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Long-term intervention of at-risk elementary students' socio-motivational and reading comprehension competencies: Video-based case studies of emotional support in teacher–dyad and dyadic interactions

Anne-Elina Salo [a,*], Marja Vauras [a], Maiju Hiltunen [a], Anu Kajamies [a,b]

[a] Department of Teacher Education, University of Turku, 20014 Turku, Finland
[b] Turku Institute for Advanced Studies, TIAS, University of Turku, Finland

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ABSTRACT

The intertwining of peer and teacher emotional support patterns for enhancing at-risk students' multi-perspective academic competencies remains scarcely mapped. The multi-level analysis in the present study uncovers emotional support trajectories within teacher–dyad and dyadic interaction contexts among at-risk elementary students over a three-semester computer-supported intervention. A cluster analysis was conducted for all students (n = 318), where most intervention students had cumulated risks in socio-motivational and reading competencies. The time spent by 12 dyads within the two interaction contexts was analyzed from a vast amount of video data. The results suggested that simply allocating support time may be insufficient and its quality should be scrutinized. An in-depth video analysis of four dyads, illustrated with interaction excerpts and summary figures, indicated that teachers differed in their ability to calibrate their emotional support dynamically. The dyadic interactions of at-risk students were mostly on-task and neutral or positive. The intertwining of teacher–dyad and dyadic emotional support indicated that mechanisms positively contributed to enhancing multi-perspective academic competencies, although some risks were noted. Acknowledging the emotional states of others and successfully regulating one's own emotions were critical. Thus, infusing support for emotional competence and regulation strategies into both teacher and basic education is recommended.

1. Introduction

Research has established that emotionally supportive teacher and peer interactions are associated with positive outcomes in social competence, academic achievement, and engagement (Curby et al., 2013; Luckner & Pianta, 2011; Pakarinen et al., 2014, 2020; Rudasill et al., 2010; Ruzek et al., 2016). In this study, emotional support is defined through positive emotional tone of teacher–student and peer interactions, paucity of negativity in these interactions, teacher's sensitivity to students' individual needs and emphasis on students' interests and perspectives in learning (Hamre et al., 2013). It is suggested that at-risk students particularly benefit from consistent and strong emotional support (Hamre & Pianta, 2005). However, most previous studies have been conducted at the classroom level, as process measures of emotional support typically guide in observing the "experience of a typical or average student

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* Corresponding author.
  E-mail address: anne-elina.salo@utu.fi (A.-E. Salo).

in the class" (e.g., CLASS, Pianta et al., 2008, p. 10). However, a teacher's ability to establish supportive relationships with the whole class may not always reflect equally positive interactions with individual students, and the reverse is also true. Accordingly, a distinction should be made between general and student-specific teacher support (Hendrickx et al., 2016).

The school context consists of multiple social microsystems or sets of individuals (e.g., teacher–student and peer dyads) who share unique interactions (Bronfenbrenner & Morris, 2006). Focusing on peer–peer interactions along with teacher–student ones can be especially important among late elementary students, as Wentzel et al. (2016) suggested that peers within this age group play a central role in creating classroom climates that either promote or endanger learning. However, most studies have prioritized teacher behavior when assessing emotional support interactions. Hendrickx et al. (2016) suggested that researchers should focus on the reciprocal and ongoing interactions (and roles) of both teacher support and peer interactions more thoroughly, which would provide a better understanding of their intertwined nature. This study contributes by observing the concurrently evolving emotional support trajectories in teacher–dyad (i.e., teacher with two at-risk students) and dyadic peer (i.e., two at-risk students) interaction contexts.

Collaboration with peers can be challenging for any student, and little is known about what characterizes the emotional quality of collaboration between students with socio-motivational vulnerabilities and reading difficulties. The present study contributes by providing new understanding for what characterizes the dyadic emotional interactions of at-risk students in collaborative learning, and what is the nature of teacher support in these situations. This study is contextualized in a three-semester intervention that was developed to promote at-risk elementary school students' socio-motivational and reading comprehension competencies. The unique contribution of this study is the provision of novel and manifold insights into at-risk students' development of competencies across the intervention through following up on how teacher–dyad and peer dyadic emotional interactions evolve in real time across the intervention. To the best of our knowledge, there is a lack of this type of longitudinal observation study for at-risk students, especially one that acknowledges the intertwined and dynamic quality of both teacher–dyad and dyadic peer emotional support trajectories (particularly over a long period of time).

1.1. Emotional support in teacher and peer interactions

According to Hendrickx et al. (2016), teachers and peers form a dynamic system in which they mutually influence each other. Furthermore, Goetz et al. (2013) suggested that teaching can elicit specific emotions in students, and that students' emotions, similarly, can influence teaching. Moreover, student characteristics (such as disruptive or externalizing behavior), may affect the teacher's ability to promote positive relationships and be emotionally supportive (Farmer et al., 2011; Hoglund et al., 2015). Here, high-quality emotional support from teachers can alleviate any tensions, as this is related to teacher-reported relationships that are closer and with fewer conflicts (Hamre et al., 2008).

Teachers tend to provide more support to students who struggle with learning. However, this support does not always lead to better learning outcomes, suggesting that the quality of support should be scrutinized (Silinskas et al., 2016). More specifically, the study by Silinskas et al. (2016) indicated that increased support time does not necessarily guarantee positive progress in elementary students' reading skills. Students who did not benefit from increased teacher support exhibited higher levels of externalizing behavior. Moreover, teachers reported higher levels of negative affect and stress when supporting them compared to students whose reading skills developed faster. Silinskas et al. (2016) suggested that the presence of negativity in teacher–student interactions can be interpreted by students as a lack of closeness and mistrust in their competence, endangering the basic psychological needs for competence, relatedness, and autonomy (Ryan & Deci, 2000). Emotional support, especially, is expected to contribute to the fulfilment of these needs, which are crucial for motivated and deeper learning (Pakarinen et al., 2014; Turner et al., 2014). Accordingly, emotionally supportive teachers are described as being sensitive to students' needs and providing appropriate levels of autonomy. In addition, they strive to minimize negative experiences, help students develop warm and supportive relationships with others, and experience enjoyment and excitement about learning (Hamre & Pianta, 2005; Pianta et al., 2008).

Although reciprocal interactions shared by individuals within a context are seen as key determinants in producing development (Bronfenbrenner & Morris, 2006), intervention studies have often afforded insufficient attention to the interactive nature of interventions. Related factors might be important in understanding students' differential responsiveness (Stichter et al., 2019). Overall, peer collaboration is promising when embedded in well-designed learning contexts (Stichter et al., 2019), and peers can play a crucial role in promoting learning and engagement (Wentzel & Watkins, 2002). However, in complex and dynamic learning interactions, negative comparisons may outweigh peers as a source of support. For example, they may lower students' self-competence beliefs, increasing the tendency toward negative affect and withdrawal behavior (Jacobs et al., 2002; Madill et al., 2014). Teachers are expected to play an important role in modelling positive learning interactions and in supporting collaboration with peers, harnessing the potential of peers to promote positive learning outcomes (Hendrickx et al., 2016; Ruzek et al., 2016).

Research that examines emotional support trajectories in both teacher–dyad and dyadic peer interaction contexts remains scarce. However, there clearly is a recognized need for understanding how teachers identify students' individual and collective (i.e., dyadic in the present study) social and academic needs (Madill et al., 2014). The present study examines emotional support trajectories within both teacher–dyad and dyadic peer interaction contexts separately and as concurrently evolving, which enables discussing whether the emotional support trajectories indicate similar patterns or whether they are different (and in what way). The adaptive calibration of support is challenging for teachers (Kajamies, 2017; Turner et al., 2014). Observing the trajectories of emotional support across time is important, as this can reveal whether the teacher learns to calibrate emotional support according to students' evolving needs. It is equally important to examine how the evolving quality of peer interactions between at-risk students supports (or hinders) the potentials of collaboration in promoting students' development of multi-perspective competencies (Garte, 2020).

1.2. Cumulative and dynamic nature of socio-motivational vulnerabilities and reading difficulties

In the present study, multi-perspective and dynamic approaches were applied to academic risks by focusing on students' initial socio-motivational vulnerabilities and reading difficulties, as well as the development of these competencies across the intervention. Socio-motivational risks are approached through vulnerabilities in prosocial behavior and task orientation, which reflect interpersonal competencies and motivational tendencies and constitute a crucial part of successful collaboration (Garte, 2020; Järvelä et al., 2010; Nolen & Ward, 2008). *Prosocial behavior* refers to the ability of students to coordinate (and control) actions and emotions in socially appropriate ways within different contexts (Junttila et al., 2006). Dunfield (2014) suggested the following categories for prosocial behavior: helping (e.g., assisting in a difficult task), sharing (e.g., borrowing a pencil), and comforting (e.g., consoling a peer who has failed). According to Dirks et al. (2018), the ability of children to recognize and respond to three distinct negative states (instrumental needs, unmet material desires, and emotional stress) is especially crucial in understanding prosocial behavior with peers. Garte (2020) goes one step further, suggesting that social competence should be interpreted as collaborative competence, which is framed by shared goals when peers collaborate with each other. Thus, Garte's (2020) perspective highlights intersubjectivity and collaborative complexity, the contextual nature of social competence, and the multidirectional nature of relationships between the environment and students' focus on interpersonal dynamics.

