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# Will you be my friend? A multilevel network analysis of friendships of students with and without special educational needs backgrounds in inclusive classrooms

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**Abstract**

The objective of this study was to determine the relationship between having a special educational needs background (SEN) and the likelihood of having friends in inclusive classes. We assumed that a combination of individual, dyadic and contextual variables can sufficiently explain the relation between a SEN diagnosis and the likelihood of friendship. Data analysis was based on a cross-sectional sample of students ($N$ = 1241) in second and third grade primary-school classes. To address the different levels adequately, the present study improves upon previous research in two ways: First, the sociometric data were analyzed with the p2 model, a specialized multilevel network model. Second, the study focused solely on friendships and emphasized the concept's unique features with respect to inclusive education. Data analysis indicated that students with SEN had a decreased probability of becoming friends with their classmates compared to students without SEN. Even when individual, dyadic, and contextual variables were included into the model, the association between a SEN diagnosis and the likelihood of friendship persisted. The implications of the results are discussed with respect to their implications for inclusive teaching practice.

**Keywords** Friendship · Inclusion · Network Analysis · Social Participation

**Willst du mein Freund sein? Eine Mehrebenennetzwerkanalyse von Freundschaften von Schulkindern mit einem und ohne einen sonderpädagogischen Förderbedarf in inklusiven Klassen**

**Zusammenfassung**

Das Ziel der vorliegenden Studie war es, den Zusammenhang zu untersuchen zwischen einem diagnostizierten sonderpädagogischen Förderbedarf (SPF) und der Wahrscheinlichkeit, Freundschaften in einer inklusiven Schulklasse zu schließen. Es wurde angenommen, dass eine Kombination aus individuellen, dyadischen und kontextuellen Variablen einen möglichen Zusammenhang zwischen einer SPF-Diagnose und der Wahrscheinlichkeit einer Freundschaft vorhersagt. Die Querschnittsanalysen basieren auf einer Stichprobe von *N*=1241 Grundschulkindern der zweiten und dritten Klasse. Die vorliegende Studie hebt sich von bisherigen Forschungsarbeiten in zwei Punkten ab: Erstens wurden soziometrische Daten mit dem p2-Modell analysiert, einem spezialisierten Mehrebenen-Netzwerk-Modell. Zweitens untersuchte die Studie ausschließlich Freundschaften im inklusiven Unterricht und geht dabei insbesondere auf die Besonderheiten des Konzeptes Freundschaft ein. Insgesamt zeigte sich, dass Schulkinder mit einem SPF eine geringere Wahrscheinlichkeit hatten, mit ihren Klassenkameraden befreundet zu sein. Selbst unter Kontrolle individueller, dyadischer und kontextueller Variablen blieb dieser Zusammenhang zwischen der SPF-Diagnose und der Wahrscheinlichkeit einer Freundschaft zu den Klassenkameraden bestehen. Die Ergebnisse werden hinsichtlich ihrer Implikationen für die Theoriebildung und das inklusive Unterrichten diskutiert.

**Schlüsselwörter** Freundschaft · Inklusion · Netzwerkanalyse · Soziale Partizipation

## 1 Introduction

The need to belong and the need for frequent, positive, and meaningful social interactions are fundamental human motives (Leary and Baumeister 1995; Deci and Ryan 2000). Their fulfillment is crucial for a person's general well-being and cognitive functioning, and their absence is causally linked to a variety of mental health issues as well as forms of cognitive malfunctioning (Leary and Baumeister 1995). When students learn together in a group, an important goal of education is to foster the social participation of all students, meaning that each student takes full and active part in daily school life as a valued and integral member of the school community (Farrell 2000). With the "Convention on the Rights of Persons with Disabilities," inclusive education for students with special educational needs backgrounds (SEN) has gained more attention both among the public and in the research community (Bossaert et al. 2013). Social participation is a key issue on the agenda of inclusive education. However, several literature reviews on the social aspects of participation have indicated that students with SEN are at greater risk of social withdrawal compared to students without SEN, perceive their peer-related social classroom climate more negatively, feel less integrated in the social processes of their class, and have fewer friends (Frostad and Pijl 2007; Lindsay 2007; Koster et al. 2009; Bossaert et al. 2013). Pijl et al. (2008) found that students with SEN have a two to three times greater risk of social exclusion compared to their peers without SEN.

Although all these features of social participation seem to be closely correlated, friendships play a special role in students' social participation. Firstly, friendships differ conceptually from non-friend peer relationships (hereafter called general peer relationships) among classmates, as friendships

are chosen freely whereas peers are given by classroom assignment. Secondly, friendships make a distinctive contribution to students' general well-being (Molloy et al. 2011). Rubin et al. (2006), for example, pointed out that even the most withdrawn students had at least one mutual best friend, which subsequently decreased the risk of internalizing and externalizing problem behavior resulting from peer rejection.

Since friendships play a central role in students' psychological well-being, it is crucial to understand the mechanisms that underlie the process of friendship formation and maintenance. According to literature overviews on students' friendships (Ladd 2005; Bagwell and Schmidt 2011), whether two students will be friends with one another is a function of each of their personal attributes as well as a product of variables shared within the friendship dyad. Personal attributes such as social skills, for example, determine whether conflicts between the two can be solved or whether they can support each other in challenging situations. Dyadic attributes, e. g. sharing the same interests, facilitate interactions as they help the two find joint activities and create enjoyable situations, which subsequently promote a state of mutual positive affect (Male 2007; Bukowski et al. 2009). Furthermore, a friendship between two students is embedded in a context of general peer relationships, such as the classroom or the neighborhood. The two members of the friendship dyad do not act independently of this context, meaning that contextual characteristics influence students' friendships as well.

To date, much is known about students' friendships in mainstream classes, but in light of current actions in most countries to develop more inclusive school systems, whether these findings hold true in inclusive classes as well remains an open question. The present study, therefore, investigated the likelihood of friendships among students with and without SEN in inclusive classes by integrating individual, dyadic, and contextual attributes into a joint multilevel friendship network model.

## 2 Theoretical background

### 2.1 Definition of friendship

General peer relationships and friendships can be situated on a continuum of social relationships ranging from complete strangers and acquaintances at one extreme to friends and best friends on the other (Berndt and McCandless 2009). In this continuum, friendships are associated with a high degree of positive affect, trust, and reciprocity (Berndt and McCandless 2009). Since friendships are formed voluntarily and horizontally, both partners are equal in status and have the same rights and duties (Bagwell and Schmidt 2011, p. 11). These distinctive features of friendships make them better suited than general peer relationships to generate a guaranteed and stable framework for frequent, exclusive, and trusting social interactions (Newcomb and Bagwell 1995; Howe 2010, p. 16). As a result, the friendship dyad serves as a foundation for students to seek and provide each other with support in mastering academic goals (Wentzel 2009), and help each other cope with difficult social and emotional situations (Juvonen 2006). Having a friend increases students' feelings of self-worth (Juvonen 2006; Bagwell and Schmidt 2011, p. 11), because they learn that they are valued by a peer and are important to a peer's well-being.

