

**First Selection, then Influence: Developmental Differences in Friendship Dynamics
Regarding Academic Achievement**

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Abstract

This study concerns peer selection and influence dynamics in early adolescents' friendships regarding academic achievement. Using longitudinal social network analysis (RSiena), both selection and influence processes were investigated for students' average grades and their cluster-specific grades (i.e., language, exact, and social cluster). Data were derived from the SNARE (Social Network Analysis of Risk behavior in Early adolescence) study, using six waves ($N = 601$; M age = 12.66, 48.9% boys at first wave). Results showed developmental differences between the first and second year of secondary school (seventh and eighth grade). Whereas selection processes were found in the first year on students' cluster-specific grades, influence processes were found in the second year, on both students' average and cluster-specific grades. These results suggest that students initially tend to select friends on the basis of similar cluster-based grades (first year), showing that similarity in achievement is attractive for friendships. Especially for low-achieving students, similar-achieving students were highly attractive as friends, whereas they were mostly avoided by high-achieving students. Influence processes on academic achievement take place later on (second year), when students know each other better, indicating that students' grades become more similar over time in response to their connectedness. Concluding, this study shows the importance of developmental differences and specific school subjects for understanding peer selection and influence processes in adolescents' academic achievement.

Keywords: academic achievement; peer dynamics; early adolescence; social networks; RSiena

**First Selection, then Influence: Developmental Differences in Friendship Dynamics
Regarding Academic Achievement**

Academic achievement in adolescence is a key determinant of future educational chances and occupational success. Hence, it is important that adolescents maximize their performance in accordance with their own abilities (Flashman, 2012; Lubinski, Webb, Morelock, & Benbow, 2001; Shin & Ryan, 2014a; Witkow & Fuligni, 2010). However, there is huge variability in the extent to which adolescents do so and set a path towards academic success. Whereas some students enjoy academics a lot, work diligently on their school work, attend school every day, and get good grades, others show less interest in school, potentially leading to underachievement (Bandura, Barbaranelli, Capra, & Pastorelli, 2001; Bissell-Havran & Loken, 2009).

Several factors affect students' academic performance. First, individual factors are important, such as students' intelligence, interest in school, persistence, and willingness to study (Neisser et al., 1996). Second, environmental factors such as the capabilities and practices of teachers and parents, affect students' academic achievement (Farmer, Mcauliffe, & Hamm, 2011). The mean level of achievement in a classroom can also affect students' academic achievement, as indicated by studies on classroom composition effects (e.g., Barth et al., 2004). However, many previous studies have shown that particularly friends in classrooms play an important role in adolescents' academic behaviors, as students spend a large amount of time with them (Altermatt & Pomerantz, 2003; for a review see Crosnoe & Brenner, 2015). Friends provide support and resources and either promote or discourage attitudes and behaviors that contribute to school success (Anderman & Maehr, 1994; Brown, Eicher, & Petrie, 1986; Eccles et al., 1993; Lynch, Lerner, & Leventhal, 2013). Therefore, the goal of the present study is to examine the role of adolescents' friendships in their academic achievement.

Background

Adolescents tend to associate and form relationships with peers who are similar regarding their involvement in school (Kindermann & Skinner, 2009), motivation (Molloy, Gest, & Rulison, 2010), and academic achievement (Blansky et al., 2013; Lynch, Lerner, & Leventhal, 2013; Ryan, 2001; Witkow & Fuligni, 2010). Together, these studies clearly demonstrate similarities in academic adjustment between friends. There are two fundamental processes capturing friendship dynamics that can explain similarity between (sub)groups of people in academic outcomes: selection and influence (Snijders, 2001; Veenstra, Dijkstra, Steglich, & Van Zalk, 2013).

Selection processes refer to mechanisms by which individuals choose to hang out or become friends with each other, whereas *influence* processes refer to changes in behavior or attitudes in response to relationships with peers (Veenstra et al., 2013). Stochastic actor-based modeling (RSiena) makes it possible to disentangle influence from selection processes by examining changes in relationships and behaviors simultaneously (Ripley, Snijders, Boda, Vörös, & Preciado, 2015; Snijders, Van de Bunt, & Steglich, 2010). Currently, this approach has been used to examine the role of peers in different domains, varying from internalizing to externalizing behaviors (Veenstra et al., 2013). To date, however, there is only limited information about these processes for academic outcomes, let alone academic achievement.

A study by Geven, Weesie, and Van Tubergen (2013) showed that students became more similar to their friends over time with respect to school engagement (homework activity and paying attention in class), but also selected friends who are similar to them in these outcomes. Shin and Ryan (2014a) examined students' achievement goals, showing both selection and influence effects for mastery goals (i.e., a focus on developing academic competence), only influence effects for performance-approach goals (i.e., a focus on demonstrating high competence to others), and no selection and influence effects for

performance-avoidance goals (i.e., a focus on avoiding demonstration of incompetence to others).

More specifically, a few studies have focused on selection and influence processes in academic achievement. Lomi and colleagues (2011) found evidence for both selection and influence processes in a small sample of 75 Italian university students (aged between 24 and 40). Flashman (2012) showed that adolescents' academic performance was influenced by their peers (seventh through twelfth grade students), but also functioned as a sorting mechanism for friendship formation, particularly in large schools (selection). Further, it appeared that high-achieving students mostly formed relationships with other high-achieving students and were positively influenced, whereas low-achieving students associated with other low-achieving students and were negatively influenced. Also, Shin and Ryan (2014b) found influence effects on early adolescents' academic achievement and (marginal) selection effects in sixth grade. Finally, a study by Rambaran et al. (2017) revealed both selection and influence processes in ninth grade students' school achievement and truancy. Friendships were particularly formed and maintained between low-achieving students and students with high truancy levels.