Task orientation refers to persistence in approaching learning tasks, with the goal of understanding them without being discouraged by challenges (Laitinen et al., 2017; for original conceptualizations, see Diener & Dweck, 1978). Task orientation reflects both the emotional attunement to learning and how to cope with learning demands. This highlights the need to see motivational tendencies as essentially interactionist and dynamic, fluctuating across situations and contexts (Vauras et al., 2009). Järvelä et al. (2010) summarized that motivation should be understood as "an individual psychological concept embedded within the social, shared and interactive processes of learning" (p. 24). The concepts of task orientation and intrinsic motivation both carry positive valence regarding the task, either through the desire to engage in efforts to understand it or through experiencing the task itself as rewarding (Murphy & Alexander, 2000).

Cognitive risk factors are approached through difficulties in decoding and reading comprehension. *Decoding skills* refer to the ability to recognize words and read fluently and accurately, which are necessary (to a certain extent) for developing *reading comprehension skills* (Psyridou et al., 2020). These skills require the coordination of cognitive, language, social, and text-specific processes, and the use of beneficial reading strategies (Sparapani et al., 2018). Psyridou et al. (2020) emphasized that the assessment of reading skills should include both reading fluency and comprehension. Even though these skills are related, they can each cause distinct difficulties. Learning in schools greatly depends on students' reading competency, and as students grow older so does the complexity of content, setting heightened demands for reading comprehension. Therefore, individualized, and sensitive scaffolding in reading comprehension throughout the school years is highly crucial to provide at-risk students with opportunities to succeed in school (Gilmour et al., 2019; Haber et al., 2016; Vauras, 1991).

Socio-motivational and cognitive risks can easily result in the further broadening of achievement gaps between at-risk students and their peers, especially if the risks are intertwined and accumulated (Vauras et al., 2009). For instance, motivational vulnerabilities and difficulties in reading can become intertwined, and a divergence of developmental paths in reading comprehension skills can lead to increased motivational and cognitive challenges (Lepola et al., 2016). A recent study by Liebfreund (2021) involving fourth and fifth grade students suggested that intrinsic motivation (consisting of involvement and curiosity) is a significant predictor of reading comprehension. Thus, promoting students' adaptive achievement behaviors and intrinsic motivation is crucial when aiming to improve their reading comprehension skills. In addition, Sparapani et al. (2018) suggested that perspective-taking (which is important for comprehending texts and being able to accept or disagree with others' ideas) might be crucial for successful participation in peer discussions and for developing higher-level reading comprehension skills, particularly in later elementary years. Overall, studies have suggested that perspective taking is probably easier for students with strong social skills (Sparapani et al., 2018), whereas students with difficulties in perspective taking risk facing cumulating difficulties, especially when interacting with others (Dirks et al., 2018; Dunfield, 2014).

1.3. Aims and research questions

The aim of this longitudinal intervention study is to explore the quality of evolving emotional support trajectories within a sample of academically at-risk peer dyads in both teacher–dyad and dyadic peer interaction contexts. This study addresses two main research questions:

RQ1. What characterizes *teacher–dyad* and *task-related dyadic peer emotional support trajectories*?
RQ2. How is at-risk students' *development of socio-motivational and reading competencies* embedded in the concurrently evolving teacher–dyad and peer dyadic emotional support trajectories?

There is a lack of prior evidence of teacher emotional support patterns and their fluctuation over a long period of time in small group interventions with diverse at-risk students. This holds even stronger for peer support patterns, given the scarce amount of research on how peer support contributes to the quality of learning interactions (Wentzel et al., 2018). As the aim of the present study is to systematically explore the interrelated pathways through which teachers and peers support learning, no specific expectations could be made concerning the embeddedness of students' development of competencies within the concurrently evolving teacher–dyad and dyadic peer emotional support trajectories. Prior research has offered the basis for a general expectation that consistent high-

quality emotional support from teachers would have a positive effect on student development (Pakarinen et al., 2020; Rudasill et al., 2010; Ruzek et al., 2016). However, there is no empirical foundation for expectations for interrelated teacher and peer emotional support for the development of at-risk students' competencies. Therefore, the present study is expected to contribute to an increased understanding of long-term interaction pathways and their significance by providing manifold insights into at-risk students' development of competencies. In addition, these insights will increase the understanding of the role of teacher and peer emotional support in the enhancement of demanding competencies, such as socio-motivational and reading comprehension.

2. Methods

2.1. Participants

The participating students (N = 318; girls 47.3%, boys 52.7%) were from six mainstream elementary schools from one medium sized city and surrounding rural communities in Finland. The students were fourth graders (approximately 10 years old) at the beginning of this longitudinal study. Initially, 40 at-risk students (girls 40%, boys 60%) were selected for a three-semester (i.e., total period of over 1.5 years) intervention, which on average constituted 78 lessons. The selection criteria were based primarily on reading comprehension and decoding skills, and secondarily on teacher assessments of students' social competence and motivational orientation. One voluntary special needs teacher from each school, who was genuinely interested in expanding their professional expertise in supporting at-risk students, carried out the interventions. In total, 12 dyads were observed that had remained the same throughout the intervention (with regard to the time they spent in teacher–dyad and dyadic interaction contexts across the intervention). This ensured that any possible effect of the quantity of teacher and dyadic support time was controlled.

To examine teacher–dyad emotional interactions and the emotional quality of student dyadic task-related interactions, four student dyads (n = 8; 4 girls, 4 boys) were chosen for fine-grained interaction analyses. The main criterion for selection was that the dyads would represent different degrees of socio-motivational vulnerability. Initially, three female special needs teachers carried out the intervention with these student groups. As the intervention was realized in an authentic school context over a long period, there were some inevitable changes, and one teacher handed over her other group to a new teacher after the 1st intervention phase (due to workload reasons).

All participation in the research was voluntary. Signed consent forms that confirmed the willingness to participate and allowed the use of video data from intervention activities for research purposes were collected from legal guardians and intervention teachers. The participants were informed why they were participating in the research and what data would be used for research purposes, and they were informed that they could withdraw during any phase of the research. In addition, members of the research group confidentially processed the video material, pseudonyms were adopted for the intervention students, and all material was stored according to the regulations. Finally, ethical principles were followed stringently and in accordance with national ethical guidelines (https://tenk.fi/en).

2.2. Measurement instruments

Students' socio-motivational and reading competencies were assessed before and after the intervention. The classroom teachers assessed the students' typical classroom behavior (prosocial behavior and task orientation) and administered decoding and reading comprehension tests during regular school lessons. Descriptive statistics for the variables are presented in Table 1.

Prosocial behavior was measured with the validated *Multisource Assessment of Children's Social Competence Scale* (MASCS) (Junttila et al., 2006). The focus here is on prosocial behavior, comprising the sub-dimensions of cooperation skills (e.g., "Effectively participates in group activities") and empathy (e.g., "Is sensitive to the feelings of others"), as this is crucial for successful peer collaboration (Dunfield, 2014; Garte, 2020). Co-operation skills signal a child's ability to compromise and accept the ideas of others in social contexts (Sparapani et al., 2018), whereas empathy is the ability to identify and respond sensitively to the experiences and behaviors of others (Schipper & Petermann, 2013). A Likert scale ranging from 1 (*never*) to 4 (*very often*) was applied, and an average score for prosocial

Table 1
Descriptive statistics over measurement points.

	Socio-motivational competencies (N = 292)		Reading competencies (N = 307)	
	Prosocial behavior[a,c]	Task orientation[a,b]	Decoding skills[a,b]	Reading comprehension[a,b]
Mean	2.90/2.90	3.23/3.37	107/164	0.43/0.49
Standard deviation	0.60/0.58	0.86/0.91	31.98/36.18	0.19/0.16
Skewness	−0.01/−0.12	0.00/−0.24	0.16/−0.34	0.15/−0.21
Kurtosis	−0.62/−0.62	−0.60/−0.60	−0.12/−0.62	−0.69/−0.34
Cronbach's alpha	0.92/0.91	0.90/0.91	NA	0.65/0.71

Note. Prosocial behavior was assessed at the delayed test instead of the post-test; that is, six months after intervention. This was adopted so as not to overtax classroom teachers with all measurements at one point.
[a] Pre-test.
[b] Post-test.
[c] Delayed test.

behavior was counted based on the five items for co-operation skills and three items for empathy.

Task orientation was assessed using the *Motivational Orientation and Coping Scale for Children*, which is based on a theoretical model developed in the context of long-term research on learning difficulties (e.g., Vauras et al., 2009) as later validated by Kajamies (2017). The focus here is on task orientation, as it reflects the positive valence for engaging in tasks (Lehtinen et al., 1995; Vauras et al., 2009) and student tendencies to react when facing difficulties, meaning that the student exhibits persistency and the desire to solve the task at hand instead of giving up (Lepola et al., 2016). An average score for task orientation was derived based on eight statements (e.g., "Strives for independent problem solving"), with a Likert scale ranging from 1 (*never*) to 5 (*very often*).

Decoding skills were tested using the Finnish Standardized Reading Test ALLU (*Comprehensive School Reading Test*; Lindeman, 1998). In this test, students were asked to separate words from chains within a limited period (2 min). Researchers scored the tests based on the number of correct words, indicating how many words students successfully separated from chains (maximum 214 words).

Reading comprehension skills were assessed through two texts related to environmental protection: *deteriorating air* and *emptying sea*. Students answered questions on the main concept and completed a cloze test related to the entire text. The tasks were coded by the researchers based on the depth of student understanding and their inference-making skills. A sum score indicating the proportion of correct answers in both tasks was used, where 1.0 was the maximum (indicating 100% of the answers were correct).