### 2.2 Antecedents of friendships

In recent decades, researchers interested in the processes underlying and accompanying friendship formation in school have focused on a variety of potentially influential variables, most notably

students' attributes, dyadic characteristics, and variables on the classroom level (Rodkin and Ryan 2012). While antecedents of friendships have been identified at all three levels, a limitation of most previous studies is that they typically only considered one or two of the aforementioned levels (Rodkin and Ryan 2012). In this respect, it is of particular relevance that a model of friendship formation in inclusive classes integrating all three levels is still lacking. The following paragraphs summarize key issues related to friendship formation, with a focus on students with SEN in inclusive classes, and conclude with an outline of an appropriate model.

*2.2.1 Individual attributes*

In the early stages of friendship formation, the process is driven mainly by partners' personality traits like openness and extraversion (Eisenberg et al. 2009). Extraverted students, for example, find it easier to reach out to potential friends than shy students (Giffordt-Smith and Brownell 2003).

However, maintaining these newly formed friendships requires a set of well-developed social-emotional and cognitive skills (Giffordt-Smith and Brownell 2003; Wentzel 2005). Newcomb et al. (1993) found in their meta-analysis that students with friends are more socially competent, show more prosocial behavior, act less aggressively towards others, and have higher self-esteem than students without any friends. Despite the fact that a reciprocal relationship between social skills and friendship is conceivable, most of the analyzed studies indicate that at least for elementary and middle school aged students, well developed social skills are a predecessor of friendship (Newcomb et al. 1993). Students with higher social skills can promote enjoyable interactions so that peers find it fun to play with them. In the long term, these skills help maintain existing friendships, since social conflicts can be solved more quickly, for example (Wentzel 2005). Another association reported for this age group is the positive correlation between achievement and number of friends. In her literature review, Wentzel (2009) pointed out that the reported relationship between school achievement and making friends can partly be explained by the higher general cognitive abilities of students who make friends more easily compared to those who struggle to form friendships. However, for elementary and middle school students it could also be plausible to assume that the popularity of high achieving peers is a function of specific norms of their classrooms (Wentzel 2005, 2009; Juvonen 2006). Students in this specific age group tend to believe that good grades and hard work are the classroom's norm and that these student characteristics are highly valued by teachers and peers. Therefore, above average achieving and hardworking peers should be more attractive and desirable as potential friends than (below) average achieving peers.

Students with SEN often differ in their social behaviors or academic achievements from students without SEN (Henke et al. 2017). For example, students with a SEN diagnosis in social-emotional development often behave inappropriately because they lack social skills and have difficulties with social information processing (Huber 2006, p. 79; Frostad and Pijl 2007; Pijl et al. 2011). Students with a SEN diagnosis in learning should have the same social skills as students without a SEN diagnosis. However, achieving above average is challenging for students with a SEN diagnosis in learning which in turn makes this group of students less attractive as potential friends. Therefore, the reported negative connotation between SEN and friendship (Koster et al. 2009) can be partially explained by differences in individual attributes between the groups of students with and without a SEN diagnosis.

In the context of inclusive education, one's status as a student with SEN is itself a potentially relevant attribute (Siperstein et al. 2007; Henke et al. 2017). Although the analysis of the effect of a SEN label on social participation has a long research tradition, the empirical results were inconsistent in past research (Siperstein et al. 2007). More recent research on the effects of a SEN label on social participation and acceptance has found no evidence for the existence of such an effect (Siperstein

et al. 2007; Avramidis and Wilde 2009; Henke et al. 2017). There are two main reasons for these rather inconsistent results. First, the definition of a SEN diagnosis, and thus the SEN label differ between the studies. In some studies the researchers used the information from a formal psychological diagnostic process (e. g. Henke et al. 2017); in other studies the SEN label was based on the teachers' assumptions (e. g. Krull et al. 2014). Second, as explained above, students with a SEN diagnosis differ systematically in various variables from their peers without a SEN diagnosis. In some of the studies on the effect of a SEN label, these known influential variables were only insufficiently considered (e. g. Wiener and Tardif 2004).

In summary, it can be stated that all three individual variables, social skills, academic achievement, and a SEN diagnosis play a role in friendship formation in school. As far as social skills go, there is clear evidence that a set of well-developed skills helps in creating and maintaining friendships. Higher academic achievement also seems to promote having friends in school, but the underlying mechanisms are so far largely unknown. The results regarding the effect of a SEN diagnosis on the chances of forming friendships widely vary, covering the whole range from negative effects to no effects at all. The main reason for this is that a SEN diagnosis is often correlated with other adverse factors for friendship formation and that these factors are not considered appropriately in all studies.

### *2.2.2 Dyadic variables*

However, an explanation of the friendships of students with a SEN diagnosis based solely on individual characteristics does not go far enough, as it does not consider the dyadic nature of these relationships. One of the most fundamental and important interpersonal characteristics is the dyadic concept of homophily. Homophily arises as the result of a process of mutual social selection and influence between individuals. With regard to social relationships, homophily means that people who share a number of similar attributes are more likely to connect with one another compared to people with dissimilar attributes (McPherson et al. 2001). It is known from general research on peer relationships that being similar or equal both on salient characteristics such as sex or age as well as less observable characteristics like academic interest or self-concept plays an important role in the formation of peer relationships (Zander and Hannover 2014).

In the literature on social participation, homophily is a well-established phenomenon that is sometimes referred to as the "similarity hypothesis" (Avramidis and Wilde 2009). According to Male (2007), being similar to one another is important, since it makes interactions expectable and predictable, and having the same interests establishes a common ground for shared activities. Being similar also increases the chance of being liked by one's (potential) partner and of being validated in one's beliefs and values.

In inclusive classes, it might be difficult for students with a SEN diagnosis to find similar peers, as there are typically only a small number of students with a SEN diagnosis in a given class (Frostad and Pijl 2007). Apart from finding another student with a SEN diagnosis in the class, these students may also have difficulties finding others with a similar set of individual attributes in general (Frostad and Pijl 2007).

Although this idea of similarity is well known and frequently cited in research on social participation, only a few studies have investigated the homophily hypothesis in the context of inclusive education. In their study of 566 fifth and sixth graders in mainstream schools, Avramidis and Wilde (2009) did not find any support for an SEN label homophily effect. Students with a SEN diagnosis did not tend to "flock" together with other students with a SEN diagnosis. Studies not limited to the context of inclusive education are inconsistent in their findings with respect to the question of which

attributes are significant for a homophily effect. For example, in their study on group formation processes and friendship selection in a sample of 14 and 15 year old students (*N* = 124), Pijl et al. (2011) found a similarity effect with respect to friendship only for social skills, but not for interests, achievement, and popularity. However, this contradicts previous findings in the general literature on peer group processes and friendship formation (e. g. Gifford-Smith and Brownell 2003), where physical attributes and shared interests are highly important at numerous stages of friendship formation (Gifford-Smith and Brownell 2003).

Homophily is a fundamental concept underlying human relationships and it plays an important role in the formation and cultivation of friendships. However, the results regarding the involved variables are mixed. Having the same sex and sharing the same interests is important for primary school students. The question whether students with a SEN diagnosis tend to keep to themselves as a group remains open, as there is currently not enough research data available. This holds also true for a potential homophily effect with respect to social skills.

### *2.2.3 Contextual variables*

Whether two students in a class become friends with one another does not only depend on the aforementioned individual and dyadic variables such as social skills and joint interests. As students' friendships are embedded in a classroom environment, peer- and teacher-related contextual variables are also important predictors of friendship formation.

