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Why not ask them? A systematic scoping review of research on dyadic teacher–student relationships as perceived by students with emotional and behavioral problems

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Introduction: Meta-analytical findings indicate that high-quality dyadic teacher-student relationships (TSRs) can act as social protective factors against the development or persistence of emotional and behavioral problems (EBPs) by fostering students' social-emotional and cognitive learning. However, previous research primarily focused on samples of students without EBPs and relied on teacher-rated TSRs. Research on dyadic TSRs from the perspective of students with EBPs is scarce, yet their self-perceptions could offer valuable insights into whether and how dyadic TSRs serve as protective factors for them. Therefore, this systematic scoping review is guided by the central question of how research on dyadic TSRs from the perspective of students with EBPs has been conducted and what insights have been gained to date.

Methods: This question is explored through a narrative synthesis of existing studies, thereby identifying current research approaches, empirical findings, practical implications, and future research needs. A database search using keywords related to EBPs and TSRs yielded 24 included studies.

Results and discussion: Synthesizing these studies reveals five overarching conclusions. First, students with EBPs and their teachers tend to experience dyadic TSRs less favorably than typically developed (TD) students and their teachers. Second, relationship-enhancing interventions focusing on either teacher-student interactions, contextual factors or individual characteristics of teachers and students appear to be effective for students with EBPs. Third, students with EBPs seem to perceive stronger positive affective relationships with their teachers than teachers do with them. Fourth, students with EBPs may perceive their dyadic TSRs as ambivalent, exhibiting both highly positive and highly negative aspects. Fifth, for the social–emotional and academic development of students with EBPs, dyadic TSR-quality seems to be a risk or protective factor, acting differently than in TD-student. However, due to the diverse nature of the included studies, these conclusions remain only preliminary. Consequently,

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the review concludes with 10 key recommendations that might guide future research on dyadic TSRs from the perspective of students with EBPs.

KEYWORDS

systematic scoping review, teacher-student relationship, emotional and behavioral problems, externalizing problems, internalizing problems, special needs, student perspective

1 Introduction

Globally, a substantial part of 15–20% of the children and adolescents experience emotional and behavioral problems (EBPs; Husky et al., 2018; Kovess-Masfety et al., 2016; Polanczyk et al., 2015). Current research indicates that establishing high-quality dyadic teacher-student relationships (TSRs) can serve as social protective factors against the development or persistence of EBPs by fostering students' social–emotional learning and contributing to their academic and cognitive growth (*cf.* Emslander et al., 2023; García-Rodríguez et al., 2023; Lei et al., 2016; Nurmi, 2012; Roorda et al., 2021 for systematic reviews and meta-analyses). However, most of these research findings are based on samples of students without EBPs and rely on teachers' ratings of TSRs (Van Bergen et al., 2020). There is a lack of research on the impact of dyadic TSRs as perceived by students with EBPs, even though these students may be particularly affected by low-quality relationships and could particularly benefit from high-quality relationships (McGrath and Van Bergen, 2015). Students with difficulties or disabilities, particularly those with EBPs, are often affected by negative social, academic, and behavioral school outcomes that impact both their present and future well-being (Conroy et al., 2020). To adequately support these students, it is crucial to establish positive, safe, welcoming, and appreciative dyadic TSRs with them. It is important that not only teachers feel they are providing such relationships, but that students themselves genuinely perceive and experience these types of relationships as well (Hunt and Mullen, 2021). Thus, understanding the internal perspectives of students with EBPs regarding their dyadic TSRs could provide valuable insights into whether and how these relationships become either risk or protective factors for them (Van Bergen et al., 2020). Therefore, the purpose of this systematic scoping review is to synthesize studies that surveyed students with EBPs on how they perceive their dyadic relationship with their teacher. The aim is to provide a foundation for deriving empirical evidence, practical implications, and future research needs in TSR-research for students with EBPs.

1.1 Emotional and behavioral problems

EBPs can be categorized as either externalizing or internalizing problems (Achenbach et al., 2016). Externalizing problems involve outwardly directed problems like aggressive, delinquent, oppositional, or hyperactive and inattentive behavior. Internalizing problems include inwardly directed problems such as depressive and anxious behavior, psychosomatic complaints, or social withdrawal (American Psychiatric Association, 2022; Sourander and Helstelä, 2005).

Behaviors of EBPs in the externalizing or internalizing domain can be described in at least three different ways: First, they can be diagnosed as mental health disorders based on criteria from classification systems like the *Diagnostic and Statistical Manual of Mental Disorders* (DSM; American Psychiatric Association, 2022). Second, they can be assessed as psychosocial problems using dimensional quantitative taxonomies, which involve scoring "individuals […] according to the degree to which they manifest a symptom or behavior" (McConaughy and Russell, 1993, p. 424). Third, they can be identified as special educational needs referred to as *social, emotional, and behavioral difficulties* (SEBDs) indicating that students require specific support in regular schools or may need to attend special schools due to their behavioral or emotional challenges. The identification of special educational needs varies greatly depending on the educational policy of the respective country or school administration (e.g., De Swart et al., 2023b). All three forms of EBPs (mental health disorders, psychosocial problems, special educational needs) can coexist or occur independently (Hennemann et al., 2020).

Especially when EBPs develop early and are left untreated for too long, they are likely to be associated with risk trajectories including long-term consequences such as substance abuse, academic failure, employment difficulties, criminality, challenges in forming social relationships, feelings of inferiority, suicidal thoughts, or suicide itself (e.g., American Psychiatric Association, 2022; Petermann, 2013). To avoid or mitigate the development of such risks, it is crucial to implement preventive and interventive approaches (WHO, 2004). For the implementation of such approaches, school – and thus, also TSRs – are considered important social contexts, given that children and adolescents spend a considerable amount of their time in schools and with their teachers (Schwab and Rossmann, 2020).

1.2 Teacher–student relationships

Teacher-student relationships (TSRs) are multidimensional and dynamic constructs (Pianta, 2006) that can be examined in three different forms: As dyadic relationships between an individual student and an individual teacher (student with teacher), as a class-wide phenomena involving all students within one class and the teacher of that class (students with teacher), or as collective relationships encompassing all students and teachers within a school (students with teachers; Roza et al., 2022). It is crucial to distinguish between these three phenomena as – due to the diverse nature of student populations – teachers and students may have contrasting experiences and perspectives on dyadic, class-wide, or collective TSRs, leading them to value the quality of these differently (Gregoriadis et al., 2022; Wubbels et al., 2015). In this context, Nurmi (2012) highlights the importance of differentiating individual student variations from classroom-wide differences, noting that individual students may each receive different instructions and responses from their teacher, thereby shaping distinct student and teacher perceptions of TSR-quality. It is

particularly students with EBPs who, unlike their typically developed peers, may be affected by relationship-damaging teacher responses, but at the same time can particularly benefit from positive dyadic experiences with their teacher. This is indicated by numerous quantitative study results revealing positive associations between low-quality dyadic TSRs and psychosocial problems, as well as negative associations between high-quality dyadic TSRs and psychosocial problems (Nurmi, 2012; Lei et al., 2016). Qualitative research further highlights that students with EBPs describe supportive dyadic relationships with teachers as highly relevant for their mental health development (Dods, 2013; Krane et al., 2017). Therefore, when examining relational dynamics between teachers and students with EBPs, it appears to be most appropriate to assess TSRs as dyadic phenomenon (Leidig et al., 2021).

According to developmental systems theory (Pianta, 2006), dyadic TSRs develop within the interplay of four core components. The (1) *individual characteristics* of both the teacher and the student, such as gender, temperament, and relational history, influence their (2) *real-time interactions*. Real-time interactions are mutually interrelated behaviors that occur in immediate moments. Over time, repetitive interactions are internalized and stored in (3) *mental relationship representations*, which remain in existence beyond the immediate moment of interaction. Mental relationship representations include perceptions of past interactions and associated emotions, as well as conceptions and expectations of oneself, the other, and the self-other relationship. With this, mental relationship representations serve as guidance systems for behaviors and feelings within future interactions, which again can change subsequent relationship representations. The interplay between these three components is embedded in and mutually interacts with (4) *contextual influences*, such as school organization, socioeconomic status, culture, and social norms (Pianta, 2006; Spilt et al., 2022).

Following Spilt et al. (2022), the developmental systems theory is an overarching framework of which two components (real-time interactions and mental relationship representations) can be exemplified by dimensions that draw from two main dyadic TSR-theories: Attachment theory approaches (Bowlby, 1969; Pianta, 2001) and self-determination theory (Deci and Ryan, 1993). They argue that attachment theory clarifies relationship representations, whereas self-determination theory rather describes teacher-student interactions.

From an attachment theoretical perspective (Bowlby, 1969), teachers represent "ad hoc attachment figures" (Zee et al., 2020a, p. 638), thereby acting as 'safe haven' and 'secure base' for students. This means that students can rely on their teachers for support and care during times of distress ('safe haven'), allowing them to confidently explore their (learning) environment and develop adaptive emotion regulation skills ('secure base'; Davis, 2003; Verschueren, 2015). TSRs in which the teacher successfully fulfills the roles of a 'secure base' and 'safe haven' are mostly characterized by high levels of *closeness*, as well as low levels of *conflict* and *dependency* (Pianta, 2001). Additionally, Koomen and Jellesma (2015) added another dimension to this framework, which is student-perceived *negative expectations*. Negative expectations refer to "the lack of confidence in a teacher's availability and responsiveness" (p. 491).

According to self-determination theory (Deci and Ryan, 1993), the quality of TSRs can be measured by the extent to which three basic psychological needs are fulfilled: The need for *social relatedness* (by teachers being available for support and demonstrating understanding towards students), the need for *competence* (by teachers providing clear instructions and feedback as well as offering guidance), and the need for *autonomy* (by teachers providing student choices and showing respect for students' perspectives; Bieg et al., 2011; Spilt et al., 2022).

1.3 The perspective of students with emotional and behavioral problems in TSR-research

Irrespective of the specific theory employed within the developmental systems framework, the framework itself highlights the interplay between individual characteristics (e.g., temperament), interactional behaviors (e.g., aggressive behavior) and perceived relationships (e.g., the level of *conflict*).

Current research indicates that the perceived dyadic TSR-quality can become a central pivotal point that affects individual characteristics and interactional behaviors both positively and negatively. Longitudinal studies indicate that conflictual dyadic TSRs can exacerbate EBPs in the externalizing and internalizing domain (Crocket et al., 2018; Husby et al., 2023; Pakarinen et al., 2018; Roorda et al., 2014; Silver et al., 2005). Likewise, dyadic TSRs characterized by low *conflict*, high *closeness* and *trust* seem to reduce externalizing or internalizing problems over time (O'Connor et al., 2011; Silver et al., 2005; Wang et al., 2013). Additionally, high-quality dyadic TSRs appear to buffer associations between EBPs and academic challenges (such as math and reading problems) as well as associations between EBPs and poor classroom adjustment (Baker et al., 2008; Hamre and Pianta, 2001; Liew et al., 2010). Longitudinal studies also reveal associations between dyadic TSR-quality and academic reputation (Hughes and Chen, 2011) as well as academic success (Hamre and Pianta, 2001). Moreover, high-quality dyadic TSRs appear to have a positive effect on students' peer relationships (Endedijk et al., 2022; Hughes and Chen, 2011; Hughes and Im, 2016), whereas low-quality dyadic TSRs appear to have a negative impact on students' prosocial behavior (Roorda et al., 2014). According to this body of research, dyadic TSRs profoundly influence school experiences of children and adolescents, affecting their social, emotional, behavioral, and academic development.

However, it is important to note that most existing research focused on typically developed students without EBPs and primarily relied on teacher-rated TSRs, rather than considering student-rated TSRs (Van Bergen et al., 2020). There is a research gap when it comes to studying dyadic TSRs from the perspective of students with EBPs, even though these students seem to gain or lose more from their TSR-experiences than do other students (McGrath and Van Bergen, 2015). Students with EBPs often face challenges in establishing positive and safe relationships on their own, making them particularly reliant on teachers to initiate relationship building (Bolz, 2021). At the same time, externalizing or internalizing problems may elicit teachers' responses that hinder the formation of positive dyadic TSRs (McGrath and Van Bergen, 2015). Specifically, the social behavior of one interaction partner (i.e., the student with EBPs) is reciprocated by the other (i.e., the teacher; Shores et al., 1993). For instance, externalizing problems (e.g., aggressive, oppositional, and inattentive student behavior) may cause angry teacher reactions, whereas internalizing

problems (e.g., social withdrawal, hopelessness, or clinginess) may cause emotional distant teacher behavior (Vösgen et al., 2023). More generally, teachers may feel mentally overwhelmed by students' EBPs and driven to regain control over their challenging behaviors, conceivably leading them to use coercive disciplinary methods such as punishment, seclusion, or even yelling at or embarrassing students (Lewis et al., 2005; Mitchell et al., 2019) rather than employing supportive strategies. According to developmental systems theory, such challenging interactions can result in negatively perceived TSRs. These perceptions, in turn, contribute to making future interactions even more challenging, thus solidifying negative TSR-representations that "become increasingly stable and are thus more difficult to change" (Spilt et al., 2022, p. 726). Consequently, problematic dyadic TSRs and EBPs may exacerbate each other, forming a sort of vicious circle (e.g., Doumen et al., 2008). Meanwhile, high-quality dyadic TSRs may disrupt such circles as positively perceived TSRs can mitigate problematic interactions, which in turn have the potential to improve TSR representations (e.g., Roorda et al., 2014). Such high-quality dyadic TSRs are typically perceived by both the teacher and the student as warm, trusting, and accepting. In these relationships, students feel secure in receiving the teacher's social–emotional and academic support, while teachers feel confident and self-efficacious in providing it (Hunt and Mullen, 2021). With such a strong relational foundation, teachers can implement essential pedagogical actions like behavior-modifying strategies – especially important for students with EBPs – without making the students feeling betrayed or punished, but rather helped by those interventions (e.g., Vancraeyveldt et al., 2015).