2.3. Identification of socio-motivational and reading profiles

The described measures were used to identify *socio-motivational and reading profiles* through K-means cluster analysis to provide a description of the multivariate nature of the selected intervention students' individual competencies prior to the intervention (Fig. 1).
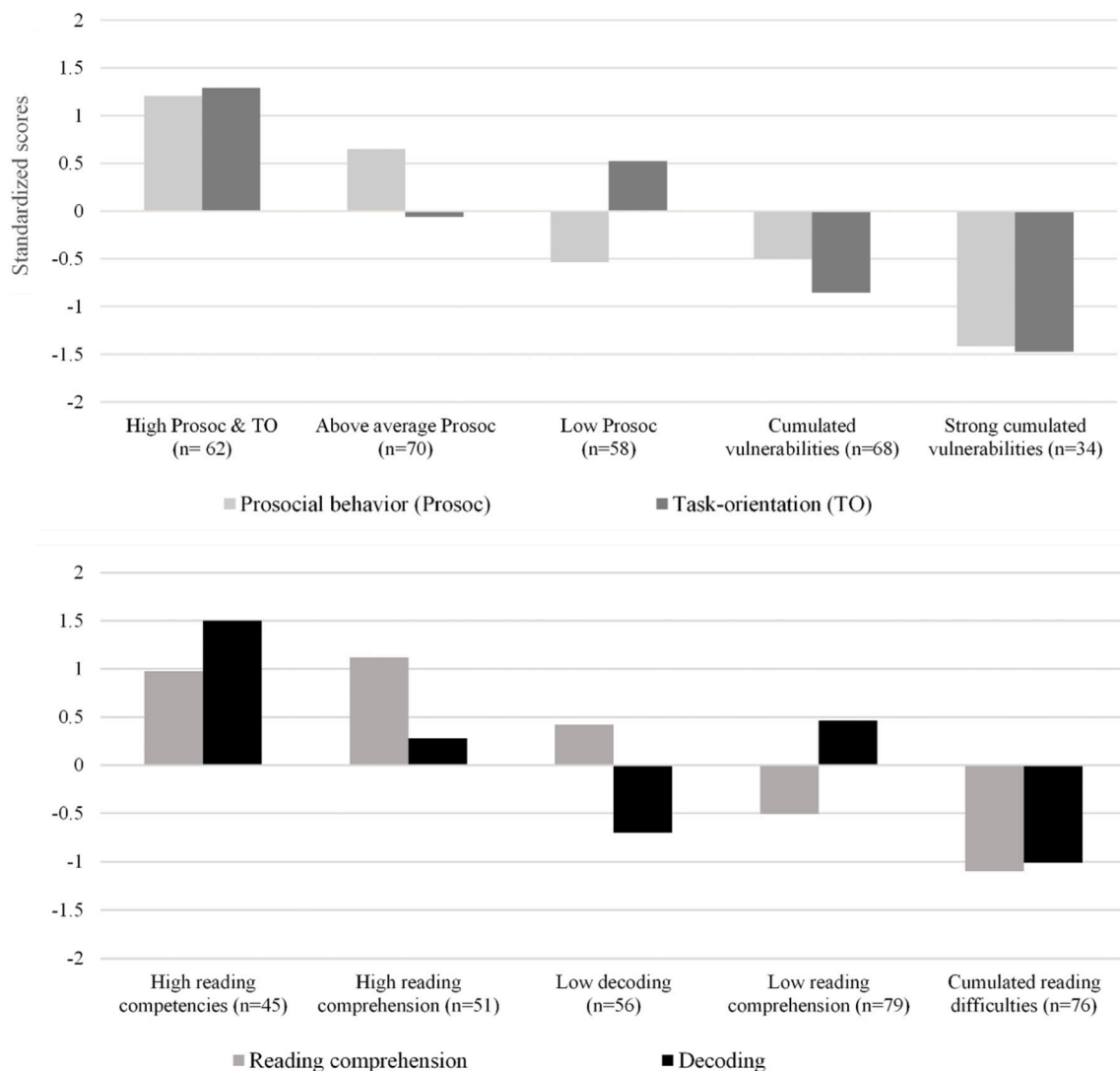

Fig. 1. Students' socio-motivational (N = 292) and reading profiles (N = 307).

The five-cluster solutions proved to be optimum pedagogically, as they also identified students with discrepant profiles: vulnerabilities on either prosocial or task orientation only and difficulties in either decoding or comprehension skills (Psyridou et al., 2020). Most intervention students (n = 24) had socio-motivational vulnerability, with three-fourths belonging to the cumulated (or strong cumulated) vulnerability profiles (n = 18; 75%) and remaining one-fourth to the two more competent profiles (n = 6; 25%). All intervention students (n = 24) had reading difficulties, with most belonging to the cumulated reading difficulties profile (n = 16; 67%) and the remainder to the discrepant profiles (only comprehension difficulties 25%; only decoding difficulties 8%).

The socio-motivational and reading profiles of the four dyads chosen for in-depth analysis (Table 2) indicated that the most pronounced cumulated risks characterized both boy dyads (2 and 4). By comparison, girl dyad 3 had strengths in prosocial behavior (despite cumulated reading difficulties), while Alisa (dyad 1) did not have decoding difficulties.

2.4. Intervention and video data collection

The learning environment was designed around a three-module computer-supported learning environment, SANTTU with Mates (Vauras & Kinnunen, 2009). Each module comprises 18–22 lessons and corresponds to the three phases of intervention in the Results section. To improve student engagement, each module was built around youth mystery books (Vauras, 2003, 2008, 2009) with in-built tasks specific to the theme of the module. Narratives were used, as they have emerged as being effective when contextualizing learning and can provide an engaging, story-centric learning environment offering guided learning and opportunities for problem solving (Shores et al., 2009).

In the first module, the core focus was on teaching and practicing text comprehension skills, such as identifying main ideas, integrating meaning, monitoring comprehension, and summarizing. In addition to continuing to build on these skills, the second module further focused on the regulation of cognition, affect, and social behavior, while the third module focused on emotion regulation and learning-related social skills. The complete software package included books, specific detached tasks (e.g., short detective problems), and help and feedback features (e.g., a within-book word explanation feature and task assessment). Further, it was explicitly designed to engage students in reading, guide them in reading comprehension, and strengthen their vocabulary and content knowledge, self- and co-regulation skills, and feelings of autonomy and competence.

The teachers carried out the intervention in one lesson a week (45 min) with groups of four students. These groupings were chosen because students with cognitive difficulties and socio-motivational vulnerabilities can be more optimally scaffolded in small groups (Van de Pol & Elbers, 2013). Although the intervention took place during school hours in small groups, the students worked as dyads within the SANTTU learning environment. This dyadic cooperation was complemented by face-to-face transactional whole-group discussions and practices. Teacher scaffolding and support were given either to the whole group or to one dyad at a time. The teacher guides, all materials, and a professional development program (with discussions on the video footage of intervention interactions) were provided to the teachers to help them optimize their support. Readers are directed to Kang and van Es (2019) for an explanation of the use of this method.

2.5. Analysis of teacher–dyad and dyadic peer interactions

The teachers were asked to video-record every third intervention lesson. The total number of recorded lessons ranged between 18 and 41 (M = 26) per dyad, as some teachers recorded more lessons than required. The teachers positioned one video camera on a tripod close to each dyad to ensure that all their interactions could be clearly observed. To avoid disturbing the interactions any more than necessary, the teachers were asked to start and stop the recordings at the beginning and end of each lesson, respectively. All verbal and relevant nonverbal communication of students and teachers were systematically analyzed from the videos using Observer XT software (Noldus, 2017). The coding steps and categories are presented in Fig. 2. In line with the situative framework (Nolen & Ward, 2008; Turner & Nolen, 2015), the present study grasps multiple layers of the focus and combines understanding of the emotional quality of interaction processes in both teacher–dyad and dyadic contexts.

2.5.1. Step 1. Interaction contexts

The first step was to narrow down the total video data of the 12 dyads (167 h 21 min) by identifying episodes that took place in the following interaction contexts: (1) *teacher–dyad interactions*, characterized by the teacher's clear presence with the dyad (e.g., talking to or standing behind them and observing their work) and (2) *dyadic peer interactions*, characterized by dyadic peer time (without help,

Table 2
Socio-motivational and reading profiles of the four selected dyads.