These findings raise several issues. First, although previous studies indicate that both selection and influence play a role in students' academic achievement, it is important to understand how these processes develop and when they unfold. Previous studies mainly focused on the development of peer relationships and academic achievement within one specific school year (Geven et al., 2013; Shin & Ryan, 2014a, 2014b) or combined information from several school years, leaving potential developmental differences invisible (Flashman, 2012; Rambaran et al., 2017). Second, previous studies relied on the GPA (Grade Point Average) as a measure of academic achievement (e.g., Flashman, 2012; Lomi et al., 2011; Rambaran et al., 2017; Shin & Ryan, 2014a). By using GPA, differences in grades

between school subjects are not taken into account, losing the variability between grades and potentially leading to more heterogeneous findings than making content-related clusters of school subjects (Voyer & Voyer, 2014). For example, an average grade of seven out of ten can indicate a seven on all school subjects, or high scores on some subjects and low scores on others. Moreover, previous studies have shown that students' motivation and goals differ across school subjects (Bong, 2001).

Therefore, the aim of the present study is to examine adolescents' friendship selection and influence processes for academic achievement in the first two years of secondary school (i.e., seventh and eighth grade). This developmental period is chosen as it is at the start of secondary education, with students entering a new peer environment. Consequently, many students have to form new friendships and to find their place in the larger peer ecology. Hence, this context is ideal for testing selection and influence processes (Altermatt & Pomerantz, 2003).

Furthermore, we examine students' average grades and their grades on three clusters of subjects, that is, languages (Dutch and English), exact/science subjects (mathematics and biology), and social subjects (history and geography). As these grades are assessed within classrooms, friendship networks were also assessed on a classroom level, which is the main context for social interaction in the Dutch school system.

In further untangling selection and influence processes we are also interested in the directions of these processes. We aim to study the general dynamics more specifically for low-achieving and high-achieving students. That is, whether there are differences between low- and high-achieving students in their preference for having low- or high-achieving friends respectively, how this relates to their own achievement (selection), and whether high performing students enhance academic achievement of their lower achieving peers or whether low achieving students drag higher achieving peers down (influence).

Friendship dynamics

During adolescence, one of the main developmental tasks is to establish friendships with peers (Witkow & Fuligni, 2010), reflecting the need to belong as a fundamental human motivation (Baumeister & Leary, 1995). Especially in the first year of secondary education, students are in a new peer context in which friendships have to be formed. Through affiliation with others, adolescents try to achieve important social goals (Steverink & Lindenberg, 2006). They want to belong to the group, be liked, seek social approval and try to avoid rejection from peers (Cialdini & Goldstein, 2004; Gifford-Smith & Brownell, 2003), which students can achieve through selection and influence processes.

Selection

Selection is an important process that can explain similarities between adolescents' academic achievement. A core principle driving selection is 'homophily', which holds that people tend to pick similar others as friends. One reason for this strong empirical regularity is that similar people on average understand one another better, which increases trustworthiness and predictability, resulting in less effortful communications and shared feelings of understanding (McPherson, Smith-Lovin, & Cook, 2001). Hence, relationships between similar people tend to be more rewarding, stable, and with less conflict (Hallinan, 1980; Veenstra et al., 2013).

Moreover, adolescence is marked by increasing academic comparisons between peers (Schunk & Pajares, 2002). The social comparisons theory holds that individuals tend to compare themselves to similar peers to gain an accurate self-evaluation for their own abilities (Festinger, 1954). Likewise, these comparisons may affect adolescent friendships by befriending similar others with regard to academic abilities. Also, adolescents might be motivated to befriend others in the classroom with a high academic achievement to benefit from these friendships by receiving help while studying (Dieterich, 2015).

Based on these ideas, we hypothesize *that the more similar the academic achievement of a peer is to a student's academic achievement, the more probable it is that this peer is nominated as a friend (hypothesis 1)*. Going beyond the overall similarity effect, we are also interested in differences between low-achieving and high-achieving students. Therefore, we will examine whether high- or low-achieving peers are most attractive for affiliations, and whether they are equally attracted to each other as friends. For example, are there mainly friendships between low-achieving students or between high-achieving students? And are high-achieving students attractive as friends, whereas low-achieving students are mostly avoided by their peers?

Influence

Influence is another process that can explain similarities between students' academic achievement. Social influence occurs when people see and interact with each other (Webb, 1989). Conformity can occur as a result of subtle, unconscious, passive influences and behaviors, or directly via overt, active social pressure (Harakeh & Vollebergh, 2012).

Unwillingness to conform to expectations and behaviors can have negative consequences, as it carries the risk of social rejection by peers (Cohen, 1977). These norms are often implicit rules, which are shared by a group of individuals, and guide their interactions with others.

With regard to peer influence, many mechanisms are put forward to explain these processes (Brechwald & Prinstein, 2011), such as social reinforcement, social norms, conformity pressures (Cohen, 1977), and modeling (Ryan, 2001). According to the prototype willingness model adolescents first determine the norms of valued peers and then establish behaviors that would be approved by these peers (Gerrard, Gibbons, Houlihan, Stock, & Pomery, 2008). The social learning theory of Bandura (1977) indicates that people learn by observing peers (imitation), as well as through reinforcement by valued peers (e.g., social rewards or rejection). This influence can work upwards by stimulating pro-school behavior

and improving the grades of lower-achieving peers. However, it can also work downwards by lowering a friends' grades. In this way, peers in classrooms can play critical roles in students' development (Barth, Dunlap, Dane, Lochman, & Wells, 2004).