Whether dyadic TSRs evolve into social risk or protective factors does not solely depend on how teachers perceive them, but also on how students view their quality (Van Bergen et al., 2020). This is because TSR representations are shaped by the specific interpretation and encoding of verbal and nonverbal interactional behaviors of the relational partner. Given the highly individual nature of these interpretations, influenced by individual experiences, backgrounds, relational histories, and beliefs, students' and teachers' judgments of TSR-quality may diverge. For example, the very same teacher-student interaction may be perceived as relationship-enhancing by the student but as relationship-hindering by the teacher (Van Bergen et al., 2020; Zee and Koomen, 2017). Regarding discrepancies between how students and teachers view their relationships, Decker et al. (2007, p. 102–103) speculate that perhaps "the behaviors that students perceive as helping them become closer to their teachers are actually the behaviors that push teachers further away." Such discrepancies between self- and other-perceptions may be particularly common among students with EBPs, given that biased perceptions of social cues are part of their symptomatology (Castello, 2017). Consequently, the TSR-perspective of students with EBPs can provide a unique and generally overlooked insight into what they perceive to be experiencing with teachers (Hajdukova et al., 2014).

Students' perspectives on dyadic TSRs do not only give insights into their current relationship experiences but also shed light on potential trajectories of future relationships. Both positively and negatively remembered relationships have enduring effects, persisting even after the relationship itself has ended (Van Bergen et al., 2020). In other words, if students have internalized past relationships with teachers negatively, it is likely that they will anticipate similar relationship patterns with future teachers, leading them to behave defensively or avoidantly towards them. Conversely, a positively perceived dyadic TSR can empower students to enter future TSRs with confidence and openness (Ettekal and Shi, 2020; O'Connor and McCartney, 2006; Van Bergen et al., 2020).

2 Purpose of the review

Whereas the current body of research indicates that dyadic TSRs have a meaningful impact on students' development, it tends to predominantly focus on typically developed samples and teacher-rated TSRs. Research that examines dyadic TSRs from the perspective of students with EBPs is scarce, despite dyadic TSRs potentially serving as key protective or risk factors, especially for these students (McGrath and Van Bergen, 2015). To understand whether and how dyadic TSRs can become protective factors for students with EBPs, their own relational perspectives could be crucial sources of information (Van Bergen et al., 2020).

Therefore, this review seeks to offer a comprehensive synthesis of empirical studies that surveyed students with EBPs on their perceptions of dyadic TSRs. In line with the nature of scoping reviews (Colquhoun et al., 2014; Peters et al., 2015), the aim is to deepen the understanding of existing findings and research gaps, thereby providing a foundation for further research and practical considerations in educational settings. Accordingly, the central research question guiding this review is: How has research on dyadic TSRs from the perspective of students with EBPs been conducted, and what insights have been gained to date? This main question can be divided into four sub-questions:

> Research question 1: What type of EBPs were identified among students who were surveyed on their dyadic TSRs?
>
> Research question 2: In what educational settings were students with EBPs surveyed about the quality of their dyadic TSRs?
>
> Research question 3: How was the dyadic TSR-quality from the perspective of students with EBPs assessed?
>
> Research question 4: Which empirical analyses were conducted using the dyadic TSR-perspective of students with EBPs, and what are the results of these analyses?

3 Methods

This review is based on the guidance for conducting systematic scoping reviews (Peters et al., 2015) as well as on the guidelines of the PRISMA Statement (Page et al., 2021). Detailed information on the methodology can be found in the PRISMA protocol, which was developed based on Shamseer et al. (2015) and is available as supplement material.

3.1 Search strategy and selection process

We searched for existing studies on dyadic TSRs as perceived by students with EBPs in the database Academic Search Ultimate, which encompasses APA PsycArticles, APA PsycInfo, ERIC, MEDLINE, PSYNDEX Literature with PSYNDEX Tests. Based on the theoretical

background of this review, we utilized keywords related to EBPs and TSRs.

The complete search matrix is as follows:

> SU ((external* OR antisocial OR persisten* OR challeng* OR defiant OR impulsive OR "attention deficit" OR hyperact* OR oppositional OR aggress* OR violent* OR delinquent OR conduct* OR disruptive OR psychosocial OR internal* OR emotion* OR insecurity OR depress* OR inhibition OR mood OR dsthym* OR mental OR psych* OR "disruptive mood dysregulation") AND (behavio* OR problem* OR disturbance OR disorder* OR conflict OR disabilit* OR difficult* OR symptom*)) OR ((behavio*) AND (disorder* OR disabilit* OR difficult* OR disturbance)) OR "ADHD" OR "ADD" OR "ODD" OR "CD" OR "high risk" OR anxiety OR "school phobia" OR depression OR hopelessness OR withdrawal OR "negative affect*" OR shyness OR "school absenteeism" OR "absence from school" OR "school refusal" OR "dropout" OR "selective mutism" AND (("teacher-student" OR "student-teacher" OR "teacher-child" OR "child-teacher" OR "teacher-pupil" OR "pupil-teacher") AND (relation* OR interaction* OR attachment OR closeness OR conflict OR relatedness)) OR ((teacher) AND (warmth OR trust OR car* OR empathy OR sensitivity OR responsiv*)) NOT turnover OR burnout OR ((university OR higher OR undergraduate OR postgraduate) AND education)).

The search was limited to peer-reviewed articles. Our initial search was conducted in June 2021. Utilizing the search matrix, 5.326 studies were found. These studies were then uploaded to the web-based application *Covidence*, which automatically eliminated 452 duplicates. Our subsequent search was conducted in September 2023, using the same search matrix but with the restriction to studies published in June 2021 or later. In this second search, 606 studies were found. They were also transferred to *Covidence*, which automatically removed 15 duplicates.

In both search rounds, abstract screening was performed initially, followed by full-text readings of the remaining studies to determine inclusion or exclusion. Studies were included if they met the following seven criteria concerning study design (first, third, and seventh criteria), language (second criteria), and population (fourth, fifth, and sixth criteria).

- It is an empirical study.
- The study is reported in English or German.
- The study is about dyadic TSRs (not about class-wide or collective TSRs).
- The study assesses students' perspectives on dyadic TSRs.
- The study includes a (sub-)sample that is identified as having EBPs at the time of survey.
- The study involves a K-12 sample.
- The study includes empirical analyses with students with EBPs only.

If a study did not meet these criteria, it was excluded. Since our aim was to provide a broad overview of the research on dyadic TSRs from the perspective of students with EBPs, the inclusion of studies was not restricted to specific interventions, comparators, or outcomes.

Abstract screening and full-text assessment for eligibility were conducted independently by the first author and the third as well as last author. Conflict cases were discussed in a team of two and on this basis excluded or included in the further PRISMA flow. In the abstract screening, the agreement was 90% with a moderate interrater reliability of Cohen's $k = 0.42$. In the full-text screening, the agreement was 89%, also with a moderate interrater reliability of Cohen's $k = 0.42$.

Figure 1 illustrates the PRISMA flow chart of the search procedure. A total of $n = 24$ studies met the inclusion criteria and were therefore analyzed and synthesized for this review.

3.2 Analyses

From the 24 included studies, we first extracted basic information, including authors, year of publication, and country of origin.

To answer the research questions, quantitative analyses (frequency analysis) and qualitative analyses (analysis of study content) were performed. For research question 1, the surveyed student groups were categorized as students with externalizing problems, internalizing problems, special educational needs, or as students without EBPs (i.e., students with other disabilities or typically developed students). Additionally, we extracted the terminology used to describe EBPs in the study (e.g., ADHD) and how they were identified (e.g., teacher-ratings). For research question 2, the educational contexts in which the students were surveyed on their dyadic TSRs were classified by type (special or regular educational context) and level (elementary or secondary school). For research question 3, it was extracted which type of teacher the students rated their dyadic TSR-quality with (e.g., class teacher). Furthermore, we provided information about the instrument used (scales, items, or questions), its methodological approach (qualitative or quantitative), and its theoretical background (e.g., attachment theory). If other perspectives on dyadic TSRs were assessed within the included studies (e.g., teachers' perspectives), information about the related instruments were also provided. For research question 4, it was first identified which empirical analyses included dyadic TSRs from the perspective of students with EBPs. These analyses were then sorted according to overarching analysis types (e.g., correlation analysis or mean difference analysis). Subsequently, the results of the included studies were summarized according to each analysis type. In the case of mean difference analyses, standardized effect sizes and significance were obtained from the studies when reported. When not reported, the standardized effect size d was computed based on statistical parameters provided in the studies (i.e., mean, standard deviation, sample sizes; see supplement material for all self-calculated values: https://pawelkulawiak.github.io/tsrsupplement/). The non-overlapping Bayesian 95% confidence interval was utilized to determine significance of group differences. For correlational analyses, the study design (cross-sectional, longitudinal, independent and dependent variables) was reported. Variables assessed for their associations with dyadic TSRs were listed, along with all significant associations, including their direction of effect. For intervention studies, study design, the interventions themselves, their duration and effects on dyadic TSRs were extracted.

Due to the nature of scoping reviews, which aim to provide a broad overview of existing evidence, we did not assess the risk of bias

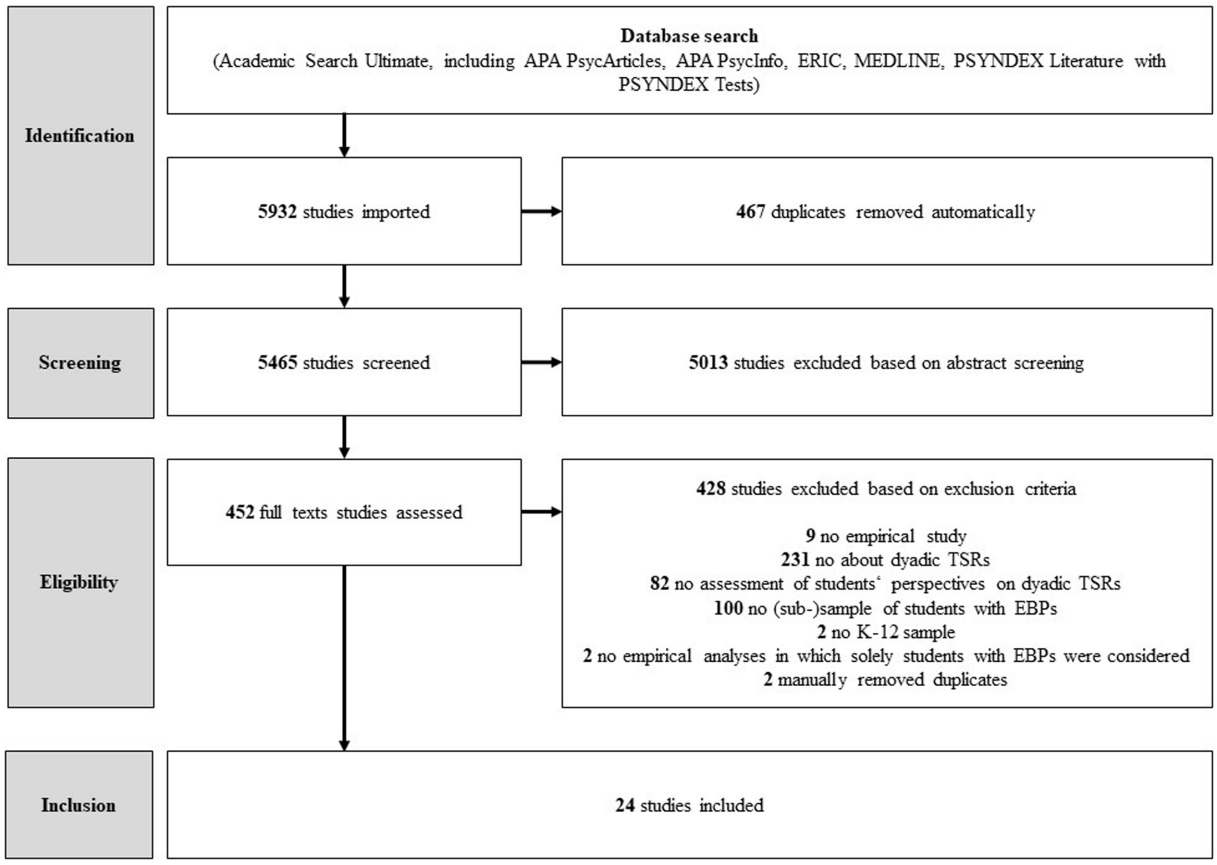

FIGURE 1
PRISMA flow diagram of the systematic search.

in individual studies, calculate meta-data, or conduct a formal evaluation of methodological quality of the included studies (Peters et al., 2015). However, we provided detailed information on study parameters (i.e., sample sizes, measurement instruments, scale reliabilities, effect sizes), allowing for conclusions about the quality of the studies. The information extraction was prepared in tables by the first author and then checked for correctness by the second author.