| Dyads	Students	Socio-motivational vulnerability	Reading difficulties
Dyad 1	Alisa	Cumulated vulnerabilities	Comprehension difficulties
	Maria	Cumulated vulnerabilities	Cumulated difficulties
Dyad 2	Mikael	Cumulated vulnerabilities	Cumulated difficulties
	Otto	Cumulated vulnerabilities	Cumulated difficulties
Dyad 3	Ella	Above average prosocial behavior	Cumulated difficulties
	Sofia	Above average prosocial behavior	Cumulated difficulties
Dyad 4	Niklas	Strong cumulated vulnerabilities	Decoding difficulties
	Leo	Strong cumulated vulnerabilities	Cumulated difficulties
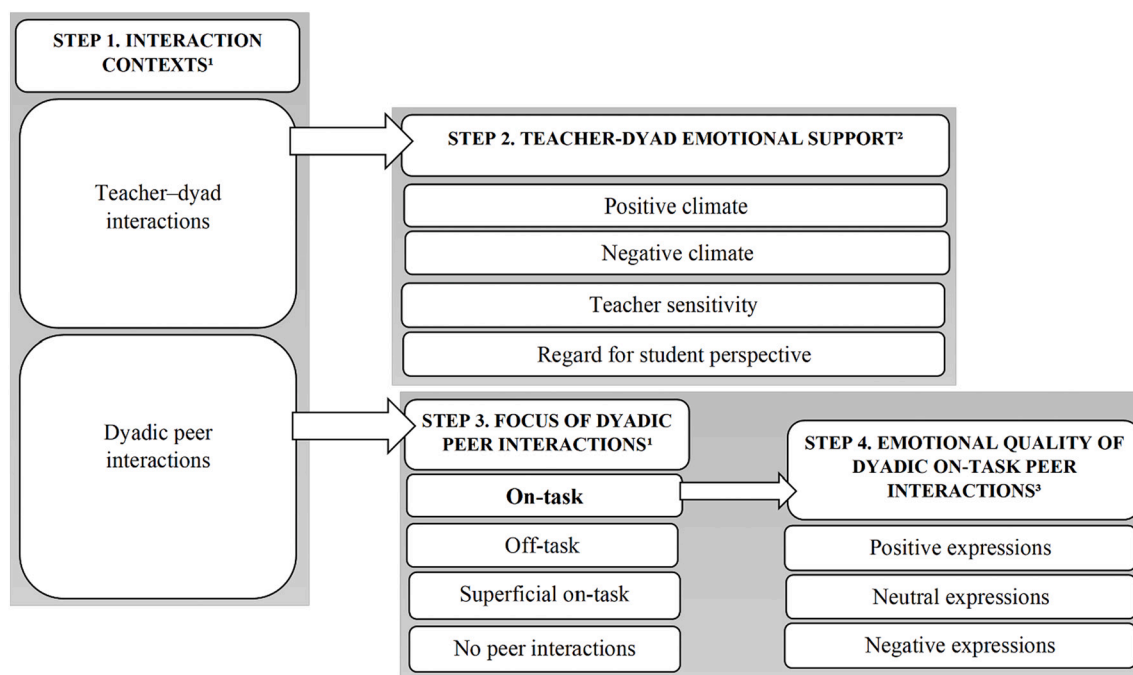
Fig. 2. The steps for the video analysis.
Note. [1]Episode level; [2]lesson level (i.e., entailing all relevant episodes during a lesson; CLASS K-3), [3]turn level.

close presence, or supervision by the teacher). These contexts were established through discussions between the first and third authors and were coded by the third author. For control purposes, all video footage that was identified within these two interaction contexts was used in the statistical analysis (total 129 h 58 min for the 12 dyads, ranging between 8 h 36 min and 13 h 2 min per dyad [M = 10 h 50 min]).

From this step onwards, only the four dyads chosen were targeted in the qualitative analyses. Further, the video data were limited to nine recorded lessons per dyad to enable fine-grained analysis of the evolving emotional quality of interactions in both contexts across the intervention. Three videos were selected randomly from each intervention phase (excluding the first or last due to their distinctive nature) for each dyad. Thus, 36 lessons were chosen for the consecutive in-depth analyses. The total length of teacher–dyad and dyadic peer interaction context episodes was 16 h 39 min, ranging between 3 h 43 min and 4 h 34 min [M = 4 h 10 min] per dyad.

2.5.2. Step 2. Teacher–dyad emotional support

An analysis of teacher–dyad emotional support was performed for all episodes identified in the context of teacher–dyad interactions (M = 10 min per lesson) using the CLASS K-3 Observation Tool. This tool primarily focuses on teacher behavior, although the average (or typical) behaviors and reactions of the students within the classroom are also included. Teacher's emotional interactions with the dyads were rated on the dimensions of *Positive Climate, Negative Climate, Teacher Sensitivity*, and *Regard for Student Perspective* on a seven-point scale (1–2 low, 3–5 middle, and 6–7 high range). Thus, the scores denoted the extent to which each dimension was characteristic of that lesson in terms of the range, frequency, intention, and tone of interpersonal and individual behavior in teacher–dyad interaction contexts (Pianta et al., 2008).

As a certified CLASS K-3 observer, the corresponding author coded all 36 videos. In addition, a researcher was acquainted with the use of the CLASS observation tool by the first author, who then independently coded 12 of the 36 videos. An intercoder agreement of 93.8% was reached, yielding a Cohen's kappa of 0.93. Through individual dimensions, 91.7% of inter-coder agreement was reached for positive climate (Cohen's kappa 0.79), 83.3% for negative climate (Cohen's kappa 0.71), and 100.0% for teacher sensitivity and regard for student perspectives (Cohen's kappa 1.0). This indicated substantial to perfect agreement (Landis & Koch, 1977), and any remaining minor discrepancies were resolved in discussions.

2.5.3. Step 3. Focus of dyadic peer interactions

For the root of subsequent analyses, a division into four episodes (with different foci) was conducted in the dyadic peer interaction context: (1) *on-task*, (2) *off-task*, (3) *superficial on-task*, and (4) *no peer interactions*. On rare occasions when students within the dyad differed, the code was based on the weakest focus. Thus, on-task episodes consisted only of interactions that were characterized by mutuality of on-task focus, such as students negotiating what to write down or discussing what happened in the story book. Off-task interactions consisted of talk that was irrelevant to the task (e.g., "*Can you whistle like this?*") and behavior such as fooling around. Interactions were coded as superficial on-task when students were seemingly performing the task (e.g., reading the text aloud by taking

turns) while simultaneously exhibiting off-task behavior. Hence, their attention was only partly on the task. When no verbal or nonverbal interaction occurred, the code "no peer interactions" was assigned (e.g., sitting next to each other or reading the book quietly).

2.5.4. Step 4. Emotional quality of dyadic on-task peer interactions

First, the students' observable verbal and nonverbal interactions were identified from all on-task episodes at the fine-grained turn level. Most nonverbal interactions (such as shared smiles or touches) occurred within the verbal turns, resulting in 6404 on-task turns for the 4 dyads across the 36 lessons (M = 178 turns per lesson per dyad). Then, the emotional quality of each turn was coded to capture the affective tone of the interactions, as follows: (1) *Positive*, (2) *Neutral*, and (3) *Negative* dyadic expressions (see positive and negative expressions in detail, Table 3). This type of fine-grained coding captured the potentially important transitory expressions of negativity and positivity, which remain undetectable in more comprehensive analyses. The coding system was strongly based on the existing research literature pertaining to emotionally supportive interactions (in general) and on socially competent, positive peer interactions (e.g., Dirks et al., 2018; Dunfield, 2014; Pianta et al., 2008) to strengthen and confirm data-driven interpretations. Neutral interactions lacked any clear signs of expressed positivity or negativity and consisted of task-related talk (such as making suggestions on what to write down) and functioned as defaults, meaning that all interactions were reflected through them. Positive expressions were presumed to signal (at least partly) any positive affective states, such as joy and excitement. Similarly, negative expressions were assumed to signify negative affective states, such as boredom, anxiety, or frustration. It is expected that these are reflected differently in the dyads' collaboration quality due to differences such as student regulation (Lobczowski et al., 2021).

The first author performed the coding for all on-task turns while simultaneously checking the agreement of the on-task episodes (as coded by the third author in the previous step). The third author then independently coded all turns for Niklas–Leo's videos and 25% of the turns for other dyads. Thus, a total of 2530 turns were independently coded by two researchers. Inter-coder agreement ranged from substantial (i.e., 0.61 to 0.80) to almost perfect (i.e., 0.81 to 1.0) (Landis & Koch, 1977). The results in more detail are as follows: Niklas–Leo 94.4% (Cohen's kappa 0.81), Ella–Sofia 96.8% (Cohen's kappa 0.78), Alisa–Maria 94.3% (Cohen's kappa 0.87), and Mikael–Otto 93.9% (Cohen's kappa 0.81). The few disagreements were resolved through discussions, and a conservative neutral code was applied, in case of any remaining discrepancies in between neutral and positive, or neutral and negative codes.

2.6. Statistical analysis of students' development of competencies across the intervention

A non-parametric Kruskal-Wallis test was applied to control whether the time spent in teacher–dyad and dyadic peer interaction contexts were differently distributed, based on the initial socio-motivational and reading profiles of all 12 student dyads. Furthermore, the possible effects of time spent in these interaction contexts were controlled for the development of task orientation, prosocial behavior, and reading competencies in *magnitude* within the whole sample (N = 318) (four categories of 25%: none or weak, slight, good, and strong).

3. Results

3.1. Emotional support trajectories in the teacher–dyad interaction context

The teacher–dyad emotional interaction trajectories differed greatly between the four dyads (Fig. 3). High emotional support in a positive climate, teacher sensitivity, and regard for student perspective were identified during some lessons for all except Ella–Sofia: For Alisa–Maria high range support fluctuated with middle range across the intervention, whereas Mikael–Otto mostly received high range emotional support except for temporary drop to middle range (lessons 5–7), and Niklas–Leo only received high range support during the 1st phase, subsequently decreasing to middle and even low range. Negative climate remained low for all except Niklas–Leo, for whom the teacher–dyad negative climate reached the middle range during several lessons after the 1st phase. In the next section,

Table 3
Coding scheme for observed positive and negative expressions during dyadic on-task interactions.