The teacher-student relationship is characterized by the amount of support and feedback students get, and is thereby recognizable by classmates (Juvonen 2006). Teachers' behavior, in turn, may influence the relation between classmates (Farmer et al. 2011). Within the "invisible hand" framework, Farmer et al. (2011) argue that teachers directly and indirectly influence the way students interact with each other in social situations. For example, teachers set classroom norms and serve as social role models for their class. Students take the teacher's behavior as an indicator of what is acceptable and desired classroom behavior (Rodkin and Ryan 2012). These assumptions are supported by a growing body of research. For example, Chang et al. (2007) found in a cross-sectional observational study of 1365 primary school students in Hong Kong that a teacher's preference for less aggressive and more prosocial students in the class strengthened the association between prosocial behavior and peer acceptance on the one hand, but weakened the association between aggressive behavior and peer acceptance on the other. Overall, the impact on aggressive behavior was stronger than on prosocial behavior. Thus, the authors concluded that the effect of teacher behavior was primarily an outcome of visible punishment.

This explanation was corroborated by the finding that the association was also weaker for the subgroup of socially withdrawn students. Chang et al. (2007) assumed that teachers had less aversive effects on socially withdrawn students than aggressive students. They concluded that students adapted their social behavior towards their peer group on the basis of what they had observed previously in teacher-student interactions and what they subsequently believed appropriate social behavior to be. In other words, if students observed that aggressive behavior was not sanctioned and believed that students showing aggressive behavior were preferred by their teacher, they will likely change their own social behavior to favor a more aggressive style.

In a longitudinal research design with 894 North American fifth graders, Luckner and Pianta (2011) found that the quality of teacher-student interactions had a positive impact on students' prosocial behavior and, furthermore, decreased the prevalence of aggression-related peer behavior. In line with Chang et al. (2007), no connection was found for socially withdrawn students. Luckner and Pianta (2011) pointed out that teachers' abilities with regard to efficient classroom management may

have supported positive and productive peer interactions as well as inhibited disruptive and problematic classroom behavior. In a longitudinal study of 713 North American primary school students, Hughes et al. (2014) pointed out that a student whose relationship to the teacher was perceived as positive by classmates was better liked by them. Moreover, this relationship influenced whether classmates viewed a student as academically experienced.

Focusing on student-student relations, research on classroom interactions (Webster and Blatchford 2013) has revealed that students with a SEN diagnosis frequently received one-to-one assistance during class by members of the school's support staff. For example, these teaching assistants helped students with a SEN diagnosis work on difficult tasks by explaining them in more detail or simply motivating them. However, the intensive individual support SEN students received subsequently decreased their likelihood of interacting with peers without SEN (Webster and Blatchfordt 2013). By interviewing students, Webster and Blatchford (2015) found that students with SEN were more likely to be placed away from their peers in a separate working space inside the classroom. In addition to reducing the opportunities for students with SEN to interact with their peers, this special treatment made them "different" from their peers (Giffordt-Smith and Brownell 2003; McCoy and Banks 2012). With regard to inclusive classrooms, this means that the way the teacher addresses the class' diversity in achievement and social behavior influences the way students are perceived by their peers (Lanphen and Wiedenbauer 2016). This contextual information matters in the process of befriending someone, especially among primary school aged children (Wentzel 2005, 2009; Juvonen 2006).

Contextual variables have, from a conceptual point of view, the most potential to improve the situation of rejected and excluded students as they are mostly under their teachers' control. The way teachers interact with students impacts the norms and values held by the class. It influences how students perceive each other and often serves as the basis of decisions in the process of befriending someone.

### 2.3 The present study

The majority of studies and literature reviews on social participation in inclusive classes have found evidence that students with SEN are disadvantaged in terms of number of friendships compared to students without SEN (e. g. Giffordt-Smith and Brownell 2003). In the past, however, the use of aggregated measures (e. g. number of friends) and less sophisticated analysis methods (e. g. linear regression) has prevented deeper insight into the relevant variables on an individual level. The goal of the present study is to analyze the friendships of students with and without SEN. Since friendships are influenced by a variety of variables at different levels (individual, dyadic, and classroom level), the friendships of students with and without SEN are analyzed here for the first time using a multilevel network model. In line with past research on the social status of students with SEN, we assume that a SEN diagnosis is negatively linked to the probability of having a friend (Hypothesis I). We further expect that this relationship can be partially explained by variables on the individual level (academic competencies, social behavior), dyadic level (mutual interest, same sex), and contextual level (quality of teacher-student interactions, teacher's ability to address diversity) (Hypothesis II).

## 3 Method

### 3.1 Sample and design

The present study is part of a longitudinal study on inclusion in the federal state of Brandenburg in Germany ("Pilotprojekt Inklusive Grundschule"; PING). The goal of the PING study was to identify

individual and contextual variables influencing the social and academic development of students with and without SEN in inclusive primary schools. Participating schools committed themselves to including all children regardless of a potential SEN background in Social Emotional Development, Learning and Language (SLL). This means that students with a suspected SEN diagnosis could not be prevented from attending a specific mainstream school and sent to a special needs school. Furthermore, among students with a potential SEN in SLL, a formal psychological diagnostic process was initiated only if the student's parents desired one. Thus, it cannot be ruled out that some students would have been diagnosed with SEN in SLL under non-inclusionary circumstances, and that there are students with SEN but without a diagnosis in a class. Since the participating schools only committed to accepting students with SEN in SLL, analyses were restricted to this subgroup of students with SEN.

For the PING study, 35 schools were selected using a stratified random sample from the total population of 84 project schools. The sample included *N* = 1241 students (619 boys, 617 girls, 5 gender missing) coming from 30 s grade and 31 third grade classes. The mean age of the students was 8.77 years (*SD* = 0.68). Class teachers were asked to provide information on their students' SEN status. Teachers of 12 classes did not respond to our request. In the remaining 49 classes, 23 students (1.9%) had been diagnosed with a SEN in the learning domain, 16 (1.3%) in the domain of social and emotional development, and 12 (1.0%) in the language domain. Because one student was diagnosed with a SEN in two domains, the sample included a total of 50 (4.1%) students with a diagnosed SEN in at least one of the three SLL domains. These students were not distributed evenly across classes. There were 23 classes without students with a SEN diagnosis, 15 with one student, five with two, four with three, one with four, and one with nine students. Students' individual characteristics were assessed from April to June 2013.

### 3.2 Data collection

Data were collected in whole-class arrangements in the first four lessons of two consecutive school days. Students' academic competencies were assessed in the first two lessons, whereas a questionnaire on students' social participation and friendships was administered in the third and fourth lessons. Data collection was conducted by trained research assistants and was based on a standardized test manual. For students with mental disabilities or visual impairments, the font size of the printed assessment materials was increased. As a consequence to the relatively young age of the students, research assistants read out all questionnaire items to the students. Due to the standardized assessment procedure of the standardized academic tests, no such assistance was provided during the assessment of academic achievement. Participation was mandatory for students and teachers.

### 3.3 Instruments

#### *3.3.1 Demographic data*

Students were asked to indicate their date of birth (month and year) and their gender. Gender was recoded into 0 for girls and 1 for boys. Information on students' SEN status was obtained from classroom teachers who were asked to indicate only students with an official SEN diagnosis.

