	.20
	Negative climate	.30	.05
	Teacher sensitivity	-.63*	.37
	Regard for student perspectives	.33	.12
<i>Classroom organization</i>	Behavior management	-.05	-.08
	Productivity	-.17	-.69*
	Instructional learning formats	-.02	-.17
<i>Instructional support</i>	Concept development	.35*	.34
	Quality of feedback	.21	.21
	Language modelling	.02	.52*

## Discussion

The recent pandemic increase in the use of digital learning at different grade levels has made it possible to study a phenomenon that until a few years ago was still in its early stages. Today, the situation has normalized: The use of online learning is part of the different practices available for the implementation of educational programs and is perceived as an additional way to manage the teaching/learning process: This provides an opportunity to study and compare the specific modes of interaction of digital learning in comparison with those of face-to-face learning. In contrast, until a few years ago, it would not have been possible to study the effects of the two different modes of teaching (face-to-face vs. online) on the same individuals.

The results of the study suggest that online learning has a significant impact on the quality of teacher-student interactions compared to face-to-face instruction in elementary schools. The results show that online mode is associated with a more positive classroom climate: this finding helps to add to the sometimes contradictory statements in the literature.

For example, Ghaderi et al. (2022) report that college students are more likely to experience positive emotions (such as joy, hope, pride) in traditional face-to-face situations. In contrast, Yang et al.'s (2019) study shows that online learning situations can foster a positive collaborative climate by supporting mutual acceptance among students.

However, it should be kept in mind that classroom climate has been little studied in relation to online learning in the elementary school context. We can hypothesize that online learning is associated with a positive classroom climate because the virtual environment facilitates group management. However, teachers' sensitivity was higher in face-to-face contexts, suggesting that teachers may find it difficult to establish meaningful relationships

with their students online: This confirms the findings of several studies showing that the digital learning context hinders the development of meaningful interpersonal relationships.

Indeed, loneliness and social isolation have long been studied as relevant effects of online learning (Kraut et al., 1998; Ali & Smith, 2015); one of the most criticized aspects of online learning is precisely the difficulty of building authentic relationships between people (Niemi & Kousa, 2020). In addition, the online mode was found to be characterized by significantly higher levels of behavior management and instructional learning formats in the classroom organization domain. This could be due to the fact that in the virtual environment it is easier to track and monitor student behavior and technological tools are available to facilitate instructional learning. This is an original finding in relation to the elementary school context: recent studies have indeed shown a positive impact of online didactics on the organization of learning formats, but in relation to higher levels of education. For example, Reyes-Mercado et al. (2023) highlighted how online didactics support the ability to perform tasks, thus facilitating learning processes.

However, in the Instructional support domain, only the Quality of feedback dimension showed a significant difference, with higher mean scores in the face-to-face context. This suggests that online teaching may have some limitations in providing effective feedback to students: This finding is consistent with the literature. In this regard, Alawamleh and colleagues (2020) suggest that online teaching is associated with lower quality feedback and deterioration of communicative interactions.

Examination of the correlations between the dimensions of CLASS and student age reveals that age is significantly associated with different dimensions of student-teacher quality of interaction in the two studied educational settings: The negative correlation between teacher sensitivity and age in face-to-face classes suggests that teachers are less responsive to learners' needs in face-to-face classes with older students. This finding could be due to higher expectations of autonomy for older learners in a context such as face-to-face instruction to which they have long been accustomed. Teacher sensitivity in the elementary school context has been studied most frequently in the literature in relation to learners with special education needs (Koenen et al., 2019) and less frequently in relation to learner age. In relation to the area of classroom organization, a negative correlation between productivity and age is observed in the online context: As students age, less organization of activities and routines by teachers is observed. This result confirms what has already been highlighted in the literature in general in relation to the difficulties associated with online learning and deepens the phenomenon in relation to the age of the students (a factor that, however, has been less studied by the research). In the area of Instructional support, a positive correlation is found between concept development and age in the face-to-face context: The older students are, the more they can benefit from the subdimensions of instructional support in the face-to-face context. Finally, a positive correlation is found between language modelling and age in the online context: This result confirms our hypothesis regarding the language modelling dimension of the instructional support domain and shows that as learners age; teachers are more likely to facilitate and promote learners' language formats in the online learning context.