| Expressions	Descriptions	Example quotes
Positivity		
Encouraging	Providing positive feedback; expressing curiosity and joy.	"*You did a great job!*"
Emotional consideration	Supportive and caring reactions to needs and emotional states.	"*That's ok, it doesn't matter if it's not all correct.*"
Promoting collaboration	Positive gestures (smile, touch); "we"-talk.	"*We did it, we are so clever!*"
Humor/shared laughter	Having fun and laughing together.	"*It was funny when he [character in the book] fell in the water*"
Negativity		
Discouraging	Discouraging remarks; avoiding commitment to the task.	"*This is so boring.*"
Overruling	Rushing the other; telling what to do without agreeing.	"*Just do it already, what's taking you so long!*"
Low cohesion/trust	Lack of trust, commitment, and shared goals in collaboration.	"*I knew it from the beginning, but you wanted to do it like this.*" [annoyed]
Harsh language/ behaviors	Insulting or dismissive language; physically hurting the other.	"*Stupid! Don't you understand anything?*"
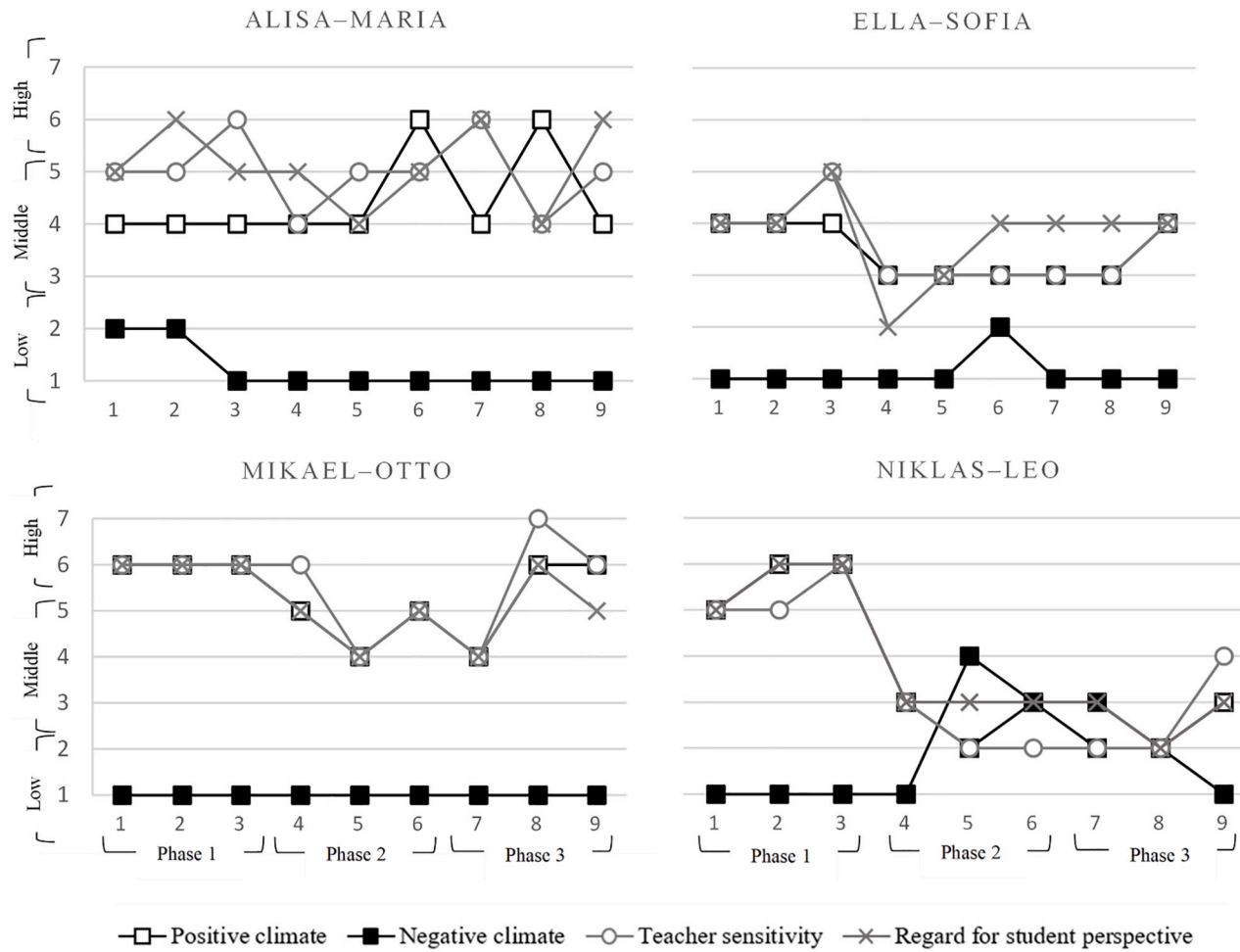
Fig. 3. Trajectories of teacher–dyad emotional interactions across the intervention.

these trajectories are discussed with qualitative excerpts.

Alisa–Maria's teacher–dyad interactions were characterized by the teacher's positivity, although this was combined with less positive dynamics of the girls. Positive climate remained at middle except for two lessons, during which the girls expressed shared enthusiasm and joy with their teacher. Their teacher frequently instigated social conversations and encouraged the girls, such as, "*I'm so glad that you were able to work on this, even though I know you were tired*". Any negativity between the girls was typically resolved quickly and disappeared completely after the 1st intervention phase. Overall, their teacher tried to balance between the girls' individual and dyadic needs, and her sensitivity fluctuated between high and middle. This was identified by differences in how proactively she acknowledged and addressed potential conflicts that the girls often had in negotiating. The teacher typically ensured that the girls had agreed about how to proceed with the task (at least at the beginning of lessons) through questions such as, "*Do you think you can continue from here on your own? Do you know what to do next?*" Regard for student perspectives also fluctuated between middle and high, depending on how actively the teacher allowed the girls freedom of choice in their ways of working. For example, she would let them select whether they preferred to use stickers or draw pictures of their own or ask them whether it was a good time to go through some questions together, instead of just interrupting their work.

Mikael–Otto's teacher clearly indicated that she enjoyed working with the boys, and the boys generally responded to this equally positively, except for the more superficial interactions in lessons 5–7. Overall, their interactions were characterized by shared enthusiasm and matched affect, with practically no signs of negativity. Especially in the 1st intervention phase (and during lessons 8 and 9), their teacher encouraged them in situations where they might usually have been discouraged by challenging tasks or experiences of failure. For instance, when the boys were worried about the low scores that they received from one task, their teacher said in a reassuring voice, "*But look, you have developed a lot from the start!*" In addition, the teacher actively ensured that the boys would have a chance to work as independently as possible, especially in the 1st and 3rd phases. For example, when the boys were writing a story and told the teacher that she could not look at it yet, the teacher smiled and said, "*Oh, I am not allowed to see it yet? — That is alright. I thought you were ready, but I can come back later. Just let me know when you are ready*." This indicated flexibility in listening to their wishes and respecting their work pace.

Ella–Sofia's first teacher expressed some joy when interacting with the dyad, although the emotional tone of the interactions was mostly flat. After the teacher was changed (2nd phase onwards), the new teacher was distant except for isolated moments of shared smiles and praise, such as, "*Well, that is a very good clue indeed.*" Despite this issue, the girls' responses to the teacher and each other remained positive, resulting overall in a middle range for positive climate. The negative climate remained low throughout the intervention, with only isolated teacher's sarcastic remarks (lesson 6). The new teacher sometimes struggled with her responses to the girls' individual and dyadic needs and was occasionally overly keen with respect to organizational matters. For example, she would advise the girls how to share their turns without being sensitive to the fact that they were already skillful in coordinating their collaborations. After the teacher was changed, regard for student perspective temporarily dropped to low, which was reflected in the repeated use of terms such as "*must*" and "*have to.*" However, regard for student perspective returned to the middle range as the intervention continued (characterized by less coercive talk), although genuine efforts to grant value to the girls' perspectives remained lacking.

Niklas–Leo's first teacher's frequent expressions of positivity and encouragement were replaced by the new teacher's characteristic perfunctory interactions with the boys (2nd phase onwards). The emotional interaction trajectory exhibited an overall radical downward change with respect to positive climate, sensitivity, and regard for student perspective, echoed by an upward change in negative climate. Except for isolated positive remarks (such as "*Good guesses*"), the new teacher seemed to have difficulty regulating her own negative affect. Her frustration with the boys, especially when they did not work in a way that she had hoped, resulted in
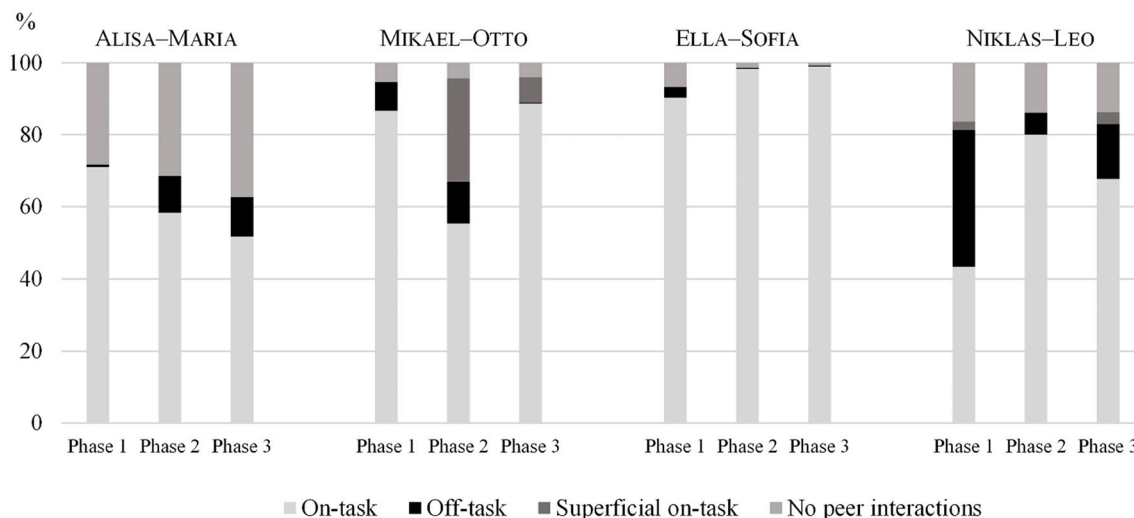

Fig. 4. Focus of dyadic peer interactions across the intervention.

rather continuous expressions of annoyance. Furthermore, mild forms of peer negativity were observed at times when the teacher was present, characterized by impatience and a lack of shared interest. It was typical that the teacher firmly reminded the boys to concentrate on their task with remarks such as "*You have to stay focused*" without determining whether they needed help. In addition, sometimes she reacted with a disrespectful tone when correcting the boys' mistakes. As in Ella–Sofia's case, it seemed that she adhered to her own agenda and teacher talk dominated when she was present, leading to rather low levels of regard for student perspective. For instance, when Niklas tried to explain to the teacher what the character in the book was doing, the teacher interrupted him, saying, "*Do not move there, you need to stay here!*". Accordingly, the teacher was more focused on how he was sitting than showing interest in what he was trying to say.