*3.3.2 Academic achievement*

Standardized reading comprehension and arithmetic tests were administered to assess students' academic achievement. Reading comprehension was measured with the text comprehension subscale of Lenhard and Schneider's (2006) reading comprehension test for first to sixth graders (ELFE 1-6). In Germany, this standardized test is widely used to assess the reading comprehension of primary school students. The text comprehension subscale consists of short expository and narrative text passages. Each passage is followed by one to two single-choice questions. In total, students are asked to answer 20 questions within a time limit of seven minutes. With Cronbach's $\alpha = 0.91$, the text comprehension subscale had high internal consistency.

Mathematical skills were assessed using the 60-item addition subscale of the Heidelberger numeracy test for first to fourth graders (HRT 1-4, Haffner et al. 2005). The test has a time limit of two minutes and items are arranged in order of increasing difficulty. Students are asked to note the calculated result of each addition task. Each correct answer was awarded one point. The internal consistency was Cronbach's $\alpha = 0.92$.

*3.3.3 Social and learning behavior*

Social and learning behavior was assessed with Petermann and Petermann's (2006) teacher checklist for students' social and learning behavior. Teachers were asked to think about each student's behavior in the last four weeks and to rate his or her concentration (e. g., "Focuses on a task when required"), cooperation (e. g., "Cooperates with others in a team"), persistence (e. g., "Works without constant feedback or assistance"), and self-regulation (e. g., "Controls impulsive behavior"). Each subscale consisted of five items. Ratings were on a four-point scale ranging from 0 (never occurs) to 3 (occurs often). For each scale, internal consistency was good (Cronbach's $\alpha > 0.87$).

*3.3.4 Interest in academic tasks*

Students' interest in reading and mathematics was assessed with six items each (e. g., "I like calculating", "I like reading"), which were based on items from the study Progress in International Reading Literacy study (Bos et al. 2005). Ratings were on a four-point scale ranging from 0 (strongly disagree) to 3 (strongly agree). Internal consistency was Cronbach's $\alpha = 0.79$ for reading and Cronbach's $\alpha = 0.75$ for mathematics.

*3.3.5 Peer related classroom climate*

Peer related classroom climate was measured with eight items adapted from Rauer and Schuck (2003, e. g., "In our class, we are all good friends"). Ratings were made on a four-point scale ranging from 0 (strongly disagree) to 3 (strongly agree). Cronbach's alpha was = 0.75.

*3.3.6 Quality of student-teacher relationships*

The quality of individual student-teacher relationships was measured with eight items adapted from Rauer and Schuck (2003, e. g., "My teachers like me") on a fourpoint scale ranging from 0 (strongly disagree) to 3 (strongly agree). Cronbach's alpha indicated that relationship quality could be reliably measured (Cronbach's $\alpha = 0.79$).

*3.3.7 Addressing diversity*

Students were asked to rate the extent to which their teachers address the diversity of the class in the subjects of German and mathematics. Each scale consisted of six items (e. g., "In our German/mathematics lessons we can choose between different tasks") which were adapted from Helmke (2010) and Kloss (2011). Ratings were made on a four-point scale ranging from 0 (strongly disagree) to 3 (strongly agree). Internal consistency was satisfactory for German (Cronbach's $\alpha = 0.65$) but poor for Mathematics (Cronbach's $\alpha = 0.57$).

*3.3.8 Friendships networks*

A forced choice sociometric questionnaire was used to collect information about students' friendship connections (Frederickson and Furnham 2001). Each student was provided with a list of all classmates' names. For each classmate, students were asked to indicate whether they were friends, a little bit friends or no friends with that particular student (smiling face = "friends", neutral face = "a little bit friends", frowning face = "no friends", empty circle = "I don't know"). In order to prepare the data for statistical analyses in a dedicated network model, the aforementioned categories were recoded into a dichotomous variable where 1 indicates the presence of a friendship and 0 indicates its absence (1 = "friends", 0 = "no friends" and "a little bit friends"). Then, a sociomatrix was formed for each class. Since the students worked independently on their sociometric questionnaires, the resulting sociomatrices were asymmetric, with each row of the matrix containing all information about the friendship choices of a particular student.

**3.4 Statistical analysis strategy**

The multilevel MCMC version of the p2 network model developed by Zijlstra et al. (2006) was used to examine the hypotheses. At its core, the p2 model is a multinomial or conditional regression model for cross-sectional network data. In contrast to traditional regression analysis, the p2 model does not model individual outcomes, but rather predicts the likelihood of sending and receiving a tie within a dyad of two individuals. Since the ties in a dyad are not necessarily reciprocal, four different outcomes are possible for two persons *i* and *j*: (1) *i* ! *j*, (2) *i j*, (3) *i* $ *j*, and (4) *i* ? *j*. In order to model these four possible outcomes for a dyad, the p2 model uses four different sets of predictors which are explained in more detail in the results section: (1) predictors for the general tendency to form a tie, (2) predictors modeling the tendency to reciprocate ties, and (3 and 4) individual sender and receiver effects indicating how active (sender) and attractive (receiver) the respective network actors are. In the multilevel version of the p2 model, all predictors are additionally allowed to vary across multiple networks. Just as in traditional regression models, parameters are interpreted under the assumption that all other parameters are absent and, therefore, equal to zero. Since the modeled outcome is categorical, all predictors are on a log odds scale. The p2 model is part of the StOCNET (Boer et al. 2006) network modeling suite. However, since the p2 model's estimation process was very slow in the original software due to the network's size; it was re-implemented[1] by the first author in R and C++/Armadillo with the random walk independence sampler for fixed and random effects, as outlined in Zijlstra et al. (2006, 2009).

[1] The re-implementation of the software will be open sourced and released as an R package on CRAN after the publication of the present study. The re-implementation was of a magnitude 100 times faster than the original software.

Several data preparation steps were conducted to provide a sensible and clear interpretation of the model estimates: (1) Since we did not intend to evaluate our models with respect to differential effects of various school subjects, the domainspecific variables academic achievement, interest in academic subject, and addressing diversity were averaged across the domains of reading and arithmetic. (2) Based on the results of an exploratory factor analysis, teachers' ratings of their students' social and learning behavior were summarized into two subscales, namely learning behavior (concentration and persistence) and social behavior (cooperation and selfregulation). (3) Subsequently, all continuous variables were z-scaled with respect to the grand mean and overall standard deviation. (4) Finally, for variables which were used to predict the network's density and tendency for reciprocity, a symmetric similarity matrix based on the absolute difference between every two students was calculated for each class. Regarding the variable interests, this means that if one of the students in a dyad had an interest value of 2 and the other a value of 3, the absolute difference effect would be 1. Thus, higher values of absolute difference indicate that the partners in a dyad are more dissimilar to one another, whereas a value of zero would indicate equivalence. A similar coding strategy was used for the same sex effect. The variable was coded with a value of 1 (if both students had the same sex) and a value of 0 (if their sexes differed).

As both the covariates and the networks contained missing data, explicit missing data handling was necessary. Although several strategies (e. g., multiple imputation) are recommended for "classical" datasets, to date there is no equivalent procedure to handle missing data in social networks (Steglich, personal communication, March 2016). Therefore, missing data in the friendship networks were either deleted (full non-response) or replaced (partial non-response) with the value 0 ("no friends"). Missing data in the covariates were treated in a single imputation step that considered the multilevel structure of the data by means of the AMELIA II R package (Honaker et al. 2011).