4 Results

Table 1 provides an overview of the included studies. Among them, one study was published before 2000, five between 2000 and 2010, and the remaining 18 were published after 2010. The majority of the studies took place in North America ($n = 10$), followed by Europe ($n = 9$), and Asia ($n = 5$). The identified studies surveyed students aged between 4 and 18, encompassing kindergarten to high school age.

4.1 Types of EBPs among students who were surveyed on their dyadic TSR-quality

As illustrated in Table 1, clearly more studies ($n = 12$) surveyed students with externalizing problems (e.g., Al-Yagon, 2016) compared to those addressing internalizing problems ($n = 3$; e.g., Longobardi et al., 2019). One study (Kern et al., 2019) surveyed students who were classified as either externalizing, internalizing, or comorbid. Additionally, nine studies concentrated on students with special educational needs due to SEBDs (e.g., De Swart et al., 2023a; De Swart et al., 2023b).

In most studies ($n = 8$), EBPs were identified using quantitative behavioral assessment instruments (e.g., Henricsson and Rydell, 2004). Among these, five studies utilized teacher-ratings, and two studies combined various rating-perspectives, such as teacher, parent- or self-ratings (Kern et al., 2019) or teacher- and peer-ratings (Meehan et al., 2003). Taghvaienia and Zonobitabar (2020) solely relied on self-ratings from students' perspectives. Additionally, teacher nominations were employed in two studies (Decker et al., 2007; Loney et al., 1976), and teacher interviews in two others (Li et al., 2018; Lin et al., 2016). Four studies reported formal diagnostic processes (e.g., De Swart et al., 2023b). In the remaining eight studies, the identification of EBPs was not specified.

In addition to students with EBPs, 10 studies included typically developed (TD) students (e.g., Baker et al., 2009), and two studies involved students with other disabilities (Al-Yagon, 2016; Zee et al., 2020b). Due to their limited representation, the group of other disabilities will not be considered in the subsequent sections of this review. Whenever feasible, the findings of TD-students will be compared with those of students with EBPs.

4.2 Educational contexts in which students with EBPs were surveyed on their dyadic TSR-quality

As shown in Table 1, 15 studies were conducted exclusively in regular education contexts (e.g., Li et al., 2018), whereas five studies were conducted solely in special education contexts (e.g., De Swart et al., 2023a). Three studies (Little and Kobak, 2003; Vervoort et al., 2015; Zweers et al., 2021) compared the two educational contexts in terms of dyadic TSR-quality, and in one study (Shechtman and Tutian, 2016) both regular and special education schools participated, but the distinction between them was not explored.

Regarding school levels, 19 studies took place in elementary schools (e.g., Little and Kobak, 2003) and four studies were carried out in secondary schools (e.g., Kern et al., 2019). One study was conducted across both school levels (Shechtman and Tutian, 2016).

4.3 Methods that were used to assess dyadic TSR-quality from the perspective of students with EBPs

Table 1 illustrates that all included studies used quantitative rating instruments to assess the quality of dyadic TSRs as perceived by students with EBPs, with one study (Salisbury, 2018) additionally employing a qualitative interview method. TSR-ratings were attributed to class teachers or other teachers with prevalent contact.

In most studies ($n = 13$), student-rated instruments were grounded on attachment theory approaches (e.g., CARTS, STRS-SV, SPARTS). Additionally, in one study (Baker et al., 2009), the instrument (SPOCQ) was linked to self-determination theory and in another (Longobardi et al., 2019), the instrument (Y-CATS) had references to both attachment theory and self-determination theory. The CWAI used in two studies (Knowles et al., 2020; Rogers et al., 2015) belongs to the alliance model theory, originating from counseling psychology (Toste et al., 2010) rather than from traditional TSR-research. The measurement instruments in the remaining seven studies were not clearly classified theoretically.

In addition to students' perspectives, 14 studies included teacher-perceived dyadic TSRs, predominantly using the attachment-based STRS (in 10 studies). Three studies involved an outside perspective, i.e., independent observations (Henricsson and Rydell, 2004; Salisbury, 2018) or peer-perspectives (Zee et al., 2020b). Due to the limited number of studies with an outside perspective, the following synthesis will only compare teacher perspectives on dyadic TSRs with student perspectives.

If reported, Cronbach's α values for both student- and teacher-rated scales ranged from acceptable to excellent.

4.4 Empirical analyses in which dyadic TSRs from the perspective of students with EBPs were included

Four overarching analysis types were identified in the included studies. First, mean difference analyses compared dyadic TSR-quality from the perspectives of students with and without EBPs. Second, analyses of mean differences compared dyadic TSR-quality from the perspectives of students with EBPs and their teachers. Third, correlation analyses explored associations between dyadic TSR-quality from the perspective of students with EPBs and various aspects of their social, emotional, behavioral, academic, cognitive, or demographic state or development. Fourth, intervention studies evaluated whether an intervention can improve dyadic TSR-quality from the perspective of students with EBPs.

4.4.1 Mean difference analyses comparing dyadic TSR-quality from the perspectives of students with and without EBPs

As illustrated in Table 2, 10 studies compared dyadic TSR-quality from the perspectives of students with and without EBPs. Among these, six studies compared students with and without externalizing problems, two studies compared students with and without internalizing problems and three studies compared students with and without special educational needs due to SEBDs.

Mean difference analyses revealed that students with EPBs perceived their dyadic TSR-quality worse than their TD-peers in nearly all 10 studies, although these differences were not always statistically significant (e.g., Longobardi et al., 2019). An exception is Henricsson and Rydell (2004), who did not find disparities in perceived dyadic TSR-quality between students with and without internalizing problems.

In all the four studies that additionally surveyed teachers' perspectives on dyadic TSRs, teachers also rated their TSRs with students with EBPs as significantly poorer compared to TD-students. The effect sizes for these differences were constantly larger than those observed in student ratings.

4.4.2 Mean difference analyses comparing dyadic TSR-quality from the perspectives of students with EBPs and their teachers

Table 3 shows that four studies compared student and teacher perspectives of dyadic TSR-quality. Two studies measured only positive TSR-dimensions (i.e., *relationship quality*, *bond*, *collaboration*) and indicated that students with EBPs perceived these positive dimensions to be higher than their teachers did (Kern et al., 2019; Knowles et al., 2020). The remaining two studies compared positive (i.e., *closeness*) as well as negative dimensions (i.e., *conflict*, *dependency*) and revealed that students with EPBs rated both positive and negative dimensions higher than their teachers did (Van Loan and Garwood, 2018; Vervoort et al., 2015).

4.4.3 Cross-sectional and longitudinal correlation analyses examining associations between dyadic TSR-quality from the perspective of students with EBPs and various aspects of their state or development

A total of 16 studies explored associations between dyadic TSRs from the perspective of students with EBPs and various aspects of their social–emotional, behavioral, academic, cognitive, or demographic state or development. Among these, nine studies examined students with externalizing problems, six studies focused on students with special educational needs due to SEBDs, and one study surveyed students with either externalizing, internalizing, or comorbid problems. Ten studies utilized a cross-sectional design, four studies employed a longitudinal approach, and two studies conducted both cross-sectional and longitudinal analyses. In eight

TABLE 1 Overview of the included studies.

Study	Student sample					Educational context		Assessment of dyadic TSR-quality				Empirical analysis			
Authors (year of publication), country	Age (years or grade)	Sample with EBPs			Sample without EBPs	Regular educ.	Special educ.	Teachers on whom TSRs were rated	Instruments			a	b	c	d
		Externalizing problems	Internalizing problems	Special educational needs due to SEBDs					Student perspective	Teacher perspective	Outside perspective				
Al-Yagon (2016), Israel	15–17, $M = 15.94$	$n = 91$, psycho-educational battery for identifying ADHD and comorbid LD (45% male)	–	–	$n = 90$ LD, $n = 99$ TD	$n = 3$ (sec.)	–	Class teachers (n = n.r.)	CATSB: *availability/acceptance*, *rejection* ($\alpha = 0.94$ and 0.88, attachment theory)	–	–	x	–	x	–
Baker et al. (2009), USA	3rd–5th grade	$n = 174$, teacher-ratings on the BASC: hyperactivity, aggression (62% male)	–	–	$n = 519$ TD	$n = 4$ (elem.)	–	$n = 68$, (type n.s.)	Classroom Life Instrument: *caring and interpersonal assistant*, *academic assistance and commitment* (α = n.r., theory n.s.); SPOCQ: *control/predictable structure/maturity* (α = n.r., self-determination theory)[2]	–	–	x	–	x	–
Decker et al. (2007), USA	K-6th grade	$n = 44$, teacher nomination of students with inappropriate school behavior (59% male)	–	–	–	$n = 5$ (elem.)	–	$n = 25$ (type n.s.)	Relatedness Scale: *psychological proximity seeking*, *emotional quality* ($\alpha = 0.86$ and $\alpha = 0.77$, theory n.s.)	STRS: computation of *closeness*, *conflict*, *dependency* ($\alpha = 0.80$, attachment theory)	–	–	–	x	–
De Swart et al. (2023a), Netherlands	$M = 11.19$[1], $SD = 0.85$[1]	–	–	$n = 586$, judgment by local committees (88% male)	–	–	$n = 13$ (elem.)	n.r.	Climate Scale: *quality* ($\alpha = 0.90$[1], theory n.s.)	TSRI: *satisfaction*, *conflict* ($\alpha = 0.85$[1] and 0.87[1], attachment theory)	–	–	–	x	–

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TABLE 1 (Continued)

Study	Student sample					Educational context		Assessment of dyadic TSR-quality				Empirical analysis			
De Swart et al. (2023b), Netherlands	$M = 11.19$, $SD = 0.85$[1]	–	–	$n = 586$, judgment by local committees (88% male)	–	–	$n = 13$ (elem.)	n.r.	Climate Scale: *quality* ($\alpha = 0.90$[1], theory n.s.)	–	–	–	–	x	–
Henricsson and Rydell (2004), Sweden	7–8, $M = 7.50$	$n = 26$, teacher-ratings on the CBQ: acting out, inattention (77% male)	$n = 25$, teacher-ratings on the CBQ: emotional problems (32% male)	–	$n = 44$ TD	$n = 20$ (elem.)	–	$n = 23$ (class teachers)	self-constructed instrument: e.g., *When I meet my teacher, I feel…* 1 = very happy to 5 = very angry ($\alpha = 0.86$, theory n.s.)	STRS: *closeness*, *conflict*, *dependency* ($\alpha = 0.79$ and 0.83 and 0.64, attachment theory)	self-constructed observation form: *disruptive behavior corrections*, *mutual anger*, *positive interactions* ($\alpha = 0.82$ and 0.76 and 0.65, theory n.s.)	x	–	x	–
Kern et al. (2019), USA	13–18, $M = 15.25$[1]	$n = 166$, teacher or parent-ratings on the CBQ: internalizing or externalizing problems/student-ratings on the MSC-2: anxiety/student-ratings on the RADS: depression (75% male)		–	–	$n = 27$ (sec.)	–	$n = 93$ (mentors)	C&C survey: *relationship quality during Check and Connect* ($\alpha = 0.94$, theory n.s.)	C&C survey: *relationship quality during Check and Connect* ($\alpha = 0.89$, theory n.s.)	–	–	x	x	–
Knowles et al. (2020), USA	1st–6th grade	–	–	$n = 182$, identification n.s. (75% male)	–	–	$n =$ n.r. (elem.)	$n = 76$ (type n.s.)	CWAI: *bond*, *collaboration* ($\alpha = 0.82$ and 0.79, alliance model theory)	CWAI: *bond*, *collaboration* ($\alpha = 0.81$ and 0.89, alliance model theory)	–	–	x	–	–

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TABLE 1 (Continued)