3.2. Trajectories of positivity and negativity in students' dyadic on-task interactions

The dyadic peer interactions indicated that there were different developmental profiles across the interventions for each dyad. This was based on the observed focus of dyadic interactions across the 1st (lessons 1–3), 2nd (lessons 4–6), and 3rd (lessons 7–9) intervention phases (Fig. 4). Ella–Sofia shared on-task interactions almost without exception (90.3%–99.0% from 1st to 3rd phase). Mikael–Otto shared a high number of on-task interactions during the 1st (86.7%) and 3rd (88.7%) phases, although their on-task interactions temporarily decreased during the 2nd phase (55.3%), indicated by the emergence of superficial on-task interactions. The on-task interactions of Alisa–Maria indicated a downward profile from 1st (71.0%) to 2nd (58.3%) and 3rd (51.7%) phases, combined with increasing periods of no peer interactions and some off-task interactions. It is important to note that no peer interactions, which the dyad had more frequently than any other observed dyad, were characterized by task-related quiet work side-by-side. Niklas–Leo started out with the highest number of off-task interactions (38.1%) out of the observed dyads and with a rather low number of on-task interactions (43.3%). However, their on-task interactions clearly increased during the 2nd phase (80.0%). Although this percentage subsequently reduced slightly, it was clearly higher in the 3rd phase (67.7%) compared to the 1st phase.
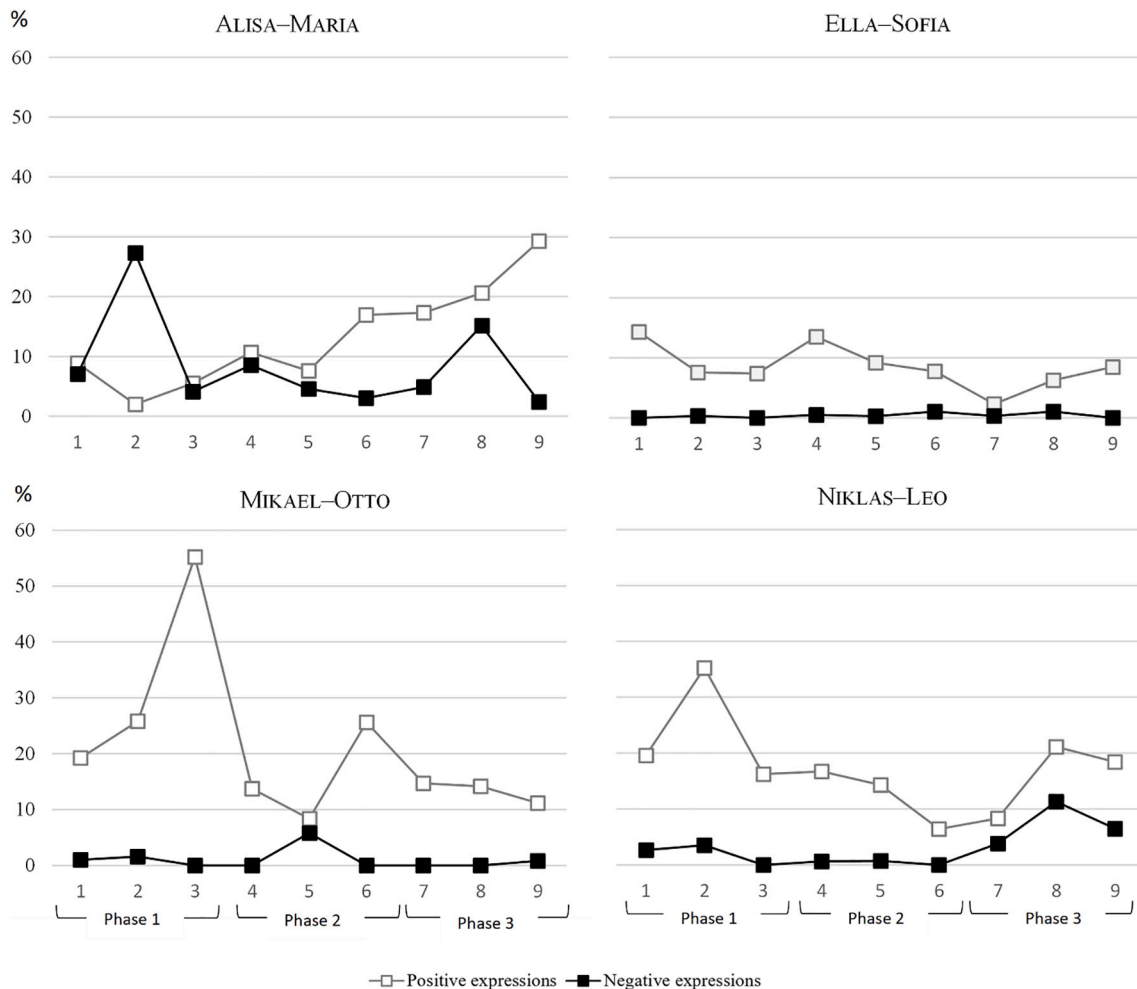

Fig. 5. Trajectories of peer dyads' expressed positivity and negativity during dyadic on-task interactions.

Next, the trajectories of the emotional quality of the students' dyadic on-task interactions with qualitative excerpts are presented and discussed. Generally, all dyads' on-task interactions demonstrated positive patterns, despite the initial socio-motivational vulnerabilities (except for Ella–Sofia), reading difficulties, and task demands (i.e., collaborating on challenging tasks). However, it is evident from Fig. 5 that students' dyadic emotional interaction trajectories differed qualitatively in terms of both levels and patterns.

Alisa–Maria's positivity strongly increased toward the end of the intervention: During lessons 6–8, positivity in their interactions fluctuated between 17.0% and 20.6%, reaching a high of 29.3% during the last observed lesson. This indicates increasingly open emotional dynamics and increasingly positive dyadic interactions. Their positivity was often expressed through humor, such as laughing together at funny parts of the book. However, Alisa–Maria did express a certain degree of negativity throughout the intervention: Peaks of heightened negativity were observed during lessons 2 (27.3%) and 8 (15.2%). Their negativity was mainly related to sharing tools, such as quarrelling about the mouse or whose turn it was. Occasionally, they also disagreed about how to complete tasks, such as when Alisa tried to get the keyboard from Maria (who was writing) by saying, "*It's all wrong now!*" Maria stopped her by saying with an anguished tone, "*I know, but I want to correct it myself!*", followed by Alisa's irritated remark, "*Well, it is still wrong.*" These disputes tended to escalate, and it often took a while for them to agree. Sometimes, they corrected each other's mistakes in a highly exaggerated and sarcastic tone or became frustrated by each other's actions. This was exemplified by Maria's frustrated remark, "*Why are you making so stupid things?*" [Sighs].

Mikael–Otto expressed positivity throughout the intervention: Overall, their positivity was at its highest in the 1st phase (19.3%–55.2%), with a peak in positivity occurring later during lesson 6 (25.6%). Their positive interactions were mainly characterized by humor, such as laughing at funny parts in the book, although they also motivated each other frequently when performing the tasks. This was illustrated through "we" talk and shared excitement and engagement, such as when Mikael smiled, turned to Otto, and said, "*Why don't we make this story even longer, up until here?*" Otto returned the smile and replied, "*Yes, let's!*" The boys expressed little negativity in their dyadic interactions, and their reactions to mistakes and uncertainties were positive overall. Moreover, they often helped each other very patiently when reading difficult words. However, the slight peak in negativity during lesson 5 (5.8%) was related to temporarily expressing mild annoyance and impatience in such situations.

Ella–Sofia's dyadic interactions were characterized by stable and high amounts of neutral interactions (85.7%–97.3%). Their positivity was highest during the first observed lesson (14.3%) and lowest (overall) during the 3rd intervention phase (2.3%–8.5%). Their positive expressions were most frequently related to their genuine enjoyment of performing the task together or shared excitement after succeeding in the task. For example, Ella once said excitedly, "*We chose just the right ones!*", followed by Sofia's reply, "*Yes, we did! We are clever!*" Even when correcting or being corrected, they remained friendly by using "we" talk, and their collaboration flowed smoothly throughout the intervention, only having to negotiate on rare occasions. They used all the provided materials and tools fluently together, expressed empathy toward each other, and used comforting language. For example, Ella comforted Sofia (who was worried about whether they would be able to achieve better scores) by saying, "*We will get there, I'm sure,*" accompanied by a smile. Negative expressions were almost nonexistent for this dyad (0.0%–1.1%).

Niklas–Leo's positivity was at its highest during the two first (19.6% and 35.3%) and last two observed lessons (21.1% and 18.4%). Their positivity mainly manifested through humor and laughter. Sometimes, they also expressed encouragement to each other, such as when Leo excitedly agreed with Niklas' suggestion on what to write down by saying, "*Yes, that's a good idea!*". The dyad's negativity was low during the 1st and 2nd phases (0.0% and 3.5%, respectively), although this increased toward the end, being at its highest during lessons 8 and 9 (11.3% and 6.5%, respectively). Especially during the last two observed lessons, the boys adopted negative attitudes toward the tasks (or working together), resulting in shared discouraging talk. For instance, Leo said, "*Let's not do this,*" to which Niklas answered, "*Yes, let's not.*" Furthermore, the boys would more easily become irritated if one did not perform the task in the way that the other had imagined, such as in this brief, irritable utterance by Niklas: "*What, you have put the wrong one there, take it away! — You should have connected it with that one*" [Irritated sigh].