Friends can also become more similar in academic achievement over time due to information sharing (Crosnoe, Cavanagh, & Elder, 2003; Flashman, 2014). Friends may help each other with homework and share information concerning course contents and teachers. These resources can promote achievement by motivating students, encouraging involvement at school, and underlining the importance of schooling (Crosnoe et al., 2003), leading to higher grades among friends.

Based on the aforementioned reasoning, we hypothesize *that adolescents' academic achievement is influenced by their friends, indicating that their grades become more similar over time in response to their friends (hypothesis 2)*. As influence mechanisms can either motivate or demotivate adolescents for school work, we will examine whether influence processes in academic achievement work upwards or downwards. Do high-achieving friends enhance the academic achievement of lower achieving peers or do low-achieving friends drag higher achieving peers down?

Structural network effects

Friendships may emerge not only as a result of similarity in particular characteristics or behaviors, but also as a result of structure-based effects. For this reason, it is necessary to control for structural network effects (Veenstra & Steglich, 2012). To overcome the bias of overestimating the effects of individual characteristics in changing relationships, the most common structural network effects are included. First, we included the outdegree, the general tendency of students to nominate peers as friends. Second, reciprocity is included, the tendency to reciprocate friendship nominations. We also accounted for group formation tendencies (transitivity and three cycles). Finally, the variation in the extent to which students

nominate peers as friends (ego effects) as well as receive nominations as friends (alter effects) have been taken into account (Geven et al., 2013; Shin & Ryan, 2014b; Van Rijsewijk, Dijkstra, Pattiselanno, Steglich, & Veenstra, 2016; Veenstra et al., 2013). These effects as well as other effects in the model are explained in more detail in both the method section and Table 1.

Present Study

In the present study we examine friendship selection and influence processes in adolescents' academic achievement over time. We focus on different school years, that is, the first and second year of secondary school, on students' average grades and their grades on specific clusters of subjects, and on the strengths and directions of selection and influence processes for low-achieving and high-achieving students. Within a school year, we focus on friendships within a classroom as students follow all courses with the same classmates and are thus surrounded by them for the entire day.

Gender has also been included in the model, as a review study by Crosnoe and Brenner (2015) showed that girls on average outperform boys in all school subjects. Finally, we include time spent on homework and satisfaction with school as control variables, as those factors can influence students' connectedness with school and peer influences in school. It has been found that students who are more engaged and put more effort in their school work, achieve better (Carbonaro, 2005). Reviews on homework research provide consistent evidence for a positive influence of time spent on homework on students' academic achievement (Cooper, 1989; Cooper, Robinson, & Patall, 2006). Furthermore, previous studies showed that feeling at ease in school is often associated with less mistreatments, more connectedness, and less harassments which benefits students' academic achievement (Brook & Willoughby, 2015; Eisenberg, Neumark-Sztainer, & Perry, 2003; Russel & Topham, 2012).

Method

Participants and Procedure

Data stem from the SNARE (Social Network Analysis of Risk behavior in Early adolescence) study, which is a longitudinal project on the social development of early adolescents with a specific focus on adolescents' involvement in risk behavior (Dijkstra et al., 2015; Franken et al., 2015). Two secondary schools in rural areas were asked and willing to participate: one in the middle (one location) and one in the north of the Netherlands (with four distinct locations), covering the full range of academic tracks.

All students received an information letter for themselves and their parents, in which they were asked to participate. If students wished to refrain from participation, or if their parents disagreed with their children's participation, they were requested to send a reply card or email within ten days. This procedure is in accordance with the Dutch law, and has been used in previous social network studies among children and adolescents (Osgood et al., 2013; Shin & Ryan, 2014a). During every assessment, it was emphasized that participation was confidential and could be terminated at any point in time. The study was approved by the Internal Review Board (IRB) of one of the participating universities.

During the assessments, a teacher and research assistants were present. The research assistants gave a brief introduction followed by the students filling in a questionnaire on an individual computer during class, containing both self-reports and peer nominations. Data were collected via questionnaires using 'Cloud Solutions Socio Software' (www.sociometric-study.com). This software was developed for SNARE and allowed students to answer peer nomination questions easily by looking up and selecting their class- or grademates' names from a database. The assessment of the questionnaires took place during regular lessons within approximately 45 minutes. The students that were absent that day were, if possible, assessed within a month.

The present study includes all first year students (seventh graders) in 2011-2012 ($N = 614$) residing in 27 classes and the same students in 2012-2013 ($N = 604$) residing in 26 classes from both participating schools. From two classrooms in the second year no information about students' school grades was received. Therefore, 24 out of the 26 classrooms were analyzed ($N = 556$) (see Appendix A for more specific information on the attrition and number of students per wave). Based on the available information, students had on average less than two classmates in secondary school who attended the same elementary school. Hence, the vast majority of students enter a new peer context when they make the transition to secondary education. Note that students in their first years of secondary school in the Netherlands follow the same courses with the same classmates every school day.

The two school years include the first six waves of the SNARE study: October 2011 (Wave 1; M age = 12.66; 48.9% boys), December 2011 (Wave 2; M age= 12.83; 48.9% boys), April 2012 (Wave 3; M age= 13.16; 48.9% boys), October 2012 (Wave 4; M age= 13.66; 49.6% boys), December 2012 (Wave 5; M age= 13.83; 49.6% boys), and April 2013 (Wave 6; M age= 14.17; 49.3% boys). Of the participants, 97.5% were born in the Netherlands, and 87.1% of their fathers and 87.7% of their mothers.