Study	Student sample					Educational context		Assessment of dyadic TSR-quality				Empirical analysis			
Li et al. (2018), China	6–13, $M = 9.59$	$n = 256$, teacher interview based on DSM-criteria of ODD (73% male)	–	–	–	$n = 14$ (elem.)	–	$n =$ n.r. (class teachers)	STRS: computation of *closeness*, *conflict*, *supportiveness*, *satisfactoriness* ($\alpha = 0.93$[1], attachment theory)	–	–	–	–	x	–
Lin et al. (2016), China	$M = 9.65$, $SD = 1.59$	$n = 256$, teacher interview based on DSM-criteria of ODD (72% male)	–	–	–	$n = 14$ (elem.)	–	$n =$ n.r. (class teachers)	STRS: computation of *closeness*, *conflict*, *supportiveness*, *satisfactoriness* ($\alpha = 0.92$, attachment theory)	STRS: computation of *closeness*, *conflict*, *dependency* ($\alpha = 0.87$, attachment theory)	–	–	–	x	–
Little and Kobak (2003), USA	9–13, $M = 11.34$	–	–	$n = 20$, identification n.s. (85% male)	$n = 40$ TD	$n = 1$ (elem.)	$n = 1$ (elem.)	n.r.	EST: *emotional security with teacher* ($\alpha = 0.91$, attachment theory) School events diary: *negative teacher events*, *positive teacher events* ($\alpha =$ n.r., theory n.s.)	–	–	x	–	x	–
Loney et al. (1976), USA	n.r.	$n = 25$, teacher nomination of active students who are not referrable for professional help $n = 16$, teacher nomination of hyperactive students who are referrable for professional help (100% male)	–	–	$n = 93$ TD	$n = 1$ (elem.)	–	$n = 15$ (class teachers)	TADS: *teacher approval and disapproval* ($\alpha =$ n.r., theory n.s.)	–	–	x	–	–	–

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TABLE 1 (Continued)

Study	Student sample					Educational context		Assessment of dyadic TSR-quality				Empirical analysis			
Longobardi et al. (2019), Italy	4–10, $M = 7.67$	–	$n = 15$, n.s. identification of SM (48% male)	–	$n = 60$ TD	$n = 15$ (elem.)	–	$n = 15$ (prevalent teachers)	Y-CATS: *warmth*, *autonomy support*, *conflict* (α = n.r., attachment and self-determination theory)	STRS: *closeness*, *conflict* ($\alpha = 0.89$ and 0.83, attachment theory)	–	x	–	–	–
Meehan et al. (2003), USA	$M = 8.18$, $SD = 0.65$	$n = 140$, teacher-ratings on the CBCL: aggressive behavior, delinquency/peer-rated sociometric: aggressive behavior (66% male)	–	–	–	$n = 15$ (elem.)	–	n = n.r. (class teachers)	NRI: computation of *intimacy*, *affection*, *admiration*, *satisfaction*, *reliable alliance* ($\alpha = 0.93$[1], attachment theory)	–	–	–	–	x	–
Murray and Zvoch (2011), USA	$M = 13.42$[1], $SD = 1.48$[1]	$n = 64$, teacher-ratings on the CBCL: aggressive behavior, delinquency (45% male)	–	–	$n = 129$ TD	$n = 3$ (elem.)	–	$n = 19$ (type n.s.)	IT-SR: *communication*, *trust*, *alienation* ($\alpha = 0.86$[1] and 0.82[1] and 0.69[1], attachment theory)	STRS: *closeness*, *conflict* ($\alpha = 0.90$[1] and $\alpha = 0.82$[1], attachment theory)	–	x	–	x	–
Rogers et al. (2015), Canada	6–11, $M = 7.94$	$n = 35$, teacher-ratings on the SWAN-T: ADHD-symptoms (75% male)	–	–	$n = 36$ TD	$n = 2$ (elem.)	–	n.r.	CWAI: *bond*, *collaboration* (α = n.r., alliance model theory)	CWAI: *bond*, *collaboration* (α = n.r., alliance model theory)	–	x	–	x	–

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TABLE 1 (Continued)

Study	Student sample					Educational context		Assessment of dyadic TSR-quality				Empirical analysis			
Salisbury (2018), UK	n.r.	–	–	*n* = 5, identification n.s. (gender ratio n.r.)	–	*n* = 5 (elem.)	–	*n* = 5 (teachers supporting children on a 1:1 basis in class)	CARQ: *closeness*, *conflict* (α = n.r., attachment theory) Open questions: *Children were asked to comment as to whether they felt that the intervention had made a difference to their relationship with the adult.*	STRS: *closeness*, *conflict* (α = n.r., attachment theory) Open questions: *Teachers were asked to comment as to whether they felt that the intervention had made a difference to their relationship with the child.*)	Self-constructed observation form: *number of positive interaction*	–	–	–	x
Shechtman and Tutian (2016), Israel	10–15	*n* = 165, teacher-ratings on the Peer Nomination Instrument: verbal, physical, relational aggression (75% male)	–	–	–	*n* = 19 (elem.) *n* = 6 (sec.)	–	*n* = 44 (class teachers)	Empathy Scale: *teacher empathy* (α = 0.87, theory n.s.)	–	–	–	–	–	x
Spilt et al. (2021), Belgium	*M* = 8.32, *SD* = 0.97	–	–	*n* = 85, report of multi-disciplinary team (83% male)	–	–	*n* = 20 (elem.)	*n* = 70 (type n.s.)	CARTS: *closeness*, *conflict*, *dependency* (α = 0.81 and 0.86 and α = 0.75, attachment theory)	STRS: *closeness*, *conflict*, *dependency* (α = 0.81 and 0.86 and α = 0.75, attachment theory)	–	–	–	x	–

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TABLE 1 (Continued)

Study	Student sample					Educational context		Assessment of dyadic TSR-quality				Empirical analysis			
Taghvaienia and Zonobitabar (2020), Iran	15–18, $M = 17.00$	–	$n = 60$, student-ratings on the BDI: depressive symptoms (100% female)	–	–	$n = 4$ (sec.)	–	n.r.	IT-SR: *communication, trust, alienation* ($\alpha = 0.78$ and 0.82 and $\alpha = 0.76$, attachment theory)	–	–	–	–	–	x
Van Loan and Garwood (2018), USA	$M = 13.3$, $SD = 1.1$	–	–	$n = 92$, identification n.s. (75% male)	–	$n = 9$ (sec.)	–	$n = 11$ (class teachers)	STRS-SV: *closeness*, *conflict* ($\alpha = 0.93$ and $\alpha = 0.81$, attachment theory)	STRS-RT: *closeness*, *conflict* ($\alpha = 0.91$ and $\alpha = 0.96$, attachment theory)	–	x	–	–	–
Vervoort et al. (2015), Belgium	$M = 8.45$[1], $SD = 1.08$[1]	–	–	$n = 82$, identification n.s. (83% male)	$n = 145$ TD	$n =$ n.r. (elem.)	$n =$ n.r. (elem.)	n.r.	CARTS: *closeness*, *conflict*, *dependency* ($\alpha = 0.81$ and 0.89 and $\alpha = 0.75$, attachment theory)	STRS: *closeness, conflict, dependency* ($\alpha =$ n.r., attachment theory) STRS-diary: *closeness*, *conflict*, *dependency* ($\alpha =$ n.r., attachment theory)	–	x	–	x	–

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TABLE 1 (Continued)

Study	Student sample					Educational context		Assessment of dyadic TSR-quality				Empirical analysis			
Zee et al. (2020b), Netherlands	7–13, $M = 10.23$	$n = 91$, n.s. diagnosis of ADHD (gender ratio n.r.)	–	–	$n = 28$ ASD, $n = 73$ dyslexia	$n = 24$ (elem.)	–	n.r.	SPARTS: *closeness*, *conflict* ($\alpha = 0.87$ and $\alpha = 0.87$, attachment theory)	STRS: *closeness*, *conflict* ($\alpha = 0.86$ and $\alpha = 0.88$, attachment theory)	peer-rated sociometric questionnaire based on STRS: *closeness*, *conflict* ($\alpha = 0.82$ and $\alpha = 0.96$, attachment theory)	–	–	x	–
Zweers et al. (2021), Netherlands	$M = 10.01$[1], $SD = 1.02$[1]	–	–	$n = 36$ in RE, identification n.s. (67% male) $n = 15$ educated SE, identification n.s. (83% male)	$n = 664$ TD	$n =$ n.r. (elem.)	$n =$ n.r. (elem.)	n.r.	SPARTS: *conflict* ($\alpha = 0.79$[1], attachment theory)	–	–	x	–	x	–

a, analysis of mean differences comparing dyadic TSR-quality from the perspectives of students with and without EBPs. b, analysis of mean differences comparing dyadic TSR-quality from the perspectives of students with EBPs and their teachers. c, correlation analysis examining associations between dyadic TSR-quality from the perspective of students with EBPs and their social–emotional, academical, cognitive, or demographical state or development. d, outcome analysis evaluating whether an intervention improves dyadic TSR-quality from the perspective of student with EBPs. [1]Value was calculated using available values of the study. [2]Scales from both instruments were computed to an overall scale. n.s., not specified; n.r., not reported; Elem., elementary; Sec., secondary; ADHD, attention deficit hyperactivity disorder; ASD, autism spectrum disorder; ODD, oppositional defiant disorder; SEBD, social, emotional, and behavioral difficulties; SM, selective mutism; DSM, Diagnostic and statistical manual of mental disorders; RE, regular education; SE, special education.

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TABLE 2 Mean differences between dyadic TSR-quality in students with and without EBPs.

Study	Rating perception	TSR dimension	Results	Effect size	
				Cohen's *d*	Other effect size as reported in the study
Al-Yagon (2016)	Student	Availability/acceptance	$M_{TD} > M_{EP}$	0.12[1], ns	$\eta^2 = 0.00$[5], p = n. r.
		Rejection	$\boldsymbol{M_{EP} > M_{TD}}$	**0.31**[1]*	$\eta^2 = 0.02$[5], p = n. r.
Baker et al. (2009)	Student	Authoritative teaching	$\boldsymbol{M_{TD} > M_{EP}}$	**0.26**[1]*	–
Henricsson and Rydell (2004)	Student	Overall rating[2]	$\boldsymbol{M_{EP} > M_{TD}}$	**0.58**[1]*	–
			$M_{IP} > M_{TD}$	0.02[1], ns	–
	Teacher	Conflict	$\boldsymbol{M_{EP} > M_{TD}}$	**2.02**[1]***	–
			$\boldsymbol{M_{IP} > M_{TD}}$	**0.70**[1]**	–
		Closeness	$M_{TD} > M_{EP}$	0.14[1], ns	–
			$M_{TD} > M_{IP}$	**0.47**[1]*	–
		Dependency	$\boldsymbol{M_{EP} > M_{TD}}$	**1.04**[1]***	–
			$\boldsymbol{M_{IP} > M_{TD}}$	**0.95**[1]***	–
Little and Kobak (2003)	Student	Emotional security with teacher	$M_{TD} \approx M_{SEBD}$[3]	–	–
		Negative teacher events	$\boldsymbol{M_{SEBD} > M_{TD}}$	**0.95**[1]***	–
		Positive teacher events	$M_{SEBD} > M_{TD}$	0.16[1], ns	–
		Worst day-event involving the teacher	$\boldsymbol{M_{SEBD} > M_{TD}}$	**0.85**[1]**	–
		Best day-event involving the teacher	$M_{SEBD} > M_{TD}$	0.22[1], ns	–
Loney et al. (1976)	Student	Academic approval	$M_{TD} > M_{EP(a)}$[4]	–	–
			$\boldsymbol{M_{TD} > M_{EP(b)}}$*[4]	–	–
		Motivational approval	$M_{TD} > M_{EP(a)}$[4]	–	–
			$\boldsymbol{M_{TD} > M_{EP(b)}}$*[4]	–	–
		Social approval	$\boldsymbol{M_{TD} > M_{EP(a)}}$***[4]	–	–
			$\boldsymbol{M_{TD} > M_{EP(b)}}$***[4]	–	–
		General approval	$M_{TD} > M_{EP(a)}$[4]	–	–
			$M_{TD} > M_{EP(b)}$[4]	–	–
		Academic disapproval	$\boldsymbol{M_{EP(a)}}$[4] $\boldsymbol{> M_{TD}}$*	–	–
			$M_{EP(b)}$[4] $> M_{TD}$	–	–
		Motivational disapproval	$\boldsymbol{M_{EP(a)}}$[4] $\boldsymbol{> M_{TD}}$*	–	–
			$M_{TD} > M_{EP(b)}$[4]	–	–
		Social disapproval	$\boldsymbol{M_{EP(a)}}$[4] $\boldsymbol{> M_{TD}}$**	–	–
			$M_{EP(b)}$[4] $> M_{TD}$	–	–
		general disapproval	$\boldsymbol{M_{EP(a)}}$[4] $\boldsymbol{> M_{TD}}$**	–	–
			$\boldsymbol{M_{EP(b)}}$[4] $\boldsymbol{> M_{TD}}$**	–	–
Longobardi et al. (2019)	Student	Warmth	$M_{TD} > M_{IP}$	0.34[1], ns	$\eta^2 = 0.03$, ns
		Autonomy support	$M_{IP} > M_{TD}$	0.04[1], ns	$\eta^2 = 0.00$, ns
		Conflict	$M_{TD} > M_{IP}$	0.15[1], ns	$\eta^2 = 0.00$, ns
	Teacher	Closeness	$\boldsymbol{M_{TD} > M_{IP}}$	**0.90**[1]**	**r = 0.41****
		Conflict	$M_{IP} > M_{TD}$	0.24[1], ns	$r = 0.12$, ns