3.3. Students' development of socio-motivational and reading competencies: relation to initial vulnerabilities and difficulties, and intertwined teacher–dyad and dyadic peer interactions

Teachers were sensitive to intervention students' (n = 24) socio-motivational vulnerability and provided more support time for those dyads with cumulated or strong cumulated socio-motivational vulnerabilities (H = 9.09[3], p = .015). Further, dyads with socio-motivational vulnerability spent less time in dyadic peer interaction context (H = 13.50(3), p = .004), compared to dyads with non-cumulated or no vulnerabilities. Quantity of support time in either of these interaction contexts did not, however, explain students' differentiating development of prosocial behavior or task orientation. Interestingly, the dyads who received more teacher support time showed weaker development of reading comprehension skills compared to their peers with less teacher support time (H = 9.63[2], p = .008). Support time effect was not found on the development of decoding skills, and neither did peer dyadic support time have any effects on the development. After controlling these effects for all the 12 intact intervention dyads it can be concluded that mere quantity of time spent in teacher–dyad or peer dyadic interactions does not allow understanding differences in the development of students' competencies. Furthermore, negative effect of higher quantity of teacher support time, but not peer dyadic support time, for development of reading comprehension skills indicates specific patterns in these interaction contexts.

Next, the focus shifts back to in-depth understanding of the interactions (four target intervention dyads). The aim was to examine whether the long-term mechanisms in the intertwining of emotional support trajectories within the teacher–dyad (Fig. 3) and dyadic (Fig. 5) interaction contexts relate to the students' development of competencies across the intervention. As the eight students differed in their initial vulnerabilities and difficulties (Table 2), their development was compared to all other students (N = 318) regarding socio-motivational and reading competencies. All eight students developed positively in some respects, but the domains and degrees of

progress differed (Table 4). Differentiation of these eight students' development across the intervention is next discussed, acknowledging their initial vulnerability and difficulty profiles (Table 2), the focus of dyadic interactions (Fig. 4) and the emotional support trajectories in teacher–dyad (Fig. 3) and dyadic (Fig. 5) interaction contexts.

Alisa–Maria both had cumulated socio-motivational vulnerabilities. Maria also had cumulated reading difficulties with particularly low reading comprehension skills, whereas Alisa only had reading comprehension difficulties. On-task interactions dominated in dyadic interaction context, although they also had the highest number of no peer interactions. Occasionally, they struggled in collaboration, although teacher–dyad emotional support fluctuated between the middle and high range with a low negative climate (even when the dyadic negativity temporarily exceeded positivity). Moreover, dyadic peer interactions became more positive throughout the intervention. Overall, both Alisa and Maria's development was prominently the most positive out of the observed dyads: It was strong in all measured competencies, except for decoding skills, where Alisa's development was weak, and Maria's was good. Their teacher's sensitivity to dyadic struggles and avoidance of falling into negative patterns seemed to buffer the girls' temporarily more negative dyadic emotional interactions: Not only did Alisa–Maria's dyadic interactions grow into more positive, but the high-quality teacher emotional support also seemed to create a favorable context for the development of their multi-perspective competencies.

Mikael–Otto had cumulated vulnerabilities and difficulties in both socio-motivational and reading domains. Their high-quality teacher–dyad emotional support was intertwined with positive on-task dyadic interactions. However, there was an observed temporary decrease: Teacher–dyad emotional support in a positive climate, sensitivity, and regard for student perspective decreased to the middle range during lessons 5–7, which was partly simultaneous with the dyad's higher superficial on-task interactions (lessons 4–6) and slight peak in dyadic negativity (lesson 5). Negative climate in teacher–dyad interactions remained low throughout the intervention, and both students developed strongly in task orientation. Otherwise, Mikael had more positive development: His prosocial behavior developed strongly, and his development in reading comprehension was good. By comparison, Otto developed only slightly in these competencies. Finally, both boys' decoding skills decreased in terms of relative position. Mostly high-quality emotional support interactions in both interaction contexts seemed to promote the development of boys' task orientation, especially, whereas the development of reading skills followed more individualized patterns.

Ella–Sofia did not have initial socio-motivational vulnerability, although they both had cumulated difficulties in reading. Their middle-range teacher–dyad emotional support (except for low regard for student perspective during lesson 4) that never reached high range and consistently low negative climate was intertwined with highly neutral on-task dyadic interactions. Their dyadic interactions did not seem to be influenced by the temporary decrease in teacher–dyad emotional support after the teacher was changed. Both girls developed strongly in terms of reading comprehension. Ella also developed strongly in decoding skills, whereas Sofia's development was minimal. Their socio-motivational competencies were initially stronger compared to the other students, although both girls still indicated positive development in prosocial behavior. Unfortunately, both girls' task orientation decreased in terms of relative position. These girls' functioning dyadic collaboration and stronger initial socio-motivational competencies, compared to other dyads, potentially partially buffered the girls from lack of high range teacher–dyad emotional support and promoted the development of their reading skills. However, they would have likely benefited from high-quality teacher–dyad emotional support to further promote the joy in learning.

Niklas–Leo both had strong cumulated socio-motivational vulnerabilities and decoding difficulties, although their reading comprehension skills were the best of all the selected eight students. Compared to Ella–Sofia (who shared the same teachers), their teacher–dyad interactions were affected more severely by the teacher change: The mainly high-quality emotional support by the first teacher was replaced by the new teacher's middle- to low-range emotional support and increasingly negative climate in teacher–dyad contexts. After the teacher change, the dyad's on-task interactions clearly increased, although the emotional quality of interactions

Table 4
Overview of the four dyads' development across the intervention.

Dyads[a]	Students' development of competencies across the intervention[b,c]			
	Socio-motivational		Reading	
	Prosocial behavior	Task orientation	Reading comprehension	Decoding
Alisa–Maria	Maria strong, Alisa good: **both** progressed to average.	**Both** strong: Alisa progressed to high, Maria to average.	**Both** strong: Alisa progressed to average, Maria to lower average.	Alisa weak, decreased in position; **Maria** good, progressed to average.
Mikael–Otto	**Mikael** strong, progressed to higher average; Otto slight, progressed to average.	**Both** strong: both progressed to average.	**Mikael** good, progressed to lower average; Otto slight, but remained low.	Mikael weak, Otto slight, but both decreased in terms of relative position.
Ella–Sofia	Ella initially high, remained high; **Sofia** good, progressed to higher average.	Sofia slight, Ella weak, although both decreased in terms of relative position.	**Both** strong: Ella progressed to average, Sofia to higher average.	**Ella** strong, progressed to higher average; Sofia slight but decreased in terms of relative position.
Niklas–Leo	Niklas slight, Leo good, but both remained low.	Niklas slight but remained low; **Leo** good, progressed to lower average.	Niklas slight but decreased in terms of relative position; **Leo** good, progressed to average.	**Niklas** strong, progressed to average; Leo slight but remained low.

[a] See prior vulnerability and difficulty profiles in Table 2.
[b] Magnitude of change (four categories of 25%: none or weak, slight, good, and strong) and relative position within the whole sample (five categories of 20%: low, lower average, average, higher average, high) were considered.
[c] Most prominent positive progress in bold (at minimum, a good change in magnitude and increase in relative position).

indicated more complex patterns. After first decreasing, dyadic positivity increased toward the end of the intervention, although this was intertwined with somewhat increased dyadic negativity. Overall, the development of this dyad was the weakest of the observed dyads across the multi-perspective academic competencies. Niklas achieved only minimal development in all competencies, apart from decoding, which strongly developed. By comparison, Leo achieved good development in prosocial behavior, task orientation, and reading comprehension skills, with an increasing relative position in all areas apart from prosocial behavior, which remained low. Unfortunately, Leo's development in decoding skills was minimal. The downward trajectory of emotional support combined with increasing negativity likely impeded these boys' development of competencies, despite their rather positive dyadic interactions. Given the boys' cumulated initial socio-motivational vulnerabilities, consistent high-quality emotional support would have likely been especially crucial.

4. Discussion

The step-by-step multi-level analysis applied in the present study provides a systematic and in-depth opportunity to uncover the emotional support trajectories within teacher–dyad and dyadic interaction contexts among at-risk students over a three-semester computer-supported intervention. Studying these dynamically evolving interactions separately (yet intertwined) enabled these scarcely mapped mechanisms, the role of peer support patterns (Wentzel et al., 2018), and the teacher's role in enhancing socio-motivational and reading comprehension competencies to be revealed.

4.1. Different mechanisms in the long-term intertwining of teacher–dyad and dyadic emotional support trajectories

Teacher–dyad emotional support trajectories differed for all observed dyads. Two dyads received teacher–dyad emotional support that evolved between the middle and high ranges in positive climate, sensitivity, and regard for student perspective. However, one dyad's support trajectory decreased from the high to low range, while another did not receive any high-range emotional support during the observed lessons, with it mostly remaining in the middle range. A common factor was that none of the observed dyads received consistent high-range teacher–dyad emotional support. Furthermore, the negative climate in teacher–dyad interactions remained low except for one dyad, where negativity reached the middle range during some lessons.