Tracked system

In the Netherlands, secondary schools are organized by a tracked system. At the end of elementary school, in sixth grade (at age 12), students select a secondary school, and the track plays a crucial role in this selection. A student's track is based on a combination of recommendations from his or her elementary school (which holds records of students' academic development over time), a national test known as 'Citotoets', and their own preferences. The three tracks are: pre-university education (with a duration of six years, called 'VWO'), general secondary education (five years, called 'HAVO'; preparation for applied universities), and pre-vocational education (four years, called 'VMBO'). Pre-vocational

education covers four sectors (i.e., technology, health and personal care and welfare, economics, and agriculture) and four learning tracks. Three of these tracks have a practical orientation and one has a theoretical orientation.

Some exceptions notwithstanding, teaching takes place in track-homogeneous classes of 20-25 students who are educated together for a whole year. Academic grades obtained in this tracked system have a meaning only within tracks, and cannot be compared across tracks. Some secondary schools offer classes at all academic tracks, whereas others only offer classes at specific tracks.

Students rarely change tracks, and when they do, this means they need to change the class of schoolmates they meet on a daily basis. When they have insufficient grades and cannot pass the year, they will repeat a year. Alternatively, they can go to a lower track and not repeat the year. Changes to a higher track are only possible when students have outstanding grades.

Of the respondents, 17.8% followed a pre-vocational education track with a practical orientation; 25.9% followed a pre-vocational track with a theoretical orientation; and 56.3% followed a pre-university/general education track.

Measures

Academic achievement was derived from administrative data, the school report cards. On these school report cards, which are issued four times per year, students' average grades on all school subjects are displayed, according to the Dutch grading system (i.e., ranging between 1 and 10, with grades of 5.5 or higher corresponding to a pass). The grades from the first three school report cards match with the waves of data collection (i.e., October, December, and April), so we could match the grades obtained for the period preceding data collection with the data collected by the questionnaire.

We also calculated the average grades over six school subjects per student: Dutch, English, mathematics, biology, history, and geography. Subsequently, average grades for the language cluster (Dutch and English), exact/science cluster (mathematics and biology), and social cluster (history and geography) were calculated (see Table 2) Because RSiena requires dependent variables to be measured on a discrete, ordinal scale, students' grades were categorized into eight subcategories that optimally differentiate the students (see Table 3).

Friendships within classrooms were assessed using a peer nomination procedure. Participants were presented with the names of their classmates on a computer screen in alphabetical order, starting at a random name and asked to nominate their friends ('Who are your best friends?'). Participants could nominate an unlimited number of same- and cross-gender classmates. Based on these nominations, we constructed an adjacency matrix for each classroom at all waves containing all friendship nominations, with 0 and 1 representing absence and presence of a nomination between actors i and j , respectively.

Doing homework was assessed by asking the average time spent doing homework in a regular week (from Monday until Sunday). Students could indicate "the number of hours per day out of school spending on doing homework or on learning for a test" on a 10-point scale, with the following options: 1 (no time), 2 (less than half an hour per day), 3 (half an hour per day), 4 (one hour per day), 5 (two hours per day), 6 (three hours per day), 7 (four hours per day), 8 (five hours per day), 9 (six hours per day), and 10 (7 hours per day or more).

Satisfaction with school was measured, using the item "How do you feel about school at present?". Answers were measured on a four-point scale, with the following options: 1 (do not like it at all), 2 (do not like it much), 3 (do like it a bit), and 4 (like it a lot) (see also Harakeh, De Looze, Schrijvers, Van Dorsselaer, & Vollebergh, 2012).

Gender was coded 0 for girls and 1 for boys.

Analytical Strategy

RSiena

Adolescents' development of academic achievement was examined using the Simulation Investigation for Empirical Network Analysis (Siena) software package in R (Ripley, Snijders, & Preciado, 2015; Snijders et al., 2010), package version 1.1.282. RSiena facilitates the estimation of stochastic actor-based simulation models to analyze the co-evolution of networks and behavior. With these models, we are able to assess the contributions of selection and influence processes to friends' similarity in achievement as well as the directions of these processes (Steglich, Snijders, & Pearson, 2010). Similarity is understood here in a correlational sense: two students are similar to the degree that their achievement scores differ in the same direction from the average student's achievement in the classroom.

Students are assumed, based on individual preferences, to change both their friendships and behaviors continuously between observation moments. Model convergence is only possible when there is enough stability as well as change between time points. Friendships may change (i.e., creating a new friendships or dropping an existing one) as well as behaviors (i.e., by going one or more steps up or down in behavior) in response to the current network structure and the 'behavior' of other students in the network. It is thus a dynamic process where the model controls for changes in friendships and behaviors as well as structural and individual effects on changes in friendships and academic achievement. The changes in friendships and academic achievement are modeled as the result of students' decisions, revealing an underlying preference measure ('objective function') indicating how 'satisfied' the students are with their local network neighborhood configuration.

In the present study, we estimated friendship dynamics (including selection parameters) and the behavioral dynamics (including influence parameters) for academic achievement. The parameters in the model are explained in the following subparagraph (model specification) and are tested using *t*-ratios (parameter estimate divided by its standard

error), just like in other generalized linear models. The estimates are obtained by MCMC maximum likelihood estimation (Snijders, Koskinen, & Schweinberger, 2010).

Model Specification

Analyses in RSiena yield parameter estimates related to both network dynamics (structural network and attribute-dependent selection dynamics) and behavior dynamics (behavior tendencies and influence effects). The parameter estimates are derived from iterative simulations using the Robbins-Monro stochastic approximation algorithm (see Ripley et al., 2015). We explain the effects that are of interest in more detail in Table 1. Most of the included effects are control effects to more accurately assess the selection and influence effects with regard to academic achievement.