The findings indicate that age-appropriate inclusion of teaching practices in digital environments is warranted. As younger elementary-aged students can draw on school

experiences that require minimal autonomy and attention control, they would benefit from synchronous online learning that includes regular teacher check-in points for teacher-directed learning experiences that last a maximum of 20 minutes each, with significantly smaller stretches where cues or visual aids are used to guide attention (Acer & Yilmaz, 2020; Koivunoro et al., 2021).

Also, structuring the routine and providing guidance (e.g., shared tasks with the whole class) create opportunities to provide a supportive structure consistent with their prior skills and knowledge. For older elementary-aged students, break room discussions with 3–4 classmates are a good strategy to replicate classroom interaction and collaboration on a shared digital platform. More asynchronous lessons that allow for more flexible scheduling would also encourage their independence and autonomy in the learning process. With increasing autonomy and independence, primary school teachers need to recognize this trend and provide space for choice in task completion and increasing attempts at self-regulation (Sureyya, 2010). Overall, the findings presented in this study have improved teaching effectiveness and knowledge acquisition skills at all grade levels.

The implications of the findings are important for practitioners and educational researchers. In practice, teachers should pay particular attention to developing meaningful relationships with their learners in online learning contexts and translating these findings into explicit learning feedback.

The results also highlight the need to explore how the online space affects different factors that are features of online interaction between teachers and learners. Although the results of this study revealed relationships between knowledge acquisition skills and online teaching strategies, some markers overlap with the existing literature on teaching and learning in face-to-face environments. Supported by the results of this study and the literature, several suggestions can enhance online learning experiences in elementary classrooms.

The use of structured routines and visual schedules not only reduces cognitive load but also creates predictability in online learning experiences, which enhances learning for young learners who are more accustomed to structured environments in face-to-face learning (Hirsh-Pasek et al., 2020). The inclusion of interactive resources such as polls, shared whiteboards or quizzes encourages learner engagement and motivation in online learning contexts (Wang, 2015). To create and maintain an emotional connection with students, the teacher is encouraged to use student' names, provide feedback through digital means that are personalized by the teacher, and include brief informal moments for sharing personal connections, as all of these help to foster students' sense of belonging and emotional engagement in their learning process (Singh et al., 2022).

Ultimately, the use of multimodal instructional materials (text, video, images, etc.) supports better understanding and accommodates different cognitive and learning styles by providing access to visually engaging and diverse online resources and strategies within their learning process (Moreno & Mayer, 2007). As this study serves to enrich the examples of online and face-to-face interactions in an Italian educational context, future studies are important to replicate this study to better understand instructional practices in other educational contexts representative of non-Western or underrepresented cultural contexts. Cross-cultural comparisons could be used to determine which aspects of teacher-student

interaction are influenced by the contextual content of the pedagogy, as opposed to the commonalities that exist between the two modalities. This type of research will allow for additional generalizability and applicability of results to educational systems consistent with this study.

This study aims to investigate the role of self-regulation in the relationship between adaptability and engagement of elementary school students in online mathematics learning. The findings answered the research questions: (1) How does adaptability predict self-regulation? (2) How does self-regulation predict student engagement? (3) How does adaptability predict student engagement either directly or through the mediation of self-regulation? We also examined whether the covariate variables, namely gender, age, and education levels of the mother and father, influence self-regulation and student engagement. In addition, this study also validated the instruments that we had adapted according to the context of the study.

The findings of research question one demonstrate that adaptability significantly influences self-regulation, including intrinsic and extrinsic regulation factors. This aligns with several researchers who state that adaptability is part of self-regulation (Holliman et al., 2018; Martin et al., 2013), specifically related to coping with situational uncertainty and novelty. Thus, adaptability is useful for monitoring, directing, and managing thinking and behavior to lead to the goals to be achieved in diverse situations (Martin et al., 2013). This finding is further supported by Xu's (2022) research on the adaptation of online learning to students' self-regulation during the COVID-19 period. Xu (2022) emphasizes the importance of self-regulation in managing emotions, behaviors, and thoughts, highlighting that the shift to online learning necessitates a quick adaptation to self-regulation, particularly for students accustomed to traditional classroom settings.