Overall, dyadic collaborations among at-risk students were functional and primarily on task. Humor and shared laughter dominated the positive expressions, which might indicate that these were used to alleviate and regulate potential tensions and negative emotions (Lamminpää & Vesterinen, 2018). Although negativity was rare overall, one dyad expressed it to some degree throughout the intervention. It was often related to struggling to share tools or turns, which reflected difficulties in recognizing and responding to the needs of others (Dirks et al., 2018; Dunfield, 2014). Otherwise, negativity mostly appeared to emanate from difficulties regulating own negative emotions (such as frustration).

When dyads initially struggled with collaboration, the teacher's ability to help students develop warm and supportive relationships with each other and to be sensitive to student needs when striving to minimize negative experiences (Hamre & Pianta, 2005; Pianta et al., 2008) played a particularly crucial role. Thus, being sensitive to dyadic struggles and being flexible and creative when providing students with the tools to cope with these challenges were perceived as important. Furthermore, the teacher's persistence in avoiding falling into negative patterns and dynamics (such as when dyadic negativity temporarily exceeded positivity) was another crucial aspect. This kind of intertwining of emotional interactions was found to alleviate tensions and increase positivity in dyadic peer interactions (Hamre et al., 2008).

The adaptive calibration of support proved not to be an easy task for teachers (Kajamies, 2017; Turner et al., 2014). For instance, one dyad completely lacked any high-range emotional support in terms of positive climate, sensitivity, and regard for the student perspective. Although this dyad did not have initial socio-motivational vulnerabilities, they were characterized as academically at risk due to their cumulated reading difficulties and could be expected to especially benefit from high and consistent emotional support (Hamre & Pianta, 2005). A lack of observable difficulties when in collaboration may have caused the teacher to perceive that no additional support was needed. However, this kind of intertwining of interactions may be problematic, as it may hinder the further promotion of joy and curiosity when learning together (Hamre & Pianta, 2005; Pianta et al., 2008). The inconsistency in emotional support faced by another dyad was observed as a further (perhaps even more) detrimental risk: they experienced a radical and unexpected decrease in emotional support and an increase in negative climate in teacher–dyad contexts. It has been suggested that inconsistency in interactions can threaten students' feelings of belongingness and predictability, which are both identified as crucial factors for feeling safe at school (Williams et al., 2018).

The change of teacher was tentatively identified as a risk factor for consistency in emotional support. While teacher change does not necessarily lead to a decrease in emotional support and may even indicate opposite patterns, findings of this study encourage to explore the potential role that the teacher change can have for the emotional quality of interactions. Here, particularly in case of the boy dyad, the new teacher seemed to adhere to her own agenda and classroom management very strictly and was generally superficial in her interactions with the students. One potential explanation might be that she lacked self-efficacy when administering an intervention that she had not been part of from inception, which could have further increased her stress levels. Moreover, stress and negative affect have been shown to reflect the quality of teacher–student relationships in different kinds of ways, such as being based on student characteristics (Yoon, 2002): This could explain why only one dyad experienced an increase in negative climate after the teacher change. If a teacher change is accompanied with increased negativity, it may severely impede accomplishing the objectives set for interventions: In fact, the present study showed that the dyad with increasing negativity in teacher–dyad interactions after the teacher change was identified with the weakest development of competencies, out of the four observed dyads.

These observed struggles raise concerns over whether students' equal rights for high-quality emotional support are realized and whether some students receive the lowest emotional support when they need it the most. However, it may be questioned whether expecting high-range emotional support without any exceptions is realistic, given the challenging and complex nature of learning interactions where both teacher and students mutually influence each other.

4.2. Student development of socio-motivational and reading competencies as embedded in the intertwined teacher–dyad and dyadic emotional interactions

Support time within both interaction contexts (teacher–dyad and dyadic) did not explain the positive development of multi-perspective academic competencies. However, teachers were sensitive to students' initial socio-motivational vulnerabilities by providing more support time to those dyads with cumulated vulnerabilities compared to dyads with no or non-cumulated vulnerabilities. Interestingly, although students' initial reading difficulties were not related to the division of support time within the interaction contexts, dyads with higher teacher support time exhibited weaker development of reading comprehension. These results align with the study by Silinskas et al. (2016), who suggested that even a considerable amount of teacher support might not be sufficient to produce positive development, and the quality would require scrutinizing. The present study further contributes by underscoring the importance of examining the emotional support interactions within both interaction contexts separately, as both were found to have unique relevance in explaining students' differentiating development of multi-perspective competencies.

The emotional quality of interactions in teacher–dyad contexts was found to be particularly crucial with regard to the positive development of task orientation: The dyads with high-quality teacher–dyad emotional support experienced the strongest development in task orientation. This aligns with the understanding that encouragement, sensitivity, and regard for student perspectives might be essential for fulfilling the needs of at-risk students in terms of relatedness, competence, and autonomy, all of which are crucial for motivated learning (Pakarinen et al., 2014; Turner et al., 2014). As these needs may be threatened by negativity in interactions (Silinskas et al., 2016), finding appropriate ways of expressing emotions (Jiang et al., 2019) can have crucial developmental relevance for students' adaptive achievement behaviors (e.g., task focus).

Two factors seemed to be relevant in promoting students' positive development of prosocial behavior: a lack of negativity in both interaction contexts and the teacher's ability to sensitively support students and minimize negativity by offering more positive models of interaction in the case of dyadic struggles. It is presumed that when modelling students even challenges can be overcome in positive ways the teacher offers a chance to practice collaboration skills safely (Farmer et al., 2011). Accordingly, the dyad with the highest observed dyadic negativity developed strongly with the help of high-quality teacher–dyad interactions, both in the observed quality of dyadic interactions and in their prosocial behavior, as assessed by their classroom teachers in typical classroom situations. The results also tentatively indicate that positively developing prosocial behavior might promote the positive development of reading comprehension skills. This suggests that the development of these competencies might (to a certain degree) be intertwined (Sparapani et al., 2018).

The dyad with strong cumulated initial socio-motivational vulnerabilities seemed to be more strongly influenced by less optimal teacher support patterns compared to the dyad with no initial vulnerabilities. Even above-average positive dyadic interactions were not sufficient to buffer the negative influences of decreasing teacher–dyad emotional support and increasing negative climate (Lepola et al., 2016; Vauras et al., 2009): Their development was the weakest of the observed dyads overall. Conversely, the highly on-task and neutral dyadic interactions of the dyad with no initial socio-motivational vulnerabilities seemed to partly buffer the lack of high-range teacher–dyad emotional support. This would potentially have crucial relevance, especially in the enhancement of prosocial behavior and reading comprehension skills. However, they seemed to be influenced by a lack of high teacher–dyad emotional support through a decrease in their task orientation, despite their otherwise positive development. This suggests that they might have benefited from enhancing the enjoyment and excitement about learning to provide them with better opportunities to cope with potentially more demanding future classroom situations outside the small group learning environment (Vauras et al., 2009).

4.3. Limitations and future directions

Innovative solutions that look beyond the average patterns of classroom interactions are encouraged, especially when the aim is to understand students' differential development of competencies across interventions. The present study suggests one such solution by adapting a global classroom observational measure on process quality (i.e., CLASS, Pianta et al., 2008) to capture individualized teacher–dyad emotional support and introducing a separate coding scheme to assess the emotional quality of students' dyadic on-task interactions. Longitudinal observations across both contexts provide a richer understanding compared to cross-sectional studies. Moreover, they reveal differences in the level and consistency of emotional support and in the long-term mechanisms for intertwining emotional interactions within the two interaction contexts. In addition, illustrating the emotional support trajectories through all four dimensions separately (i.e., positive climate, negative climate, teacher sensitivity, and regard for student perspective), instead of the more traditionally used overall score for emotional support, enables observing the specific patterns through which emotional support is realized. Finally, it is suggested that examining students' development across multi-perspective academic competencies enables the identification of potential intertwining in their development.

Due to the complex nature of social interactions and individual development, the present study also raises new questions. For instance, the development of reading competencies (especially decoding skills) indicated individual patterns, not all of which could be related to differences in the observed emotional support trajectories. It is suggested that other meaningful aspects of teacher and peer support (such as instructional support and cognitive aspects of the quality of dyadic collaboration) might enable diving deeper into the

complex mechanisms that produce differences in students' development of competencies. Furthermore, conducting even finer-grained analyses on emotional support that targets individual students (instead of student dyads) might further deepen the understanding of the potentially individualized patterns and processes. The sample size was small (n = 8) and included at-risk elementary students participating in an intervention in a computer-supported learning environment carried out by special education teachers. Thus, future studies with larger data sets and within different educational settings are required to draw generalizable conclusions.

4.4. Practical implications and concluding remarks

Observing the long-term intertwining of teacher–dyad and dyadic emotional support enabled the identification of mechanisms that positively contributed to harnessing the potential of dyadic collaboration for enhancing the multi-perspective academic competencies of at-risk students. However, risks related to these processes were also observed. A change in teacher was tentatively identified as a risk factor for consistency in emotional support. As these changes inevitably take place in authentic school life, ensuring that students' developmental needs are met in emotionally sustainable ways and preferably even better during these transitions is encouraged. Due to the identified struggles that one of the teachers had in finding appropriate emotion expressions, it is further recommended that teachers' emotion-competence skills and beneficial emotion regulation strategies be encouraged and practiced during teacher education and throughout their careers. Infusing regular, carefully planned and implemented emotion recognition, expression, and regulation instruction into the curriculum of elementary students is further recommended. This is because the emotional quality of dyadic peer interactions was similarly identified as crucial for enhancing multi-perspective competencies. Combined, these are expected to provide students with better opportunities for positively adapting to collaboration and increase teachers' preparedness to find appropriate emotion expressions when faced with a negative affect that might be raised by experienced stress or students' struggles in collaboration.

Acknowledgements

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