The network dynamics part of the model consists of the following effects. *Rate parameters* refer to the rate of change in friendships between time points, indicating whether there is enough change in the network (friendships). The most common *structural network effects* were also included in the model (Veenstra et al., 2013). *Density* reflects the tendency of individuals to nominate others. *Reciprocity* reflects the tendency to reciprocate received nominations. *Transitive triplets* and *reciprocated transitive triplets* refer to the transitive closure of individuals ('friends of friends become friends') and its iteration with reciprocity, respectively (Block, 2015). *Three cycles* represent nonhierarchical cycles of generalized reciprocity (i.e., student A nominates student B, student B nominates student C, and student C nominates student A). Furthermore, *ego* (sender) effects, referring to given nominations, and *alter* (receiver) effects, referring to received nominations, were included for grade. *Grade ego* and *grade alter* show to what extent academic achievement affects the number of nominations given and received, respectively.

Also, we estimated the *grade ego* * *grade alter* effect (selection effect), which measures whether students with high (low) academic achievement selected others who also

scored high (low) in similarity, showing whether similarity between ego and alter increases the probability of a friendship between them. For gender, we measured the *same gender* effect, indicating whether girls nominate more girls and boys nominate more boys as friends. Additional analyses (unreported) revealed that boys and girls did not significantly differ in terms of how many friendship nominations they sent or received, so we did not include ego and alter effects of gender in the reported model specification.

The behavior dynamics part of the model includes the following effects. *Rate parameters* indicate the rate of change in students' school grades between time points. The *average alter effect* (influence effect) estimates whether students' academic achievement was higher for students whose friends' average grades were also higher, indicating whether a student over time tends to get grades similar to those of his friends. Hence, it indicates the tendency of students to change their academic achievement to closely resemble their friends' average academic achievement. We controlled for the overall mean and variance of academic achievement by including the *linear shape* effect (overall tendency) and the *quadratic shape* effect (a negative parameter indicates regression to the mean effect, whereas a positive parameter indicates polarization). Finally, we controlled for gender, time spent on homework, and satisfaction with school on changes in academic achievement.

All aforementioned effects were first estimated per classroom for the first year and second year students, using the MCMC Maximum Likelihood method. Then, meta-analyses were conducted per school year to estimate the overall effect over the classrooms for each of the four outcome measures (dependent variables): students' average grades and their grades on the three different clusters.

Finally, based on our estimates, we calculated ego-alter selection effects in order to gain more insights in whether low-achieving and high-achieving students (represented by the lines for each of ego's scores in the figures) differ in their preference for low-achieving and

high-achieving friends (on the x-axis). The effects in the ego-alter selection figures give a comprehensive interpretation of the ego, alter, and ego * alter (selection) parameters as they integrate these effects. The values represent the combined log odds that students of the line-specific achievement category nominate students of the x-axis-specific achievement category as friends (Ripley et al., 2015). In a similar way we also calculated the ego-alter influence effects, based on the influence estimate in combination with the linear and quadratic shape effect. This allows a closer examination of how peer influence effects vary by an individuals' level of academic achievement.

Results

Descriptive Statistics

Students' grades. In Table 2, students' average grades and standard deviations in both the first and second year are shown. The means are displayed for all school subjects separately, for the average grades, and for students' grades on the three clusters. Also, the table shows that students' mean grades are between 6.30 and 7.37 (out of 10) and that these grades decline somewhat over time.

Network variables. Descriptions of network and individual variables are presented in Table 4. The average number of friendship nominations given varied between 4.67 and 5.68 across the six waves. The friendship network was characterized by a high reciprocity index with participants reciprocating about 60% of the friendship nominations. There was also a tendency for friendships to occur in cohesive subgroups, indicated by a high transitivity index in the network (on average 63%). Similar to previous studies, most friendship nominations were same sex (about 82%).

The Geary's *C* network autocorrelation coefficient was used to indicate the degree to which there is closeness of friends in terms of academic achievement (Steglich et al., 2010). The values of Geary's *C* lie between 0 and 2. Values lower than 1 demonstrate positive

network autocorrelation, indicating that students who are friends are also close to each other in terms of their academic achievement. In the present study, the index was on average .94, which indicates that the network was not strongly structured on achievement. The Jaccard index indicates the amount of stability in friendship nominations and is on average 53%. In order to conduct longitudinal network analysis in RSiena with adequate statistical power, this index should be higher than 30% (see Veenstra et al., 2013).

Time spent on homework. Across the six waves, the mean score (*SD*) varied between 4.43 (1.45) and 4.69 (1.32), indicating that students spent on average between 1 and 2 hours per day on their homework.

Satisfaction with school. Across the six waves, the mean score (*SD*) varied between 3.00 (.84) and 3.46 (.68), indicating that students generally liked school a bit to a lot.

RSiena analyses

First year (seventh grade). Table 5 shows the results of the RSiena meta-analysis on academic achievement for the first year students, regarding their average grades and their grades on each cluster. The table includes the mean estimate and the standard error for each effect. Estimates can be interpreted as log odds for a relationship to exist (friendship part of the model) or for achievement to increase (achievement part; Ripley et al., 2015). A negative significant effect for outdegree was found (Est.= -2.44), indicating that participants on average selected few peers (less than half of the classroom) as friends. Moreover, adolescents tended to reciprocate friendships (Est.= 1.77) and were likely to become friends with friends' friends (Est.= 0.37). However, reciprocation was weaker within transitive triplets (Block, 2015). Also, students select same-gender peers as friends (Est. = 0.88) and students with high grades were nominated more by peers as friends (grade alter; Est.= 0.04). No significant effects on grade ego effects were found, indicating that students' grades did not affect the amount of given friendship nominations.