(Continued)

TABLE 2 (Continued)

Study	Rating perception	TSR dimension	Results	Effect size	
				Cohen's *d*	Other effect size as reported in the study
Murray and Zvoch (2011)	Student	Communication	$M_{TD} > M_{EP}$	0.09[1], ns	–
		Trust	$\mathbf{M_{TD} > M_{EP}}$	**0.41**[1]*	–
		Alienation	$M_{EP} > M_{TD}$	0.30[1], ns	–
	Teacher	Closeness	$\mathbf{M_{TD} > M_{EP}}$	**0.74**[1]*	–
		Conflict	$\mathbf{M_{EP} > M_{TD}}$	**1.91**[1]*	–
Rogers et al. (2015)	Student (boys)	Bond	$M_{EP} > M_{TD}$	0.09[1], ns	–
		Collaboration	$M_{TD} > M_{EP}$	0.27[1], ns	–
	Student (girls)	Bond	$\mathbf{M_{TD} > M_{EP}}$	**1.28**[1]*	–
		Collaboration	$\mathbf{M_{TD} > M_{EP}}$	**1.62**[1]*	–
	Teacher	Bond	$\mathbf{M_{TD} > M_{EP}}$	**4.67**[1,6]**	$\mathbf{\eta^2 = 0.14}$**
		Collaboration	$\mathbf{M_{TD} > M_{EP}}$	**1.13**[1]**	$\mathbf{\eta^2 = 0.19}$**
Vervoort et al. (2015)	Student	Closeness	$\mathbf{M_{TD} > M_{SEBD}}$	**0.25**[1]*	–
		Conflict	$\mathbf{M_{SEBD} > M_{TD}}$	**1.12**[1]*	–
		Dependency	$\mathbf{M_{SEBD} > M_{TD}}$	**0.47**[1]*	–
Zweers et al. (2021)	Student	Conflict	$\mathbf{M_{SEBD\ in\ SE} > M_{TD}}$*[7]	–	–
			$M_{SEBD\ in\ RE} > M_{TD}$	–	–

EP, externalizing problems; IP, internalizing problems; SEBD, social, emotional, and behavioral difficulties (special educational needs); TD, typically developed; SE, special education; RE, regular education.

[1]Effect sizes were self-calculated using available values from the study. [2]Higher values indicate poorer TSR-quality. [3]The ratings of the two groups (SEBD vs. TD) did not significantly differ, but exact values were not reported. [4]EP(a) refers to active students and EP(b) to hyperactive students. [5]This effect size refers to the mean differences between three student groups (EP, TD, LD). [6]This very high self-calculated effect size of $d = 4.76$ might be due to ceiling effects as well as very small standard deviations within the data (On a five-point scale, teachers rated bond with $M = 4.32$ ($SD = 0.09$) for students with externalizing problems and with $M = 4.74$ ($SD = 0.09$) for the TD-group.) [7]This significance value is based on non-overlapping Bayesian 95% CI.

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$, ns, not significant. *̲/ns = significance/non-significance was self-calculated (95% CI) using available values from the study. Written in bold, significant effect sizes.

TABLE 3 Mean differences between dyadic TSR-quality as perceived by students with EBPs and their teachers.

Authors	Sample	TSR-dimensions	Results	Effect size (Cohen's *d*)
Kern et al. (2019)	EP/IP	Relationship quality during mentoring program	$M_{SP} > M_{TP}$	0.22, ns[3]
Knowles et al. (2020)	SEBD	Bond	$M_{SP} > M_{TP}$	0.31[1], p = n.r.
		Task/goal (collaboration)	$M_{SP} > M_{TP}$	0.56[1], p = n.r.
Van Loan and Garwood (2018)	SEBD	Closeness	$M_{SP} > M_{TP}$	0.25[1], ns[4]
		Conflict	$\mathbf{M_{SP} > M_{TP}}$	**0.47**[1]**[4]
Vervoort et al. (2015)	SEBD	Closeness	$M_{SP} > M_{TP}$	0.36[1], p = n.r.
		Conflict	$M_{SP} > M_{TP}$	0.42[1], p = n.r.
		Dependency[2]	$M_{SP} > M_{TP}$	1.08[1], p = n.r.

[1]Effect sizes were self-calculated using available values from the study. [2] Vervoort et al. (2015) suggested that students possibly assign a more positive value to dependency as compared to their teachers. [3]Significance is based on dependent t-test. [4]Significance is based on independent t-test.

EP, externalizing problems; IP, internalizing problems; SEBD, social, emotional, and behavioral difficulties (special educational needs); SP, student-perception; TP, teacher-perception. n.r., not reported.

**$p < 0.01$, ns, not significant. Written in bold, significant effect sizes.

studies, student-rated dyadic TSR was examined as an independent variable, while four studies considered it a dependent variable. Three studies conducted bidirectional analyses, meaning TSR was both a predictor and an outcome. Spilt et al. (2021) performed correlation analyses, using TSR as construct variable within construct validity analyses. Table 4 describes the variables assessed in the respective studies and their significant associations with dyadic TSR-quality as perceived by students with EBPs. Where available, it also provides information about significant associations between the assessed variables and dyadic TSRs from the perspectives of TD-students (e.g., Al-Yagon, 2016) or teachers (e.g., Murray and Zvoch, 2011).

The variables assessed for their associations with student-perceived TSRs can be grouped into nine partly overlapping areas.

Concerning *(1) students' disruptive behavior*, longitudinal findings suggested bidirectional links between dyadic TSR-quality from the

TABLE 4 Associations between dyadic TSRs in students with EBPs aspects of their state or development.

Authors	Design	Variables assessed for their associations with dyadic TSRs		Sample	Significant associations with student-perceived dyadic TSRs	Significant associations with teacher-perceived dyadic TSRs
Al-Yagon (2016)	cross-sectional, TSR as independent variable	(1)	Student-rated externalizing problems	EP	- *Rejection* positively predicts externalizing problems.	- n.a.
				TD	- *Rejection* positively predicts externalizing problems. - *Availability/acceptance* negatively predicts externalizing problems.	- n.a.
		(5)	Student-rated negative affect, student-rated positive affect, student-rated internalizing problems	EP	- none	- n.a.
				TD	- *Rejection* positively predicts externalizing problems and internalizing problems. - *Availability/acceptance* negatively predicts internalizing problems.	- n.a.
		(6)	Student-rated peer-network loneliness, student-rated peer-dyadic loneliness	EP	- none	- n.a.
				TD	- none	- n.a.
Baker et al. (2009)	Cross-sectional (with moderation), TSR as independent variable	(2)	Teacher-rated classroom adjustment	EP	- *Authoritative teaching* positively predicts classroom adjustment.	- n.a.
				TD	- *Authoritative teaching* positively predicts classroom adjustment.	- n.a.
		(3)	Student-rated school satisfaction, student-rated academic competence, reading or language art grades	EP	- *Authoritative teaching* positively predicts school satisfaction and academic competence.	- n.a.
				TD	- *Authoritative teaching* positively predicts school satisfaction and academic competence.	- n.a.
Decker et al. (2007)	Cross-sectional, TSR as independent variable	(1)	Teacher-reported numbers of behavior referrals, teacher-reported numbers of suspensions	EP	- *Proximity seeking* positively predicts behavior referrals and suspensions. - *Emotional quality* negatively predicts behavior referrals and suspensions.	- *Relationship quality* negatively predicts behavior referrals and suspensions.
					- *Relationship pattern* negatively predicts behavior referrals and suspensions.	
		(2)	Student-rated social skills, teacher-rated social skills	EP	- *Relationship pattern* positively predicts student- and teacher-rated social skills.	
		(3)	Observed academic engaged time, curriculum-based measurement (reading), tested letter naming fluency, student-rated engagement, teacher-rated engagement	EP	- *Emotional quality* positively predicts academic engaged time. - *Proximity seeking* positively predicts letter naming fluency.	- none
					- *Relationship pattern* positively predicts student- and teacher-rated engagement.	

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TABLE 4 (Continued)

Authors	Design	Variables assessed for their associations with dyadic TSRs		Sample	Significant associations with student-perceived dyadic TSRs	Significant associations with teacher-perceived dyadic TSRs
De Swart et al. (2023a)	Longitudinal (bidirectional, partly with moderation), TSR as independent and dependent variable	(1)	Teacher-rated externalizing problems, teacher rated ADHD-symptoms	SEBD	- *Quality* at T1 (in February) positively predicts ADHD-symptoms at T2 (in June). - The association between *quality* at T1 and externalizing problems at T2 is moderated by the severity of externalizing problems (i.e., for students with low externalizing problems, *quality* positively predicts externalizing problems and for students with high externalizing problems, *quality* negatively predicts externalizing problems).	- *Conflict* at T1 (in February) positively predicts externalizing problems at T2 (in June). - Externalizing problems and ADHD-symptoms at T1 positively predict *conflict* at T2.
		(7)	Student-rated quality, teacher-rated closeness, teacher-rated satisfaction	SEBD	- *Quality* at T1 (in February) positively predicts *satisfaction* at T2 (in June)	
		(4)	Student-rated classroom structure	SEBD	- Structure at T1 (in February) positively predicts *quality* at T2 (in June). - *Quality* at T1 positively predicts structure at T2.	- none
De Swart et al. (2023b)	Longitudinal (bidirectional), TSR as independent and dependent variable	(2)	Teacher-rated social competence, student-rated social competence	SEBD	- none	- n.a.
		(4)	Student-rated classroom structure	SEBD	- Structure at T1 (in February) positively predicts *quality* at T2 (in June). - *Quality* at T1 positively predicts structure at T2.	- n.a.
Kern et al. (2019)	Cross-sectional, TSR as dependent variable	(7)	Student-rated helpfulness of school talk, future plans talk, family talk, or friendship talk	EP/IP	- Perceived helpfulness of school talk and future plans talk positively predicts *relationship quality* during mentoring program (Check and Connect).	- Perceived helpfulness of family talk and friendship talk positively predicts *relationship quality* during mentoring program (Check and Connect).
		(9)	teacher-student gender match, teacher-student ethnical minority status match	EP/IP	- none	- none

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TABLE 4 (Continued)

Authors	Design	Variables assessed for their associations with dyadic TSRs		Sample	Significant associations with student-perceived dyadic TSRs	Significant associations with teacher-perceived dyadic TSRs
Li et al. (2018)	Cross-sectional and longitudinal (bidirectional), TSR as independent and dependent variable	(1)	Parent-rated ODD-symptoms, teacher-rated ODD-symptoms	EP	- Cross-sectionally, *relationship quality* negatively correlates with parent- as well as teacher rated ODD-symptoms. - T1 *relationship quality* negatively predicts T2 teacher-rated ODD-symptoms (1 year later). - T1 parent- and teacher-rated ODD-symptoms negatively predict T2 *relationship quality* (1 year later).	- n.a.
		(7)	Student-rated relationship quality	EP	- T1 *relationship quality* positively predicts T2 and T3 *relationship quality* (1 resp. 2 years later). - T2 *relationship quality* positively predicts T3 *relationship quality* (1 year later).	- n.a.
Lin et al. (2016)	Cross-sectional, TSR as dependent variable	(8)	Parent-rated emotional abuse, emotional neglect, or physical abuse	EP	- Emotional abuse negatively predicts *relationship quality*	- none
Little and Kobak (2003)	Cross-sectional (with moderation), TSR as independent variable	(5)	Student-rated self-esteem	SEBD	- SEBDs moderate the association between *negative teacher* events and self-esteem (i.e., for student with SEBDs, there is a higher negative association between *negative teacher events* and self-esteem than for their TD-peers). - *Emotional security* moderates the association between self-esteem and *negative teacher* events (i.e., for students with high *emotional security,* the negative association between *negative teacher events* and self-esteem is lower than for students with low *emotional security*).	- n.a.
				TD	- none	- n.a.
Meehan et al. (2003)	Cross-sectional and longitudinal (unidirectional), TSR as independent variable	(1)	Teacher-rated aggressive behavior, student-rated aggressive behavior	EP	- T2 *teacher support* negatively predicts T2 teacher-rated aggressive behavior.	- n.a.
		(1)/(7)	Parent-rated negative parenting (as moderator of the association between TSRs and aggressive behavior)	EP	- none	- n.a.
		(1)/(9)	Students' ethnical minority status (as moderator of the association between TSRs and aggressive behavior)	EP	- Minority status moderates the cross-sectional association between *teacher support* and teacher- as well as student-rated aggressive behavior (i.e., the negative association between *teacher support* and aggression is stronger for Black and Hispanic children than for White children).	- n.a.