## **Conclusion**

The study highlighted the benefits of online instruction, including a more positive classroom climate, improved behavior management, and greater use of classroom learning formats. These findings suggest that the virtual learning environment can provide opportunities to promote a conducive and engaging learning atmosphere. On the other hand, face-to-face instruction showed strengths in terms of teacher sensitivity and quality of feedback. This underscores the importance of face-to-face interactions and tailored feedback in traditional classroom settings.

Correlations between subdimensions of CLASS and student age provided valuable insights into the dynamics of teacher-student interactions. The negative correlation between teacher sensitivity and age in face-to-face instruction suggests potential challenges in meeting the needs of older students. In addition, the negative correlation between productivity and age in the online context raises concerns about maintaining organizational aspects as students age.

On this basis, a number of recommendations emerge. First, online teachers should consider how to build meaningful and supportive relationships with their students while using various digital tools. It is important to experiment with different feedback strategies while

engaging students in learning outcomes through the effective use of digital tools.

Second, attention must be paid to the age gap in the design of online teaching practices, as well as the way in which senior students receive support by providing them with an appropriate level of decompression and organizational structure.

Third, further research is needed to investigate the relationship between different student characteristics (e.g., digital literacy, socio-economic situation) and the nature and quality of online interaction between teachers and students, as well as teachers' online teaching skills and their relationship with the quality of online interaction between teachers and student.

Fourth, research should be conducted to evaluate the reliability and validity of certain tools, including CLASS, to assess their use in different digital learning contexts in order to demonstrate the quality of mapping (i.e., to see the impact of online interactions compared to more traditional forms of interaction).

Fifth, there is a need for more comprehensive studies that examine the nature of online interactions in a range of educational systems and countries. Interactions can be examined by comparing one practice to another, taking into account the unique contextual variables that affect technology, socialization, pedagogy, and teacher training (e.g., computers and other technologies, including other strategies to support learning) that may have influenced or collectively changed the effectiveness of online teaching. These studies would improve the generalizability of findings and help to generate policy insights across a range of contexts.

In summary, this study provides valuable insights into the benefits and limitations of online instruction in the elementary school context. By understanding the nuances of teacher-student interactions in virtual environments, teachers can adapt instructional strategies to maximize student engagement and promote positive learning outcomes. Continued research in this area is essential to further improve the effectiveness of online instruction and advance educational practice in the digital age.

### ***Limitations***

This study compares the effects of online learning and face-to-face learning on the quality of student-teacher interactions in elementary school and presents original findings on this research question.

Previous research and this study have shown that CLASS (Pianta et al., 2008) is a viable tool to examine the constructs of the study; however, online learning environments are wild and have a high degree of heterogeneity in the way they are organized and delivered compared to traditional, face-to-face teaching. There are only a very small number of studies that have used CLASS as an observational tool to study interactions in online learning environments. Future studies should continue to investigate validity and reliability studies in other formats and contexts.

Furthermore, relying solely on direct observations does not adequately capture how participants experience and make sense of their lives. Future research might consider a mixed methods approach, where observational data is supplemented with qualitative data (i.e., interviews, focus groups, or participant self-report) to capitalize on the complex ecology of interactions that individuals embody in a classroom context.

The context of the COVID-19 pandemic should also be considered as an episodic context or a unique moment with unique conditions that influence the overall results. Although the sample was exclusively Italian schools and the transferability of the results is therefore questionable and influenced by COVID-19, the rapid and frenetic digital transformation meant that the online experiences introduced during the pandemic may have both adaptive and disruptive aspects for the quality of teaching. There were also contextual subtexts that were not systematically measured, such as equitable access to digital resources, differences in teachers' ICT skills, and differences in school infrastructure, all of which may contain important elements that influenced the quality of interactions as study variables. These potential influences should be reported and systematically evaluated in future studies to gain a greater understanding of contextual influences on teaching quality

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