In line with hypothesis 1 concerning the selection of friends based on academic achievement, a significant positive selection effect for grade on the three different clusters was found (mean estimate was about 0.05). This stands in contrast with the analysis of average grades, where no significant selection effect was found. Adolescents thus tend to nominate friends with similar grades on the same kinds of subjects (GPAs), but not with similar average grades.

For the behavior dynamics no influence effect was found, revealing that adolescents were not affected by the academic performance of their friends. This is in contrast to our second hypothesis, in which we expected social influence effects. Also, time spent on homework, satisfaction with school, and gender did not significantly predict students' grades.

Second year (eighth grade). Table 6 concerns the meta-analysis results on friendship and academic achievement for the second year students. Significant effects were found on all friendship network dynamics, except for transitive reciprocated triplets and grade ego and grade alter scores. These results indicate that most students nominate only few of their classmates as friends (density is -2.50), friendships are often reciprocated (Est.= 1.46), students were likely to befriend friends' friends (Est.= 0.36), and students mostly select same-gender peers as friends (Est.= 0.81). Also, related to hypothesis 1, only significant selection effects were found on students' average grades (Est.= 0.11) and their grades on the language cluster (Est.= 0.04).

Results for behavior dynamics showed no significant effects from gender, time spent on homework, and satisfaction with school on students' grades. However, students were significantly influenced by peers on both their average grades (Est.= 0.09) and their grades on all clusters (mean estimation of clusters was Est.= 0.09), indicating that their grades become more similar over time in response to their connectedness. This is in line with hypothesis 2.

Further results with regard to selection. The ego-alter selection figure for the first year students (see Figure 1) presents the attractiveness of selecting friends on the basis of academic achievement for the language cluster, which is chosen as an illustrative figure representative for each cluster. On the left part of the figure, it is shown that there are especially strong preferences for low-achieving students to befriend similar achieving peers (attractiveness), whereas high-achieving students are not inclined to nominate low-achieving peers as friends. These attraction and avoidance patterns are weaker for high-achieving peers (see right part of the figure). The ego-alter selection effects in the second year (see Figure 2) for students' average grades show that similar-achieving students mainly select each other as friends. These effects are more polarized than in the first year, that is, strong effects (both attraction and avoidance) were found for low-achieving (see left part of the figure) as well as high-achieving students (see right part of the figure).

Further results with regard to influence. We only found a significant influence effect in the second year and therefore only calculated ego-alter influence effects for this schoolyear (see Table 7). The first column shows the different values of academic achievement of the peers (running from 1 to 8), whereas the values in the rows indicate the relative attractiveness of these behavior for adolescents, varying by their own level of academic achievement (also running from 1 to 8). Comparing the values between rows indicates that the better peers academically achieve, the more likely it is that adolescents will move upwards in their own academic achievement. This is shown by the fact that the attractiveness of peer behaviors, indicated by the values in the rows, turn from negatively to more positive values. However, these effects become weaker for the highest values of academic achievement of peers. This suggests a regression to the mean effect, with low-achieving adolescents who profit from better achieving peers but high achieving adolescents decreasing a bit in their academic achievement.

Discussion

This study contributes to our understanding how friendship relationships affect adolescents' academic achievement (influence processes) and how academic achievement affects their friendship relationships (selection processes) by looking at these processes in the first two years of secondary school with regard to students' average grades and their grades on different clusters of subjects. Building on previous studies, we advanced current knowledge by studying the development of selection and influence processes in students' academic achievement during two years and grades per language, science, and social cluster next to students' average grades.

Three main conclusions can be derived from the results. First, selection and influence processes develop differently over the years. First year students, who do not know each other in the beginning of the year, tended to select similar others with regard to cluster-specific school grades but were not significantly influenced by their friends' academic achievement. However, one year later the converse pattern was found. Friends were influenced by each other with regard to their average grades and their grades on different clusters, whereas selection was less prominent. These results suggest that students initially (first year) tend to select friends on the basis of similar grades and that influence processes on academic achievement emerge later on (second year), when the students know each other better.

Influence processes thus seem to take more time to unfold, which might explain non-significant peer influence effects on adolescents' grades in a previous study regarding sixth graders (Dieterich, 2015). This timing effect may be explained by the fact that influence processes operate through social processes such as imitation (Bandura, 1977). An adolescent may be influenced by a friend's pro-school behavior, but it takes some time to really improve the grades. Another explanation can be that students first need to know their peers well in order to be influenced by them. Students have to establish friendships in the first year in a

new peer context, whereas these friendships are stronger and more stable in the second year (Altermatt & Pomerantz, 2003). Differences in selection and influence processes might also be explained by students' developmental phases. In the first year, early adolescents are in a new school context in which parents might still be their most important supporters. In the second year these adolescents know the school system and their friends better, leading to more susceptibility to their friends' behaviors.

A second conclusion is that similarity in achievement seems to facilitate friendship, as low-achieving as well as high-achieving students show mutual attractiveness in the tendency to nominate each other as friends. However, especially high-achieving students seem to have a low tendency to nominate low-achieving peers as friends (avoidance). This finding is in line with the social comparison theory of Festinger (1954), which holds that people tend to move into groups whose abilities are near to their own in order to satisfy their need for a positive self-evaluation. With regard to influence, this study shows that students mainly get higher grades when having high-achieving friends. Friends can thus influence students' grades upwards by improving the grades. This might be explained by the fact that friends share information and motivate and encourage each other for school involvement (Crosnoe et al., 2003). Also, low-achieving students might be motivated to achieve well due to carrying the risk of not passing in the end of the year and subsequently losing their peers in the classroom and losing frequent contact with friends.