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TABLE 4 (Continued)

Authors	Design	Variables assessed for their associations with dyadic TSRs		Sample	Significant associations with student-perceived dyadic TSRs	Significant associations with teacher-perceived dyadic TSRs
Murray and Zvoch (2011)	Cross-sectional, TSR as independent variable	(1)	Student-rated conduct problems, teacher-rated externalizing problems	EP	- *Alienation* positively predicts conduct problems.	- *Conflict* positively predicts externalizing problems.
		(2)	Teacher-rated school competence	EP	- *Trust* positively predicts school competence.	- *Closeness* positively predicts school competence.
		(3)	Student-rated school satisfaction, teacher-rated academic competence, teacher-rated school engagement	EP	- *Communication* positively predicts school satisfaction.	- *Closeness* positively predicts academic competence and school engagement. - *Conflict* negatively predicts school engagement.
		(5)	Student-rated depressive symptoms, student-rated life satisfaction	EP	- *Alienation* positively predicts depressive symptoms. - *Communication* positively predicts life satisfaction.	- none
Rogers et al. (2015)	Cross-sectional, TSR as independent variable	(3)	student-rated academic motivation	EP	- *Bond* positively predicts academic motivation.	- none
				TD	- *Collaboration* positively predicts academic motivation.	- *Collaboration* positively predicts academic motivation.
Spilt et al. (2021)	Cross-sectional, TSR as correlation/construct variable	(7)	observed task completion, negativity, teacher guidance, and resolution during Autobiographical Emotional Events Dialogue (AEED)	SEBD	- *Closeness* positively correlates with task completion and resolution. - *Closeness* negatively correlates with negativity. - *Conflict* negatively correlates with task completion, teacher guidance, and resolution.	- *Conflict* positively correlates with negativity.
Vervoort et al. (2015)	Cross-sectional, teacher-rated TSR as independent variable, student-rated TSR as dependent variable	(3)	Student-rated feelings about school	SEBD	- none	- n.a.
				TD	- Feelings about school positively predict *closeness*. - Feelings about school negatively predict *conflict*.	- n.a.
		(7)	Student-rated feelings about the teacher	SEBD	- Feelings about the teacher positively predict *closeness* and *dependency*. - Feelings about the teacher negatively predict *conflict*.	- n.a.
				TD	- Feelings about the teacher positively predict *closeness*. - Feelings about the teacher negatively predict *conflict*.	- n.a.
			Teacher- and student-rated closeness, conflict, and dependency (scales), teacher-rated closeness, conflict, and dependency (diary)	SEBD	- Teacher-rated *closeness* (scale) positively predicts student-rated *closeness*. - Teacher-rated *closeness* (scale) negatively predicts student-rated *conflict*. - Teacher-rated *conflict* (scale and diary) positively predict student-rated *conflict*. - Teacher-rated *conflict* (diary) negatively predicts student-rated *closeness*.	

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TABLE 4 (Continued)

Authors	Design	Variables assessed for their associations with dyadic TSRs		Sample	Significant associations with student-perceived dyadic TSRs	Significant associations with teacher-perceived dyadic TSRs
Zee et al. (2020b)	Longitudinal (unidirectional), TSR as dependent variable	(1)	Teacher reported ADHD	EP	- none	- ADHD at T1 positively predicts *conflict* at T2 (3 months later).
Zweers et al. (2021)	Longitudinal (unidirectional), TSR as dependent variable	(1)	Teacher-rated externalizing problems	SEBD	- none	- n.a.
		(3)	Tested academic performance (reading, spelling, math)	SEBD	- none	- n.a.
		(4)	School type (regular school vs. special school)	SEBD in special schools	- For students with SEBDs, who were supported in special schools from T2 onwards, *conflict* significantly decreased over 1.5 years.	- n.a.
				SEBD in regular schools	- none	- n.a.
				TD	- none	- n.a.
		(5)	Student-rated self-esteem, teacher-rated internalizing problems	SEBD	- none	- n.a.
		(6)	Peer-rated peer acceptance	SEBD	- none	- n.a.
		(7)	Student-rated conflict	SEBD	- *Conflict* at T1 (before students with SEBDs were provided with additional support) positively predicts student-rated *conflict* at T2 (after students with SEBDs were provided with special educational support in regular and special schools).	- n.a.
		(9)	Students' gender, students' age	SEBD	- Students' gender (i.e., being a girl) at T1 positively predicts *conflict* at T2.	- n.a.

(1) Disruptive behavior. (2) Prosocial behavior. (3) Academic performance, behavior, or feelings. (4) School/classroom structure. (5) Affective-emotional state or satisfaction. (6) Student–student interactions or relationships. (7) Teacher–student interactions or relationships. (8) Parent–child interactions or relationships. (9) Demographic aspects. EP, externalizing problems; IP, internalizing problems; SEBD, social, emotional, and behavioral difficulties (special educational needs). Written in italics = TSR-dimension. n.a., not assessed.

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perspective of students with EBPs and their oppositional behavior (Li et al., 2018). Another longitudinal study (De Swart et al., 2023a) and cross-sectional analyses (Al-Yagon, 2016; Decker et al., 2007; Li et al., 2018; Meehan et al., 2003; Murray and Zvoch, 2011) demonstrated that TSRs from the perspective of students with EBPs predicted the severity of their externalizing problems, such as conduct problems, aggressive and oppositional behavior, hyperactivity, or disturbing behavior in class.

Among the cross-sectional studies analyzing *(2) students' prosocial behavior*, dyadic TSRs were identified as significant predictors of classroom adjustment (Baker et al., 2009), social skills (Decker et al., 2007), and school competence (Murray and Zvoch, 2011).

Regarding *(3) academic performance, behavior or feelings*, significant cross-sectional associations were found between dyadic TSRs (as the independent variable) and academic competence (Baker et al., 2009), academic engagement (Decker et al., 2007), academic motivation (Rogers et al., 2015), school satisfaction (Baker et al., 2009; Murray and Zvoch, 2011), and reading fluency (Decker et al., 2007) among students with EBPs.

In terms of *(4) school/classroom structure*, longitudinal and bidirectional influences were indicated between dyadic TSR-quality from the perspective of students with EBPs and teachers' classroom structure (De Swart et al., 2023a; De Swart et al., 2023b). Zweers et al. (2021) examined TSR-trajectories across four measurement time points over 1.5 years. For students with EBPs who were supported in special schools self-perceived TSR-*conflict* decreased significantly over time, whereas TSR-*conflict* from the perspective of students with EBPs who remained in regular schools did not change significantly.

Cross-sectional studies examining *(5) students' affective-emotional state or satisfaction* found that dyadic TSRs from the perspective of students with EBPs significantly predicted their depression as well as life satisfaction (Murray and Zvoch, 2011). Furthermore, Little and Kobak (2003) identified a negative association between negative teacher-student interactions and students' self-esteem. They further demonstrated that this association was lower for students with highly perceived dyadic TSR-quality.

Two studies (Al-Yagon, 2016; Zweers et al., 2021) examined cross-sectional links between dyadic TSRs and *(6) peer-relationships* but did not find significant results.

Regarding *(7) teacher-student interactions or relationships*, significant cross-sectional associations were found between dyadic TSRs from the perspective of students with EBPs and the quality of teacher-student interactions during a mentoring program (Kern et al., 2019) as well as during teacher-child dialogues about children's emotional experiences (Spilt et al., 2021). As part of an instrument validation, Vervoort et al. (2015) revealed cross-sectional associations between TSR-dimensions from the perspective of students with EBPs and their teachers. Li et al. (2018) as well as Zweers et al. (2021) showed that dyadic TSRs from the perspective of students with EBPs persisted longitudinally, and De Swart et al. (2023a) indicated that student-rated TSR-quality longitudinally predicted teacher-rated TSRs.

In terms of *(8) parent–child relationships*, Lin et al. (2016) found that parents' emotional abuse significantly predicted student-perceived dyadic TSRs in a cross-sectional analysis.

In terms of *(9) demographic aspects*, the cross-sectional analysis by Meehan et al. (2003) showed that dyadic TSR was a stronger predictor for aggressive behavior in Black and Hispanic children that it was in White children with EBPs. Zweers et al. (2021) found that being a girl with EBPs longitudinally worsened dyadic TSR-quality.

In almost all studies, the signs (positive or negative) of the significant associations between dyadic TSR-dimensions from the perspective of students with EBPs and their social–emotional, behavioral, academic, cognitive, or demographic aspects aligned with expectations. That is, positive TSR-dimensions (like *emotional quality*) were positively related to competencies or strengths (such as academic engagement) and negatively related to difficulties (such as oppositional behavior). Likewise, negative dimensions of TSRs (like *alienation*) were positively linked to difficulties and negatively associated with competencies or strengths. However, Decker et al. (2007) found an unexpected positive link between *proximity seeking* and letter naming fluency. Vervoort et al. (2015) observed an unexpected positive association between *dependency* and feelings about the teacher. Furthermore, De Swart et al. (2023a) found an unexpected positive association between student-rated TSR-quality and ADHD-symptoms.

Those eight studies that included both students' and teachers' perspectives of dyadic TSRs indicated that both viewpoints can have varying levels of importance regarding the assessed variables. For example, in the study by Murray and Zvoch (2011), student-rated dyadic TSRs were significantly linked to students' depressive symptoms, whereas teacher-rated dyadic TSRs were not. The study by Decker et al. (2007) was the only one that examined the TSR-pattern between teacher- and student-perspectives. They developed a three-level scale representing negative agreement (both student and teacher low in TSR-quality), disagreement (one high in TSR-quality and one low), and positive agreement (both high in TSR-quality). This pattern-scale was found to be negatively associated with disruptive, prosocial, and academic behavior.

Four out of five studies that not only examined students with EBPs but also included TD-students indicated that TSRs can have different effects in these two distinct groups. For example, Little and Kobak (2003) found that SEBDs moderated the association between negative teacher events and students' self-esteem. That is, for students with special educational needs due to SEBDs, there was a higher negative association between dyadic TSRs (negative teacher events) and self-esteem than for their TD-peers.

4.4.4 Intervention studies evaluating if an intervention can improve dyadic TSR-quality from the perspective of students with EBPs

Table 5 describes the three studies that evaluated whether an intervention improved dyadic TSR-quality from the perspective of students with EBPs. The three interventions are quite different and target varying student groups, yet all demonstrated improvements in dyadic TSRs.

Salisbury (2018) investigated whether 10 min of attachment-enhancing play, such as bubble tennis, conducted over 2 weeks, could improve dyadic TSR-quality in elementary school students identified with special educational needs due to SEBDs. The study found a decrease in TSR-*conflict* and an increase in TSR-*closeness* from both students' and teachers' perspectives.

TABLE 5 Interventions that aim to improve dyadic TSRs from the perspective of students with EBPs.

Authors	Design	Intervention		Sample	Impact on student-perceived dyadic TSRs	Impact on teacher-perceived dyadic TSRs
		Description	Duration			
Salisbury (2018)	Mixed methods, i.e., pre-post-test design with single cases ($n = 5$) and qualitative interviews to gather perspectives on TSRs after the intervention	attachment enhancing activities based on Theraplay	10 min. daily for 2 weeks	SEBD	- *Closeness* improved for 3 out of 5 children with an average improvement of 3%. - *Conflict* decreased for 2 out of 5 children with an average decrease of 22%. - experienced improvement of relationship (e.g., "I think it helped us get on better.")	- *Closeness* improved for 4 out of 5 children with an average improvement of 10%. - *Conflict* decreased for 5 out of 5 children with an average decrease of 16%. - experienced improvement of relationship (e.g., "I do feel that the activities have created a bond between the child and me.")
Shechtman and Tutian (2016)	pre-post-test design with intervention ($n = 109$) and control group ($n = 56$) comparison (not randomized)	teacher training for aggressive children	12 × 4h sessions for theoretical training +12 × 45min. practice with students	EP	- For the intervention group, *teacher empathy* increased with an effect size of $\eta^2 = 0.113$ ($p < 0.001$). - *Teacher empathy* increased significantly more in the intervention group as compared to the control group.	n.a.
Taghvaienia and Zonobitabar (2020)	Pre-post-test design with intervention ($n = 27$) and control group ($n = 26$) comparison (randomized)	positive intervention based on the principles of positive psychology	2 h weekly for 8 weeks	IP	- For the intervention group *communication* and *trust* increased with effects of $d = 0.17$ ($p < 0.01$) and $d = 0.14$ ($p < 0.01$) and *alienation* decreased with an effect of $d = 0.11$ ($p < 0.05$).	n.a.

EP, externalizing problems; IP, internalizing problems; SEBD, social, emotional, and behavioral difficulties (special educational needs). n.a., not assessed.

Additionally, both teachers and students verbally expressed that their dyadic TSRs improved as a result of the intervention.