In accordance with the recommendations of Zijlstra et al. (2006, 2009), the random walk independence sampler was used for all models. For the results presented here, a single chain of the MCMC estimation algorithm was run with 60,000 iterations. Samples from the posterior distribution of the parameters were taken with a thinning interval of 10, resulting in a sample of 6000 simulated draws for each model. Prior to sampling, the MCMC chain was run with a length of 10,000 burnin iterations. Within the burn-in period, the covariance matrices of the multivariate normal proposal distribution for the random and fixed effects were adapted every 100th iteration. As no prior knowledge was accessible for the models in question, all prior distributions were specified as flat or rather non-informative. Convergence of the sampler was assessed by visual inspection of the traceplots.

## 4 Results

### 4.1 Descriptive statistics

We first examined the association between status as a student with SEN and number of friends. Since friendship was measured asymmetrically, we calculated the number of sent ties ("outdegree"), the number of received ties ("indegree"), and the number of reciprocated ties. In order to compare these measures across classes, they were divided by the class size minus one for the descriptive analyses. The resulting measures can be interpreted as friendship class coverage, where a value of 0% in the outdegree, for example, means that no classmates were considered friends, whereas a value of 100% in the outdegree means that on average all classmates were identified as friends.

As Table 1 shows, both students with a SEN diagnosis and students without a SEN diagnosis nominated one third of the class as friends (Row: "Outdegree"). However, students with a SEN diagnosis received friendship nominations from only 22% of their classmates, whereas students without a SEN diagnosis received friendship nominations from one third of their classmates (Row:

"Indegree"). This difference resulted in a decreased rate of reciprocation of friendship ties among students with a SEN diagnosis compared to those without a SEN diagnosis (Row: "Reciprocal").

In a second step, we examined the overall variability in terms of the intraclass correlation and the correlation between indegrees and outdegrees. All three measures showed considerable overall variance (*SDindegree* = 17%, *SDoutdegree* = 19%, *SDreciprocated* = 13%), and the ICCs indicated that the three measures of friendship identification differed significantly across classes (*ICCindegree* = 0.23, *ICCoutdegree* = 0.17, *ICCreciprocated* = 0.28). The significant correlation coefficient of *r (1239)* = 0.40, $p < 0.001$ between indegree and outdegree reflected the pattern of the mean values between in- and outdegree and reciprocated ties for students with and without SEN diagnoses.

**Table 1** Descriptive statistics for the friendship nominations of students with a SEN diagnosis and students without a SEN diagnosis

| | No SEN (%) | SEN (%) |
|---|---|---|
| Indegree[a] | 32.2 | 21.5 |
| Outdegree[b] | 31.6 | 31.6 |
| Reciprocal[c] | 19.2 | 12.5 |

All measures are standardized within a class by dividing the raw count through the class size minus one. A value of 100% in the outdegrees, for example, means that all classmates were considered as friends.

[a]The number of received friendship nominations
[b]The number of send friendship nominations
[c]The number of mutual friendship nominations

### 4.2 Multilevel network analyses

Since the models were estimated within the framework of Bayesian statistics, classical measures of statistical significance were not available. However, to be consistent with prior research in the field, 95% confidence intervals were calculated as quantiles of the parameter distribution, and subsequently treated as measures of statistical significance (for an in-depth discussion of this approach, see e. g. Kruschke 2015, Chap. 11).

The following analyses correspond to the hypotheses and are organized as follows: First, a null model (Model 1; Table 2) without any covariates was specified. This model is used to illustrate model and parameter interpretation, and also serves as a benchmark for later model comparisons. Second, the individual, dyadic, and contextual variables were included into the model (Model 2 to Model 4; Table 2 and 3) one after the other in a blockwise approach. Finally, a model (Model 5; Table 3) with all effects combined was estimated.

The null model (Model 1; Table 2) incorporates an intercept for network density, an intercept for the network's general tendency for tie reciprocation, two latent parameters reflecting the individual tendency to send and receive ties, and a variance parameter for the network density parameter which takes into account that students are nested within classes. Since individuals' parameters for sending and receiving ties are latent, their means are fixed at zero and only their covariance matrix appears in the results table. The negative density parameter in the null model (Model 1; Table 2) indicates that the null dyad, where neither of the two potential partners nominates the other as a friend, is the most likely outcome. Moreover, since the density parameter in the p2 model can be interpreted as the log odds of the probability of one partner sending a tie vs. neither of

the partners in the dyad sending a tie, a negative density parameter indicates a network density below 0.5, meaning that less than 50% of all potential friendship nominations in a network are realized. This is a common finding in social network research, and as can be seen in Table 1, is totally in line with the descriptive sample statistics. The positive parameter estimate for reciprocation is also in line with prior research on social networks. Together with the density parameter, the reciprocation parameter can be interpreted as the log odds of the probability of a dyad in which one of the partners nominates the other as a friend vs. a dyad where both partners nominate each other as friends. A positive sum for the density and reciprocation parameters thus means that once it is known that one of the partners nominated the other as a friend, the probability that the nomination will be reciprocated is above 50%. Plugging the estimated parameter values in to the model equations makes it possible to derive the expected probabilities for all four possible outcomes of the dyad. With the parameters of the null model (Model 1; Table 2), assuming two randomly chosen average students with a zero sender and receiver effect in an average network within the sample, the most likely scenario is that they did not nominate each other as friends, since the empty dyad is the most likely outcome, with a probability of 62%. The probability that they both nominated each other as friends equals 18%, whereas the probability of an unreciprocated nomination is 10% for each of the asymmetric outcomes. Given the highly positive parameter estimate for tie reciprocation, one might wonder about the rather low probability of 18% for a dyad with mutual nominations. When interpreting the reciprocity parameter, a common pitfall is to neglect the fact that the reciprocation parameter refers to cases where it is already known that one of the potential partners nominated the other as a friend; thus, the impact of the reciprocation parameter is better illustrated using a conditional probability rather than a joint probability. The conditional probability in the p2 model refers to the probability of sending a tie, given that one has already received a tie. In the case of the null model (Model 1; Table 2), this probability equals 65%. The negative sign of the covariance of the latent sender and receiver effects indicates that there is an imbalance between sending and receiving ties. Students who are likely to send out ties have a decreased likelihood of receiving ties and vice versa. Moreover, the variance of the latent sender effects is slightly higher compared to the variance of the latent receiver effects, indicating that students are more similar in their tendency to receive ties than to send out ties.

Additionally to the null model, Model 2 (Table 2) includes separate sender and receiver covariates for SEN diagnosis, which differ significantly from zero. The negative sign of the receiver parameter indicates that students with a SEN diagnosis had a decreased likelihood of being nominated by others as a friend compared to students without SEN. At the same time, students with a SEN diagnosis tended to nominate more classmates as friends than students without a SEN diagnosis. The joint probability of the asymmetric dyads therefore decreased to 5% for the case of a student with a SEN diagnosis being nominated and increased up to 15% for a student with a SEN diagnosis nominating a classmate as a friend. The negative effect on receiving friendship nominations and the positive effect on nominating others also indirectly impacted the reciprocation of ties, as an investigation of the conditional probabilities shows. Given that a student with a SEN diagnosis nominated another student as a friend, the negative SEN receiver effect decreased the probability of the nomination being reciprocated to 49%. Given that a student with a SEN diagnosis received a friendship nomination, the positive sender effect increased the probability that the student reciprocated the nomination up to 74%. The other model parameters did not change compared to the null model (Model 1; Table 2). Altogether, these findings support the first hypothesis that students with a SEN diagnosis are less likely to establish and keep a friendship.