Third, it seems meaningful to distinguish between students' average grades and their grades on content-related clusters of subjects as this study shows different effects between the average and cluster-specific grades. The different peer selection and influence effects for the average and cluster-specific grades may be explained by the fact that students' average grades are based on grades on different subjects, with much variability in these grades. Also, selection of similar others with regard to specific grades might indicate that these students

share the same, specific interests. As students might attribute more salience to specific subjects than others, they may talk with some classmates about those subjects and work together with them once they see that a specific peer is engaged in that subject. This can be a determinant of an emerging friendship. Moreover, the finding that students select friends on the basis of similar grades in specific clusters might indicate that they have subject-specific academic self-concepts, which is consistent with earlier findings (e.g., Marsh, Walker, & Debus, 1991). Due to knowledge about their own and their peers' academic abilities in all different school subjects, they compare themselves with their peers in specific clusters (Bong, 2001).

Related to this, it might be that similar achieving students choose their seats close to each other, as students that are highly motivated for specific school subjects often sit in the front and are less motivated students in the back of the classroom. In this way, academic behavior and motivation by surrounding peers, for instance through making notes and paying attention to the teacher, can unconsciously or consciously affect students' behavior. This is in line with the idea that teachers in elementary schools determine classroom seating arrangements and subsequently influence social network processes in the classroom (Gest & Rodkin, 2011; Van den Berg, Segers, & Cillessen, 2012). By choosing seats close to each other, these peers see each other more during that specific lesson and have more opportunities to become friends and to be influenced with regard to those specific grades.

These findings have some practical implications. The fact that similar achieving students seem to select each other as friends and that especially high-achieving students show the tendency to avoid befriending low-achieving students, can have negative consequences. It carries the risk of underachievement for low-achieving students as it limits their possibilities of being positively influenced by friends. Stimulating and facilitating contact between low- and high-achieving students might be an important way to increase liking among peers with

different academic achievement and to prevent students from exclusion of a network with pro-school behavior. This can be accomplished for instance by school assignments including cooperation between students and strategies to manage classroom social dynamics, for example by placing students with different abilities close to one another to get to know each other and to provide each other support with school work (Gest, Madill, Zadzora, Miller, & Rodkin, 2014; Van den Berg et al., 2012).

Limitations and Future Studies

The results of the present study should be interpreted in light with its limitations. First, students have different academic capacities. Although everybody can work hard and might be motivated to achieve well, students can only reach their own maximum. Therefore, students can only be positively influenced regarding their grades within their own capabilities.

However, students in the Netherlands are tracked and students are supposed to be able to achieve well (and reach high grades) within their own educational track. Within each educational track as well as within classrooms there is much variability in students' grades, so changes in academic achievement can be analyzed by relating it to their friendships. The results of the present study have indeed shown that adolescents' friendships can contribute to their academic development. The educational systems in the Netherlands, with tracks, differs from many other systems such as the US, where students with different academic abilities attend the same high school. However, even with this tracked system we find important friendship selection and influence effects, making it plausible that even stronger effects can be found in classrooms with more academic ability differences.

A second limitation is that students' academic achievement does not always reflect their academic abilities, as non-cognitive skills such as students' attitudes, behaviors, and strategies are also crucial to their performance (review by Farrington et al., 2012). Especially because students in our study were tracked, grades cannot be compared between tracks.

However, we focused on students' grades within their classroom and whether their friendships with classmates are related to it. We based students' academic achievement on their report card grades, which is often used in other studies as well (e.g., Rambaran et al., 2017; Shin & Ryan, 2014b) and is supposed to be an objective and thus reliable measure of students' grades. Moreover, grades are provided by different teachers and for different courses (multiple informants) making them even more reliable. Focusing on students' actual grades is important as it determines whether a student passes a class and subsequently further educational opportunities (Witkow & Fuligni, 2010).

A third limitation is that the expectation that students become friends with similar achieving peers does not necessarily imply that these students consciously seek out a friend with a particular level of academic achievement (Flashman, 2012). Similarity attraction may also be related to other factors, such as meeting opportunities via the seating arrangement in the class (Gremmen, Van den Berg, Segers, & Cillessen, 2016) or to other personality and character traits that students actively desire in their friends (e.g., motivation, and attitudes). These unobservable individual factors could have played a role as well, and warrant inclusion in further research. Moreover, contextual factors such as peer norms on the class level can also play a role in students' academic achievement, and the way peer processes either contribute to or deteriorate academic success (cf. Dijkstra & Gest, 2015; Laninga-Wijnen, Harakeh, Dijkstra, Veenstra, & Vollebergh, 2017a; Laninga-Wijnen et al., 2017b).

However, Gest, Domitrovich, and Welsh (2005) have found evidence that peers can influence an individual students' academic achievement through peer academic evaluations. Peers in classrooms observe each other's engagement for school and specific school subjects, by first-hand experiences such as working with classmates and noticing their work habits and skills. As a result, classmates have unique information about the academic behavior and grades of peers (Gest et al., 2005), besides the fact that they often know their peers' report

card grades as well. Social comparisons with especially friends can predict changes in students' own reasoning about their achievement and motivation levels (Altermatt & Pomerantz, 2003; Ryan, 2001).

A related issue is that in view of statistical power and related convergence problems due to analyses on the classroom level we could not control for other factors that are potentially relevant for selection processes, such as differences between educational tracks, the classroom size, or the percentage of boys in a classroom.