Shechtman and Tutian (2016) evaluated an intervention comprising two phases: teacher training and teacher practice with aggressive children. During the training phase, teachers were educated about the unique characteristics of aggressive behavior, whereas in the practice phase they applied their newly acquired knowledge with the participating students. The aim was to help aggressive children in becoming aware of their behavior, understanding its triggers, developing motivation for change, and learning skills for self-control. As compared to the control group, the intervention group showed an increase in student-perceived teacher empathy. This heightened empathy, in turn, contributed to a reduction of aggressive student behavior.

Taghvaienia and Zonobitabar (2020) conducted 2-h sessions of *Positive Psychology* over 8 weeks. In these sessions, led by specialized coaches, secondary school girls with internalizing problems learned about principles of *Positive Psychology*, such as understanding feelings and emotions, discovering strengths, reinterpreting unhappy emotional experiences, and enhancing communication skills. The intervention group exhibited an increase in perceived TSR-*communication* and -*trust*, along with a decrease in TSR-*alienation*.

5 Discussion

This systematic scoping review aimed to synthesize the current research on dyadic TSRs as perceived by students with EBPs, encompassing those with externalizing problems, internalizing problems, or with special educational needs due to SEBDs. The central research question was: How has research on dyadic TSRs from the perspective of students with EBPs been conducted, and what insights have been gained to date? This question was divided into four sub-questions. Research question 1 focused on identifying the types of EBPs among students who were surveyed on their dyadic TSRs. Research question 2 explored the educational settings in which students with EBPs were surveyed about their dyadic TSRs. Research question 3 delved into how dyadic TSRs from the perspective of students with EBPs were assessed, and the answers to research question 4 summarized empirical analyses that were conducted using the dyadic TSR-perspective of students with EBPs.

The answers to research question 4 allow us to identify five overarching conclusions, including main findings and practical implications. By recognizing the limitations of these conclusions alongside the answers to research questions 1, 2, and 3, we can further delineate 10 key future needs in student-perceived TSR-research.

5.1 Empirical findings and practical implications

Conclusion one: Students with EBPs and their teachers seem to experience more stressful relationships with each other than TD-students and their teachers do. Thus, it is crucial to create positive relationship-experiences that counteract the negative ones.

The synthesized body of research (Al-Yagon, 2016; Baker et al., 2009; Henricsson and Rydell, 2004; Little and Kobak, 2003; Loney et al., 1976; Longobardi et al., 2019; Murray and Zvoch, 2011; Rogers et al., 2015; Vervoort et al., 2015; Zweers et al., 2021) indicates that students with EBPs – particularly those with externalizing problems and special educational needs due to SEBDs – experience more stressful interactions with their teachers than their TD-peers do. Consequently, they seem to form mental representations in which the dyadic relationship with the teacher is memorized as being bad or difficult. Teachers appear to undergo similar experiences, also perceiving their interactions with students with EBPs as more stressful compared to those with TD-students, leading to more negatively perceived relationships with students with EBPs (Henricsson and Rydell, 2004; Longobardi et al., 2019; Murray and Zvoch, 2011; Rogers et al., 2015).

Research by Li et al. (2018) and Zweers et al. (2021) illustrates that once students with EBPs establish a TSR representation, it tends to persist over time. Therefore, a negative perception of a dyadic TSR may endure if not corrected by positive relationship experiences, such as those facilitated within relationship-specific interventions (see conclusions 2, 3, and 4 for further indications).

Conclusion two: Relationship-specific interventions for students with EBPs appear to be effective when they either address individual characteristics of teachers or students, teacher-student interactions, or contextual influences.

According to the developmental systems theory, relationship-specific interventions can focus on individual characteristics of the relationship partners, teacher-student interactions, their individual TSR-representations, or on contextual factors (Spilt et al., 2022).

The teacher training, as evaluated by Shechtman and Tutian (2016), began by altering individual characteristics of teachers, specifically focusing on their understanding of the causes of aggressive behavior (e.g., low levels of empathy and self-control). The authors assumed that the enhanced knowledge led teachers to behave more sensitive towards aggressive children, thereby positively influencing teacher-student interactions. These modified interactions, in turn, led students feeling more understood and accepted, resulting in improved TSR representations. Salisbury's (2018) findings suggest that the joy experienced by students with special educational needs and their teachers during daily attachment-enhancing play (i.e., during interactions) improved their TSR-representations. This improvement, in turn, may have fostered more positive mutual behaviors and feelings in their everyday school life. The intervention as evaluated by Taghvaienia and Zonobitabar (2020) focused on individual characteristics of students with internalizing problems by teaching them mechanisms of *Positive Psychology*, such as satisfaction, present happiness, and future hope. These newly acquired skills may have influenced their interactional behaviors towards the teacher, such as communicating about stress. This, in turn, might have changed how teachers reacted to them and, thus, improved students' TSR-representations.

Even though these three intervention studies have very different focuses, they all share the assumption that changes in teacher-student interactions are linked to changes in TSR-representations. The results of Spilt et al. (2021) and Kern et al. (2019) support this assumption by demonstrating significant positive associations between teacher-student interactions within school activities and the perceived TSR-quality by students with EBPs. Spilt et al. (2021) explored correlations between dyadic TSRs and the quality of teacher-student interactions during *Autobiographical Emotional Events Dialogue* (AEED), a structured activity for discussing the student's past emotional experiences. Higher quality in interactions within AEEDs (e.g., dialogue coherence, acceptance and understanding of negative events, or providing guidance and structure) were associated with more favorable ratings of dyadic TSRs by students with EBPs. Kern et al. (2019) analyzed the correlations between teacher-student interactions and relationship quality within the *Check & Connect* mentoring program for adolescents with EBPs. Mentoring programs aim to offer students consistent and long-term support through regular meetings with an adult mentor who serves as a key contact for both school-related and non-school-related topics, such as friendship, family, and future plans. These programs foster students' social–emotional, cognitive, and identity-related development, resulting in improved personal and academic outcomes (e.g., increased well-being or higher grades; Rhodes, 2005). According to the *model of youth mentoring* by Rhodes (2005), achieving these outcomes requires a positive mentor-mentee (or teacher-student) relationship characterized by mutuality, trust, and empathy. To build this kind of relationship, positive teacher-student-interaction dynamics are considered crucial (Rhodes and Dubois, 2008). Kern et al. (2019) provided empirically evidence for this by showing that the perceived helpfulness of the mentor-mentee interactions significantly influenced the quality of their dyadic relationship.

Furthermore, the study by De Swart et al. (2023a) indicates that TSR-quality from the perspective of students with EBPs has a long-term impact on teacher-perceived TSR-quality. Therefore, it is possible that if an intervention improves TSRs from the perspective of students with EBPs, it may also co-improve the TSR-representations of their teachers.

Four of the studies in this systematic review support the notion that a relationship-specific intervention could also address contextual influences. The findings of Zweers et al. (2021) as well as those of Little and Kobak (2003) indicate that special schools may offer a more favorable environment (e.g., small classes) for fostering positive relationships than regular schools do. Zweers et al. (2021) observed that a special school environment, compared to a regular school environment, can reduce perceived TSR-*conflict* among students with EBPs. Little and Kobak (2003) showed that students with EBPs improved their self-esteem though perceived dyadic TSR-quality in a in a special school setting, as opposed to a regular school setting. The studies by De Swart et al. (2023a) and De Swart et al. (2023b) indicate a positive impact of well-managed classrooms on dyadic TSRs as perceived by students with EBPs. The authors suggest that a structured classroom climate enhances safety and predictability for students, enabling them to regulate themselves better and, in turn, to behave more socially competent towards their teachers.

Accordingly, it seems promising to implement relationship-enhancing interventions for teachers and students with EBPs that address either teacher characteristics (e.g., pedagogical knowledge),

student characteristics (e.g., emotion regulation strategies), teacher-student interactions (e.g., joyful games), or contextual influences (e.g., structured classrooms).

Conclusion three: Students with EBPs seem to perceive stronger positive affective relationships with their teachers than their teachers do with them. Thus, teachers of students with EBPs might benefit from training their emotional awareness of their TSR-representations.

Based on the research synthesis, it appears that students with EBPs may perceive positive affective relationship dimensions (*quality*, *closeness*, *bond*) more strongly than their teachers do (Kern et al., 2019; Knowles et al., 2020; Van Loan and Garwood, 2018; Vervoort et al., 2015). This could be due to the challenges teachers face in managing the social–emotional needs of these students, making it difficult for them to fully recognize and appreciate positive relational experiences (Knowles et al., 2020). Additionally, students with EBPs may struggle with identifying and expressing their emotions (Bolz et al., 2023), making it challenging for them to communicate their feelings of being close to the teacher in a way that is easily understood. To address this, it could be beneficial for teachers of students with EBPs to reflect on their emotional awareness of their TSR-representations, for example through *Teacher Student Interaction Coaching* (Bosman et al., 2021; Koenen et al., 2021). By engaging in such reflections, teachers may develop a greater understanding of their students' behavior related to closeness and eventually improve their perceived relationships with these students (Poling et al., 2022).

Conclusion four: Students with EBPs might perceive their dyadic TSRs to be ambivalent, i.e., to be highly positive and highly negative at the same time. This could be linked to insecure attachment styles and suggests that students with EBPs may particularly benefit from attachment-based interventions.

Even though the current state of research is limited, the findings of Van Loan and Garwood (2018) as well as those of Vervoort et al. (2015) suggest that students with EBPs may perceive their dyadic TSRs as ambivalent. This means that they may experience both positive (*closeness*) and negative aspects (*conflict*) within their relationships as being intense. These perceptions and experiences could be attributed to the students' EBPs being associated with insecure/resistant attachment styles, which develop during infancy and result in internal working models (Ainsworth and Bell, 1970; Bowlby, 1988). These working models are likely to shape interpretations of teacher initiations and responses, thus influencing students' behaviors towards the teacher as temporary attachment figure (Davis, 2003; Verschueren, 2015). The study by Lin et al. (2016) confirms that parent–child relationships (i.e., emotional abuse) predicts dyadic TSRs from the perspective of students with EBPs.

Students with insecure attachment styles may benefit from teacher behaviors and environmental contexts that provide corrective relationship experiences contrary to their early childhood attachment experiences. In other words, experiences in which the teacher serves as safe haven and secure base (Verschueren, 2015). These experiences can be facilitated through attachment-based interventions. Unlike interventions based on learning theory, attachment-based interventions do not aim to modify disruptive student behavior through punishments or praises, but rather aim to provide emotional support that is offered regardless of the students' behavior. The goal for the students is to realize that their behavior, whether prosocial or challenging, does not determine or restrict their ability to rely on the teacher's availability (Julius, 2009).

The intervention study by Salisbury (2018) demonstrates that attachment-based approaches can improve dyadic TSRs from the perspective of elementary school students with EBPs. Another promising attachment-based intervention that has not yet been evaluated from the perspective of students with EBPs is called *Banking Time*. In a *Banking Time* intervention, a teacher-student dyad regularly spends about 10–15 min together (e.g., three times a week over a period of 8 weeks). During these sessions, the student is given the opportunity to take the lead in the activity, while the teacher adopts a non-directive approach (i.e., observing the student's actions, narrating the student's behavior, labeling the student's emotions) and refrains from teacher-directed practices such as choosing activities, asking questions, giving praise, and using commands. The purpose of *Banking Time* is to create a stress-free and low-conflict atmosphere, where the teacher and student can have more positive interactions and reactions towards each other than it is the case in everyday lessons. This aims to modify their mental TSR representations, which in turn are expected to positively guide subsequent behaviors and perceptions in the classroom (Williford and Pianta, 2020).

Conclusion five: For the social–emotional and academic development of students with EBPs, dyadic TSR-quality seems to be a risk or protective factor, acting differently than in TD-students. Student- and teacher-perspectives seem to have varying levels of importance in this regard. Thus, teachers of students with EBPs should foster high-quality TSRs as the foundation of all learning. They should also be mindful of the student's perception of the relationship and compare it with their own perception to ensure a supportive learning environment.

This systematic scoping review indicates that dyadic TSR-quality can have an impact on the social–emotional and academical development of both students with EBPs and TD-students. However, studies that surveyed both groups of students (EBPs and TD), revealed that TSRs affect these groups in distinct ways (Al-Yagon, 2016; Little and Kobak, 2003; Vervoort et al., 2015). Thus, TSRs appear to play a unique role for students with EBPs, highlighting the importance of studying them separately.