**Table 2** Parameter estimates of the multilevel p2 models investigating the effect of individual and dyadic variables on the likelihood of friendships

| | Model 1 | | | Model 2 | | |
|---|---|---|---|---|---|---|
| | est | CI | | est | CI | |
| | | 2.5 | 97.5 | | 2.5 | 97.5 |
| Fixed Effects | | | | | | |
| **Dyadic Level** | | | | | | |
| *Density* | | | | | | |
| Intercept | **–1.839** | –1.915 | –1.751 | **–1.825** | –1.915 | –1.726 |
| Different Sex | **–** | **–** | **–** | **–** | **–** | **–** |
| Different Interests | – | – | – | – | – | – |
| *Reciprocity* | | | | | | |
| Intercept | **2.448** | 2.364 | 2.524 | **2.440** | 2.326 | 2.555 |
| Different Sex | **–** | **–** | **–** | **–** | **–** | **–** |
| Different Interests | – | – | – | – | – | – |
| **Individual Level** | | | | | | |
| *Sender* | | | | | | |
| SEN | **–** | **–** | **–** | **0.433** | 0.181 | 0.714 |
| Social Behavior | – | – | – | – | – | – |
| Learning Behavior | **–** | **–** | **–** | **–** | **–** | **–** |
| Academic Competence | – | – | – | – | – | – |
| *Receiver* | | | | | | |
| SEN | **–** | **–** | **–** | **–0.637** | –0.877 | –0.387 |
| Social Behavior | – | – | – | – | – | – |
| Learning Behavior | **–** | **–** | **–** | **–** | **–** | **–** |
| Academic Competence | – | – | – | – | – | – |
| **Class level** | | | | | | |
| *Density* | | | | | | |
| Teacher-Student Relations | – | – | – | – | – | – |
| Addressing Diversity | **–** | **–** | **–** | **–** | **–** | **–** |
| Random Effects | | | | | | |
| **Individual level** | | | | | | |
| Sender Variance | **0.829** | 0.730 | 0.930 | **0.817** | 0.720 | 0.922 |
| Sender-Receiver Covariance | **–0.395** | –0.463 | –0.328 | **–0.378** | –0.452 | –0.310 |
| Receiver Variance | **0.538** | 0.466 | 0.620 | **0.519** | 0.447 | 0.597 |
| **Class level** | | | | | | |
| Density Variance | **0.055** | 0.021 | 0.118 | **0.056** | 0.021 | 0.106 |

***Bold*** Zero is outside the confidence interval for the parameter estimate and can be considered significant

**Table 3** Parameter estimates of the multilevel p2 models investigating the effect of individual, dyadic and contextual variables on the likelihood of friendships

| | Model 3 | | | Model 4 | | | Model 5 | | |
|---|---|---|---|---|---|---|---|---|---|
| | est | CI 2.5 | | est | CI 2.5 | | est | CI 2.5 | |
| Fixed Effects | | | | | | | | | |
| **Dyadic Level** | | | | | | | | | |
| *Density* | | | | | | | | | |
| Intercept | **–0.967** | –1.096 | –0.829 | **–1.842** | –1.941 | –1.747 | **–0.994** | –1.127 | –0.869 |
| Different Sex | **–1.494** | –1.588 | –1.397 | **–** | **–** | **–** | **–1.499** | –1.592 | –1.389 |
| Different Interests | –0.053 | –0.112 | 0.006 | – | – | – | –0.037 | –0.098 | 0.024 |
| *Reciprocity* | | | | | | | | | |
| Intercept | **1.957** | 1.797 | 2.120 | **2.442** | 2.334 | 2.557 | **1.967** | 1.795 | 2.155 |
| Different Sex | **0.211** | 0.024 | 0.386 | **–** | **–** | **–** | **0.206** | 0.015 | 0.399 |
| Different Interests | –0.042 | –0.142 | 0.072 | – | – | – | –0.045 | –0.157 | 0.067 |
| **Individual Level** | | | | | | | | | |
| *Sender* | | | | | | | | | |
| SEN | **0.442** | 0.163 | 0.719 | **0.383** | 0.098 | 0.678 | **0.380** | 0.137 | 0.648 |
| Social Behavior | **–** | **–** | **–** | –0.020 | –0.109 | 0.067 | –0.007 | | |
| Learning Behavior | | | | –0.035 | –0.132 | 0.063 | –0.028 | | |
| Academic Competence | – | – | – | –0.029 | –0.104 | 0.046 | –0.028 | –0.108 | 0.049 |
| *Receiver* | | | | | | | | | |
| SEN | **–0.667** | –0.877 | –0.480 | **–0.385** | –0.631 | –0.139 | **–0.340** | –0.566 | –0.138 |
| Social Behavior | **–** | **–** | **–** | **0.240** | 0.167 | 0.312 | **0.275** | 0.192 | 0.351 |
| Learning Behavior | – | – | – | **0.151** | 0.070 | 0.229 | **0.166** | 0.085 | 0.240 |
| Academic Competence | – | – | – | 0.052 | –0.009 | 0.114 | 0.044 | –0.020 | 0.110 |
| **Class level** | | | | | | | | | |
| *Density* | | | | | | | | | |
| Teacher-Student Relations | – | – | – | – | – | – | **0.215** | 0.035 | 0.428 |
| Addressing Diversity | – | – | – | – | – | – | 0.116 | –0.076 | 0.319 |
| Random Effects | | | | | | | | | |
| **Individual level** | | | | | | | | | |
| Sender Variance | **1.017** | 0.897 | 1.149 | **0.823** | 0.726 | 0.928 | **1.026** | 0.907 | 1.155 |
| Sender-Receiver Covariance | **–0.268** | –0.352 | –0.188 | **–0.367** | –0.436 | –0.302 | **–0.260** | –0.337 | –0.185 |
| Receiver Variance | **0.617** | 0.535 | 0.711 | **0.420** | 0.356 | 0.489 | **0.498** | 0.424 | 0.580 |
| **Class level** | | | | | | | | | |
| Density Variance | **0.093** | 0.034 | 0.177 | **0.075** | 0.036 | 0.130 | **0.099** | 0.037 | 0.188 |

***Bold*** Zero is outside the confidence interval for the parameter estimate and can be considered significant

In the third model (Model 3; Table 3), the dyadic covariates different sex and dissimilar interest were added. However, only the effect of different sex was significant. With respect to density and

reciprocity, adding the dyadic covariates resulted in a shift of the meaning of the model's intercept parameters. The intercepts now refer to the likelihood of a friendship for a same sex dyad. As the decreased parameter estimates for the intercepts, and the highly negative parameter estimate for the different sex density effect show, a friendship nomination is more likely within a same sex dyad than in a mixed sex dyad. The positive parameter estimate for the mixed sex reciprocity effect may seem surprising, as one might think from the established theory that a mixed sex dyad should not have a higher probability than a same sex dyad. However, when interpreting the obtained parameters one needs to consider the density and reciprocity parameters simultaneously. Please note that just the density and reciprocity intercept, together representing a same sex dyad with similar interests, results in a high probability for a mutual friendship (72%). This probability drops to 38% when the negative mixed sex effect for the density is taken into account and slightly increases (43%) when the positive mixed sex effect for the reciprocity is considered. The positive mixed sex parameter for the reciprocity part of the model therefore caps the overall mixed sex effect. Compared to Model 2 (Table 2), the parameter estimates for the SEN sender and receiver effects did not change in either magnitude or sign.