Research suggests that students with EBPs who perceive their dyadic TSRs to be high in quality, tend to have fewer externalizing (Decker et al., 2007; Li et al., 2018; Meehan et al., 2003) and internalizing problems (Little and Kobak, 2003; Murray and Zvoch, 2011). Likewise, students with EBPs who perceive their dyadic TSRs to be of low quality, tend to exhibit higher externalizing (Al-Yagon, 2016; Decker et al., 2007; Murray and Zvoch, 2011) and internalizing problems (Little and Kobak, 2003; Murray and Zvoch, 2011). Moreover, high-quality dyadic TSRs from the perspective of students with EBPs tend to exhibit more prosocial behavior (Baker et al., 2009; Decker et al., 2007; Murray and Zvoch, 2011) and display more positive academic competences, emotions, or behaviors (Baker et al., 2009; Decker et al., 2007; Murray and Zvoch, 2011; Rogers et al., 2015). It is important to note that various dimensions of dyadic TSRs are involved in these associations: Student-perceived *rejection*, *proximity seeking*, *emotional* or *relational quality*, *support*, and *alienation* are associated with externalizing problems. *Emotional security*, *alienation*, and *communication* are linked to internalizing problems. *Trust* and *authoritative teaching* are correlated with prosocial behavior, while *emotional quality*, *communication*, *bond*, and *authoritative teaching* are associated with academical aspects. Although no specific patterns can be identified from these correlations, they suggest that dyadic TSRs are multidimensional constructs.

Since only the study by Li et al. (2018) is longitudinal, this systematic review cannot offer information about the direction of associations. Therefore, it remains unclear whether the level of social–emotional and academic competencies in students with EBPs influence the quality of their TSRs or, if the quality of their TSRs, in turn, impacts the extent of their social–emotional and academic competencies. However, all cross-sectional studies that analyzed these associations assume the latter direction of effect: They treated dyadic TSRs as independent (i.e., influential) variables, conceptualizing them as risk- or protective factors that affect the psychosocial, behavioral and educational development of students with EBPs (Al-Yagon, 2016; Baker et al., 2009; Decker et al., 2007; Little and Kobak, 2003; Meehan et al., 2003; Murray and Zvoch, 2011; Rogers et al., 2015). This assumption aligns with attachment theory, which suggests that students cannot fully engage in school if they are uncertain about the emotional support of their teacher (Davis, 2003). This highlights the importance of establishing secure dyadic TSRs as the foundation for all learning. Lessons should be designed in a manner that promotes the development of positive TSRs. In this context, Bergin and Bergin (2009, p. 158) offer six key tips for teachers: Increasing sensitivity in teacher-student interactions; structuring lessons clearly and communicating transparent expectations; providing choices whenever possible; using induction rather than coercive discipline (i.e., explaining the reasons for rules and consequences instead of using threats); providing students with opportunities to be kind, helpful and caring towards each other; implementing interventions for specific, challenging relationships.

The implementation of such strategies is more likely to be successful if teachers and students have a shared understanding of their relationship (De Los Reyes et al., 2022). In addition to the above-mentioned analyses of mean differences, which indicate that students with EBPs and their teachers view their TSR-quality differently (Kern et al., 2019; Knowles et al., 2020; Van Loan and Garwood, 2018; Vervoort et al., 2015), correlation analyses reveal that TSRs have varying effects on social–emotional and academical aspects, depending on whether TSRs were rated by teachers or students (Decker et al., 2007; De Swart et al., 2023a; Murray and Zvoch, 2011; Rogers et al., 2015). Notably, Decker et al. (2007) demonstrates that when students with EBPs and their teachers share a positive perception of their dyadic TSRs, it can lead to a decrease in students' disruptive behavior and an increase in their social skills as well as academic engagement.

Therefore, it might be important for teachers to be mindful of how students view the dyadic TSR and to compare it with their own perception. If the student perceives the TSR more positively than the teacher does, the teacher could try to consciously appreciate and acknowledge positive relationship behaviors of the student (such as showing closeness). By incorporating these positive experiences into their own representation of the TSR, teachers can potentially enhance their self-efficacy, which can have positive implications for future relationship building (Hajovsky et al., 2020) and overall classroom management (Lazarides et al., 2020). On the other hand, if the student perceives the relationship as being less favorable than the teacher does, the teacher could strive to accurately recognize and interpret the student's cues. With this understanding, the teacher can offer better responsiveness to students' distress and provide more comfort for them (Bergin and Bergin, 2009).

5.2 Limitations and further research

When interpreting the five main conclusions described above, it is important to consider the diversity among the included studies. They originated from different cultural contexts, employed different analysis methods, and utilized varied instruments to assess dyadic TSR-quality. This variability complicates the comparison of the study results. For instance, given the diverse cultural contexts of the included studies (North America, Europe, and Asia), it is important to acknowledge that the interpretation and expression of high-quality dyadic TSRs can vary across continents, including differences due to individualistic or collectivistic cultural backgrounds (Chen et al., 2019; Xu et al., 2023). Additionally, the included studies operationalized EBPs quite heterogeneously and used different sample sizes. In most of the included studies, sample sizes of students with EBPs were under $n = 100$, and in some cases, even below $n = 50$. These small sample sizes may have contributed to inaccuracies or distortions in the study results (Döring, 2023). Furthermore, only designs and parameters of the included studies were specified, with no assessment of their methodological quality. Due to the purpose of scoping reviews, data from individual studies were not combined and meta-data was not calculated. Additionally, given the broad synthesis of the included studies, inter-rater reliability for data extraction is not available. Another important limitation of the present review is the strict inclusion and exclusion criteria, which may have excluded relevant studies on the topics addressed. For example, we excluded studies focusing on dyadic TSRs from the perspective of students who were not identified with EBPs but exhibited risks and/or disabilities associated with EBPs or are often comorbid with EBPs (such as autism or bullying problems). Furthermore, studies analyzing class-wide or school-wide TSRs from the viewpoint of students with EBPs were also excluded. Moreover, a publication bias can be assumed as we limited our search to peer-reviewed articles. Non-peer-reviewed papers on the topic (e.g., doctoral theses) were therefore not included.

Nevertheless, this systematic scoping review provides an initial overview of the state of research on dyadic TSRs from the perspective of students with EBPs. To deepen this understanding, further studies should expand our knowledge in this area. The following 10 key recommendations might guide future research.

Recommendation one: Study further differences in how students with and without EBPs perceive the quality of their dyadic TSRs, considering the specific problems of the students.

The studies presented in this review point to quite clear findings concerning differences in dyadic TSR-quality as perceived by students with and without EBPs. However, they vary in the samples they examined. For instance, some studies surveyed students with aggressive behavior alongside their TD-peers (e.g., Murray and Zvoch, 2011), whereas others focused on students with hyperactive behavior and their TD-peers (e.g., Rogers et al., 2015). Therefore, future studies could distinguish between different forms of EBPs to identify relationship-needs according to specific behavioral or emotional difficulties.

Recommendation two: Evaluate further interventions aimed to enhancing dyadic TSRs from the perspective of students with EBPs.

Given the crucial role of self-perceived dyadic TSR-quality for students with EBPs–both in fostering their present well-being with their teacher and in shaping their expectations or concerns regarding

future TSRs (Van Bergen et al., 2020)–it is noticeable that only three studies have thus far evaluated a relationship-based intervention from the perspective of students with EBPs, indicating a remarkable research gap. Further intervention studies could find out which types of relationship-enhancing interventions prove especially beneficial for students with EBPs, taking into account the specific challenges faced by these students.

Recommendation three: Examine educational contexts (regular vs. special education) that contribute to better dyadic relationships between students with EBPs and their teachers.

The question of whether special or regular schools foster higher quality dyadic TSRs from the perspective of students with EBPs remains unanswered due to the limited number of studies available to date (cf. Zweers et al., 2021 as an expectation). Further studies on this topic could offer valuable insights for educational policy and pedagogical decision-making regarding the schooling of students with special educational needs due to EBPs or SEBDs. Additionally, with regard to inclusive education, it may be useful to explore relationship-enhancing conditions of special schools that are transferrable to regular schools, potentially benefiting students with EBPs or SEBDs in those settings as well.

Recommendation four: Analyze the differences between the perceived dyadic TSRs of students with EBPs and their teachers and explore ways to bridge the gap between these perspectives.

The results of this review indicate that students with EBPs and their teachers hold differing perspectives regarding their dyadic relationships (e.g., Van Loan and Garwood, 2018). However, this finding necessitates further exploration in additional studies. If substantial differences exist between student and teacher perceptions, it could be beneficial to train teachers in consciously observing and understanding the relationship behaviors exhibited by students with EBPs. Such trainings might enable teachers to adjust their own relationship behaviors towards students with EBPs, e.g., by reciprocating and responding to students' perceived closeness, or by proactively addressing student-perceived conflicts within the relationship dynamic.

Recommendation five: Investigate whether EBPs are related to insecure attachment styles and how this affects students' perception of their dyadic TSRs.

Although there is empirical evidence linking EBPs to insecure early attachment experiences (e.g., Madigan et al., 2016) which, in turn, can manifest in relationship behaviors towards teachers (e.g., Nehaus et al., 2021), there are barely studies that have explored connections between attachment/parenting styles and dyadic TSR-quality from the perspective of students with EBPs (*cf.* Lin et al., 2016 as an expectation). Future studies investigating these associations could shed light on whether students with EBPs might benefit particularly from attachment-based pedagogical activities (e.g., Geddes, 2007).

Recommendation six: Study long-term associations between dyadic TSRs from the perspective of students with EBPs and their social–emotional or academic development.

The current state of research on the associations between dyadic TSRs from the perspective of students with EBPs and their social–emotional or academic development is primarily based on cross-sectional analyses (*cf.* Li et al., 2018 as an expectation). Because cross-sectional studies do not allow conclusions about causality, longitudinal studies are needed to offer insights into the directions of effects.

Recommendation seven: Utilize instruments that capture dyadic TSRs from the perspective of students with EBPs multidimensionally.

Many studies included in this review operationalized dyadic TSRs as a multidimensional construct (e.g., encompassing *closeness*, *conflict*, and *dependency*, or involving *communication*, *trust*, and *alienation*). Some studies revealed that different dimensions of TSRs are linked to various social–emotional or academic aspects. For instance, in the study by Murray and Zvoch (2011), *alienation* positively predicted conduct problems, whereas *trust* was positively associated with school competence. Therefore, to comprehensively understand both the positive and negative mechanisms of dyadic TSRs from the perspective of students with EBPs, it is crucial to employ instruments that capture dyadic TSRs in their multidimensional nature and to analyze each dimension separately.

Recommendation eight: Survey both students with EBPs and their teachers regarding their dyadic TSR-perceptions. Do not only consider the perspectives separately, but also the agreement or disagreement between them. For this, ensure that the instruments used are consistent with each other.

This review indicates that students' perceived dyadic TSR-quality can have different impacts on their outcomes than teachers' perceived dyadic TSRs do (e.g., Murray and Zvoch, 2011). Remarkably, only one study has delved into whether shared positive or shared negative views of dyadic TSRs are linked to school-related outcomes for students with EBPs (Decker et al., 2007). Since biased perceptions of social and relationship-related cues are part of the characteristic symptoms of EBPs (Castello, 2017), future research should shed light on how discordant or concordant views of TSRs impact the social–emotional or academic growth of students with EBPs. Using instruments that assess congruent TSR-dimensions from teacher and student perspectives, such as the STRS (Pianta, 2001) and SPARTS (Koomen and Jellesma, 2015), is important for such research.

Recommendation nine: Ask not only elementary school students with EBPs, but also those from secondary schools when studying student-perceived dyadic TSR-quality.

The majority of the studies included in this review were conducted in elementary rather than secondary schools (*cf.* Al-Yagon, 2016 as an expectation). However, it is important to note that not only children but also teenagers and young adults benefit from warm, supportive, and low-conflict dyadic TSRs (Liu et al., 2018; Roorda et al., 2011). Given that students with EBPs are more likely than their TD-peers to face psychosocial challenges stemming from their backgrounds (e.g., socioeconomic deprivation, dysfunctional family conditions, or experiences of violence; Herz and Zimmermann, 2018), it becomes particularly crucial for this group of students to have a teacher they can rely on as a secure adult attachment figure. This need extends beyond childhood and into adolescence, especially for them (Cefai and Cooper, 2010).

Recommendation ten: Do not forget those who have been immensely underrepresented in student-perceived TSR-research: Students with internalizing problems.

The analyses in this review considered only three studies that surveyed students with internalizing problems (e.g., Henricsson and Rydell, 2004). Thus, it can be assumed that research addressing the impact of student-rated dyadic TSRs for the specific population of children and adolescents affected by internalizing problems is notably scarce. Since teachers might misunderstand internalizing behavior like calmness and social adaption as signs of positive relationships (Gander

and Buchheim, 2013), it seems particularly important for the target group of internalizing students to capture their own perspectives on their dyadic relationship experiences. For future studies, it might be interesting to find out whether these students perceive their dyadic TSRs differently from TD-students, to explore the extent to which dyadic TSRs can act as a protective factor for their development, and to identify strategies to improve their perception of dyadic TSRs.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

MV-N: Conceptualization, Data curation, Formal analysis, Methodology, Visualization, Writing – original draft, Writing – review & editing. PK: Data curation, Formal analysis, Methodology, Visualization, Writing – review & editing. TB: Conceptualization, Data curation, Formal analysis, Project administration, Writing – review & editing. HK: Conceptualization, Writing – review & editing. TH: Conceptualization, Resources, Writing – review & editing. TL: Conceptualization, Formal analysis, Methodology, Project administration, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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