In the fourth model (Table 3), covariates for modeling the sender and receiver effects of the model were added, and the dyadic effects were temporarily excluded. Regarding the sender effects, only the SEN diagnosis effect turned out to be a significant predictor of the likelihood of nominating others as friends. Neither social nor learning behavior, nor a student's academic achievement predicted their tendency to make friendship nominations. It was a different picture for the receiver effect, where both social and learning behavior differed significantly from zero. Unlike for the sender effects, including the behavioral covariates affected the magnitude of the SEN diagnosis receiver effect, as it was nearly halved. However, having a SEN diagnosis remained a negative predictor of receiving friendship nominations. In interpreting the behavioral effects, it is important to note that these variables are z-scaled. This would theoretically mean that a student with a SEN diagnosis and teacher-rated social and learning behavior which is one standard deviation above the average could compensate for the negative effect of having a SEN diagnosis.

Finally, the fifth model (Model 5; Table 3) combined all effects at once and was augmented by the classroom-level variables average student-rated quality of teacherstudent relations, and the student-rated class average for the teacher's ability to address diversity. None of the parameters contained in previous models changed in value. Since the class average ratings of the two variables are centered at the sample mean, the interpretation of the other parameters stays the same as before. As can be seen from Model 5 in Table 3, only the class average of the quality of student-teacher interactions had a significant effect on the individual patterns of friendship nominations. However, the variable teacher's ability to address diversity missed the 5% significance level. The impact on the likelihood of friendship nominations was relatively large for a class level effect. For example, in a class with a quality of teacher-student interactions one standard deviation above the average, any given student is 1.5 times more likely to get a friendship nomination than in a class one standard deviation below the average. A same sex dyad in a class one standard deviation above the average has a probability for mutual friendship nominations of 0.43%, with probabilities of 13% for the two asymmetric dyads. In contrast, in a class with an average quality of student-teacher interactions one standard deviation below the sample average, a same sex dyad would have a joint probability of mutual friendship nominations of 37%, with the probability for the asymmetric dyad remaining stable due to the high impact of the same sex parameter. For the behavioral variables in the receiver effect, the parameter value estimate for the quality of teacher-student interactions approximately equals the SEN diagnosis receiver effect in absolute value. So, being a student in a class with a quality of teacher-student interactions one standard deviation above the average somehow compensates for the negative SEN diagnosis effect. In hypothesis II it was proposed that variables on

the individual, dyadic, and contextual level explain the negative effect of a SEN diagnosis on the probability of having a friend. The results of Model 3 to 5 only partially confirmed this. The dyadic and contextual variables did neither alter the effect of the SEN diagnosis sender, nor the receiver effect. Only the individual level behavioral variables had an effect, as they halved the SEN receiver effect in magnitude.

## 5 Discussion

The present study analyzed the association between having a SEN diagnosis and the likelihood of friendships. In contrast to previous studies in the field of inclusive education and social participation, this was the first time to our knowledge that a multilevel network model was used to analyze the link between a SEN diagnosis and the likelihood of identifying others, and being identified by others as a friend. The advantage of the present multilevel network model was that we could use it to control the effect of a variety of variables known to have an influential effect on different levels, as there were individual attributes, contextual classroom-level factors, and dyadic effects to consider here.

Another advantage of the present study was its special data structure. Traditionally, the German school system segregated students with a SEN from students without a SEN. That both groups of students learn together in one and the same class is a relatively new phenomenon in Germany. Furthermore, in the present study the formal psychological diagnostic process for a SEN diagnosis in SLL was only carried out when initiated by the student's parents. In that sense, this constitutes a setting where students with and without a formal SEN diagnosis share the same learning environment. While carrying the formal SEN label, these students were otherwise indistinguishable from their peers without a formal SEN diagnosis, as they possibly showed the same social behavior and school achievements. This, as a result, opened up the opportunity for research questions that directly address the effect of said label.

In line with our first hypothesis, the analysis revealed that students with a SEN diagnosis were disadvantaged when it comes to making and keeping friends compared to students without a SEN diagnosis. Having a SEN diagnosis resulted in a decreased likelihood of being nominated by others as a friend. In terms of describing the degree of social participation, this leads to two major consequences for students with a SEN diagnosis. First, the reduced likelihood of being nominated as a friend leads to a situation where they will more often experience an unfavorable sociometric status such as being ignored or even excluded. Second, a lower number of friendship nominations entails fewer possibilities for reciprocated or mutual friendship nominations; thus, students with a SEN diagnosis not only have a lower sociometric status but have fewer friends, too. Our finding of a significant negative SEN diagnosis receiver effect is aligned with a large body of literature on social inclusion, which reports adverse effects of being a student with a SEN diagnosis on sociometric measures and the number of mutual friendships (Lindsay 2007; Koster et al. 2009).

Along with the negative receiver effect, the positive sender effect supports the notion that self-assessment is a biased estimate of social inclusion. Students with a SEN diagnosis received a below average number of friendship nominations but overestimated their social situation in class because they nominated an above average number of students as friends. However, it should be noted that the negative association between sending and receiving friendship nominations was a pattern which was typical for the whole sample and was found in all tested models. The significant negative covariance between the latent sender and receiver effects revealed that an imbalance effect between nominating others and being nominated as a friend should be expected in the sample independently of a possible SEN diagnosis. Basically, the negative covariance might indicate that students who receive numerous friendship nominations do not answer with an equal number of nominations. Our results indicated that the opposite holds true for students with a SEN diagnosis. The

negative association for students with a SEN diagnosis was fixed in the disadvantageous direction, with sending out more nominations leading to receiving fewer nominations. Even though the decline in the probability of receiving friendship nominations and the increase in the probability of sending friendship nominations can both be considered small in terms of effect size measures, they nevertheless indicate a systematic perception bias on behalf of students with a SEN diagnosis and a systematic risk factor for social exclusion. This result adds to the existing literature on social participation. In prior studies, indicators of social participation relied on self-assessments (e. g. How do you feel in your class?). The resulting estimates, however, are seen as flawed and biased (Pijl et al. 2008), and it is a well-known result that when asked about their social situation in a class, students with and without a SEN diagnosis report similar scores on social inclusion scales (Koster et al. 2010).

To see whether these effects of a SEN diagnosis can be at least partially explained by other variables, a series of models with predictors on the individual, dyadic, and contextual level was tested, in accordance with the second hypothesis. The negative receiver and positive sender effect for students with a SEN diagnosis were maintained when well-known influential variables for friendship and peer dynamics were introduced into the models. Moreover, the effects were unchanged after controlling simultaneously and separately for individual variables like social skills (Newcomb et al. 1993), academic achievement (Wentzel 2009), mutual interests, same sex, and variables on the contextual level (Huber 2006). Although this pattern of imbalance between sending and receiving ties was reproduced in all models, there were notable differences between them in the magnitude of the SEN diagnosis receiver effect. When individual level variables were introduced into the model, the negative receiver effect of having a SEN diagnosis nearly halved. This means that the negative SEN receiver effect could be at least partially explained by individual level variables, such as the students' social and learning behavior. In line with prior research, social behavior was the most important individual level variable explaining interindividual differences in receiving friendship nominations. In contrast to prior findings (e. g. Wentzel 2005), academic achievement had no effect on the probability of receiving friendship nominations. One explanation for this pattern of results could be that it is not academic achievement itself but rather one's reputation in the class as a hard-working and diligent student that explains the positive link between academic achievement and friendship nominations. In contrast to the receiver effect, the positive SEN diagnosis sender effect could not be explained by individual, dyadic, or contextual variables. It appears as though the increased tendency to nominate others as friends is exclusively linked to the SEN diagnosis itself.

One possible explanation of the effect of a SEN diagnosis is that students' selfassessed measures on social participation are positively biased to enhance students' self-image about their social position in class (Pijl et al. 2008; Koster et al. 2010). This result implies that for a student with a SEN diagnosis, having the skills to exhibit positive social and learning behavior would be advantageous to compensate for the adverse effect of the SEN diagnosis receiver effect. However, from both an empirical and a theoretical-pedagogical perspective, this logic is problematic. First, it is known that students with a SEN diagnosis often have below average ratings in social behavior or lack social skills (Frostad and Pijl 2007). The present data supported this association, since the social and learning behavior effects sum up to the same amount as the SEN receiver effect was reduced when the social and learning behavior were included into the model. Second, inclusion and especially social participation are joint tasks meant to be worked on by the whole class. It is not something only students with a SEN diagnosis are responsible for. Moreover, in their literature review, Garotte et al. (2017) pointed out that interventions aimed at improving the social acceptance of students with a SEN diagnosis have large effects when they have a broad focus, with the intervention addressing all students in a class, not only those with a SEN diagnosis.

On the classroom level, only one of the two tested contextual effects was linked to the probability of friendship nominations. The class average quality of teacher-student interactions was positively associated with the probability of friendships within that class. The strength of the association was of the same amount as the relationship between friendship nominations and social behavior. Thus, a student with a SEN diagnosis had the same likelihood of receiving a friendship nomination in a class with a quality of student-teacher interactions which was one standard deviation above the sample average as a student without a SEN diagnosis in an average class. From a pedagogical and educational perspective, this is of particular interest, as the qual ity of student-teacher interactions is potentially under the teacher's control and can thus be manipulated. In line with the "invisible hand" framework by Farmer et al. (2011), the research results of Chang et al. (2007), and Luckner and Pianta (2011), the present study supports the view that the teacher is a cornerstone for the social participation of students with a SEN diagnosis. Teachers act as role models for their students, thus influencing how students interact with each other. More precisely, students derive their individual beliefs about what is considered appropriate social behavior from their observations of teacher-student interactions (Chang et al. 2007). Furthermore, students in primary school align their social preferences for specific classmates with the social preferences they believe their teachers hold about these students (Hughes et al. 2014). Since teachers serve as a reference frame for students' social preferences and social behavior, it is important that teachers promote a classroom climate characterized by frequent positive classroom interactions with all students.

Although the aforementioned variables explained nearly half of the SEN diagnosis receiver effect, this effect remained in existence throughout all models. This finding could be seen as indicating a SEN diagnosis labeling effect. A labeling effect would mean that the SEN label is associated with negative attributes and that students with a SEN diagnosis are systematically less likely to be nominated as friends because of their SEN diagnosis. Whether the SEN diagnosis receiver effect is the result of a labeling effect or is instead the byproduct of unmodeled individual effects remains an open question for future studies. With respect to earlier studies by Siperstein et al. (2007) and Henke et al. (2017), such a labeling effect is rather unlikely for primary school aged students, as they are usually not informed about the SEN diagnosis of their classmates. Instead, indirect mechanisms such as differential treatment by the teacher or students' social behavior are more likely seen as mediators of the effect between the label and the probability of friendship nominations. However, more research focusing on a broader range of individual and dyadic variables is needed to answer this question.

**5.1 Limitations and prospects**

First and foremost, the number of students with a SEN diagnosis in the present study is quite small compared to the number of students without a SEN diagnosis. Additionally, the students with a SEN diagnosis were not evenly distributed across classes, and there were some classes with no students with a SEN diagnosis. While such a small number of students with a SEN diagnosis in the sample is normal for most studies in the field of inclusive education and corresponds to the prevalence of SEN diagnosis in the population (Dietze 2013), it decreases the study's test power. Due to the use of a multilevel network model, the uneven distribution of students with a SEN diagnosis and the presence of classes with no students with a SEN diagnosis did not interfere with the test power. The reason for this is that due to the hierarchical nature of the model, the parameter estimates are "pooled" between the classes (for a thorough explanation of this effect for linear regression models see e. g. Gelman and Hill 2007, Chap. 12), and thus classes with no students with a SEN diagnosis "borrow" from classes with students with a SEN diagnosis.

Furthermore, the items used to measure social skills are school-specific and might not cover the entire range of relevant social behavior. A similar limitation applies to the measure of joint interests. One possible reason joint interests did not become a significant predictor of friendship

nominations might be that the variable only measures interest in academic subjects and does not capture joint interests in other activities important to the students. Future studies, therefore, should incorporate variables that are more focused on leisure and playground activities.

Turning to the estimated effects in the present study, the SEN diagnosis sender effect remains an interesting open question. It is not clear whether this is an effect exclusively linked to students with a SEN diagnosis or if this positive perception bias applies to all students with an adverse social position in their class. In future studies, this effect should be studied further and validated with more objective instruments such as sociometric badges (e. g. Mastrandrea et al. 2015). Sociometric badges are technical devices which measure social interactions via radio communication, and thus they are by definition free of perception bias. With these devices, for example, it would be possible to relate the asymmetric friendship nomination caused by the positive sender effect to specific contact patterns to get a better understanding of the underlying social processes of a positive sender effect. Mastrandrea et al. (2015) showed for example that specific social constructs such as friendships, and general peer relations are associated with different interaction patterns among the students.

In conclusion, there are three limitations regarding the outcome measure that apply to the present study. First, the collected data on students' friendships do not contain information about the quality of the friendships. It is, however, known that the students' friendships differ in various dimensions, e. g. the extent to which they self-disclose or support each other (Rubin et al. 2006; Berndt and McCandless 2009). Moreover, the work of Rubin et al. (2006) indicates that this is especially important when it comes to rejected or shy and withdrawn students. In the study of Rubin et al. (2006) these students not only had fewer friends than their peers, they also rated their friendships lower with respect to intimate disclosure, help, and guidance or the ability to resolve conflicts (Rubin et al. 2006). The divergent SEN diagnosis sender and receiver effect might be a hint that quality could also be an issue in the present study. The next limitation of the present study is that a cross-sectional sample was used and the relationships between effects cannot be disentangled causally. Lastly, higher order network statistics should be incorporated into the modeling process, since it is known that the friends of withdrawn and rejected students are also at risk of social withdrawal and rejection and students with a SEN diagnosis are among these rejected students.

## 6 Conclusion

In conclusion, our findings strongly support the idea that students with a SEN diagnosis are at risk of social exclusion. Further analysis revealed that this negative effect is a combination of students' social and learning behavior, and a potential SEN diagnosis labeling effect. The present study also showed that students with a SEN diagnosis have a positively biased perception of their social position and situation in class, and that self-assessment tools might not be sufficient to measure social inclusion. The results concerning classroom level variables once again highlighted the importance of multilevel modeling. Finally, the link between the quality of teacher-student interactions and the likelihood of friendships provides evidence for the critical role of teachers in the further development of inclusive education as well as the psychological well-being of students.

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