One avenue for future research is to test on specific mechanisms underlying peer selection and influence processes. For example, friendships can be defined more specifically according to the frequency of contact or the shared intimacy. Some students might indicate to be friends within the classroom, but it is also interesting to know whether they meet each other out of school, how much personal information they share with each other, and what kinds of shared activities they have (e.g., doing homework together). Future studies can also focus more on the interplay between adolescents' academic achievement and other behaviors, by examining both direct and indirect socialization effects by peers (Giletta, Burk, Scholte, Engels, & Prinstein, 2013). For example, to what extent does the interplay with other behaviors (such as risky and prosocial behaviors) affect students' preferences for specific friends and the extent to which they adjust their academic achievement to their friends?

Next to this, future studies should take different kinds of subjects, instead of only average grades, into consideration. Results show selection of peers based on different interests in the first year, possibly reflecting different types of students (e.g., more technically oriented students and students who are more interested in languages). In the present study, these selection effects would have remained invisible when only average grades would have been studied. On top of that, it is important to investigate developmental differences on the impact of peer processes on students' academic achievement. Previous studies mainly included one

year in secondary school (Geven et al., 2013; Rambaran et al., 2017; Shin & Ryan, 2014a, 2014b), or did not differentiate in the analyses between school years (Flashman, 2012).

However, our study shows different processes in the second compared to the first year.

Frank and colleagues (2008) found that especially girls are responsive to social norms with regard to mathematics. It was beyond the scope of this study, but this calls for a more detailed investigation of gender differences in peer dynamic studies. Previous studies have found friendship and individual differences between girls and boys concerning academic behavior (Van Houtte, 2004; Warrington, Younger, & Williams, 2000). So it might be the case that selection and influence processes differ between boys and girls. Is selection on languages for example more important for girls, whereas selection on science-related, technical subjects is more important for boys?

Finally, previous studies have found differences between schools and classes in the extent to which selection and influence processes in academic achievement take place (Dieterich, 2015; Flashman, 2014). Therefore, future studies should aim to understand the causes of these differences. Between-class variations might be explained by the classroom context, for instance through peer norms (Dijkstra & Gest, 2015). Peer norms reflect the expected and accepted behavior of a social group, making it interesting to study the role of these norms on peer processes. In some classes pro-school behavior (e.g., helping behavior, concentration) may be the norm and thus be seen as attractive, whereas in other classrooms popular students have low academic scores and promote anti-school behavior (e.g., distracting behavior).

To conclude, this study shows the important role of friendship selection and influence processes in adolescents' academic achievement. Developmental differences were found, as well as differences between students' average and cluster-specific grades. The results suggest

that students initially tend to select friends on the basis of cluster-specific grades (selection), and that they adjust their academic achievement to friends in the second year (influence).

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Appendix A

Attrition within school year 2011-2012 (first year). Between waves 1 and 2, two students entered school and one student moved to another classroom within the school. Between waves 2 and 3, four students entered school and nine students moved to another classroom within the school. Also, at wave 1, the data of one student was found unreliable and was deleted. Across the school year 2011-2012, a total of seven students had refused to participate in the study. All their data was deleted, including their previously filled out data. In addition, five students did not fill out the questionnaire at wave 1, eight students at wave 2, and 19 students at wave 3. This leaves us with 601, 600, and 591 participants at wave 1, wave 2, and wave 3 respectively.

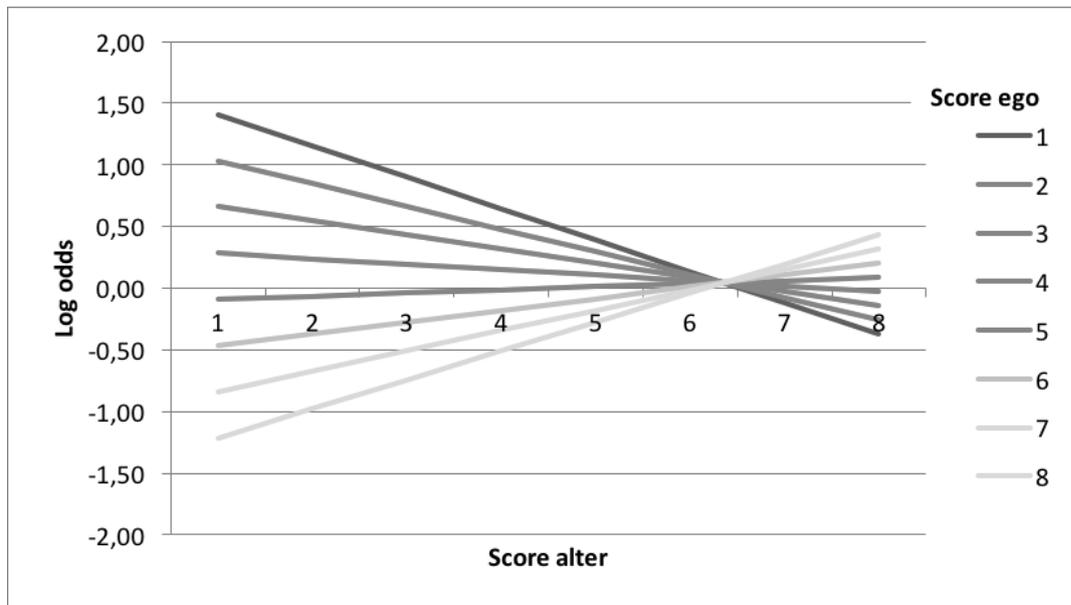
Attrition between school years (first and second year). Between wave 3 and wave 4, 10 students had to repeat a class.

Attrition within school year 2012-2013 (second year). Between waves 4 and 5, seven students entered school and two students moved to another classroom within the school. Between waves 5 and 6, the number of students remained the same. Across the school year 2012-2013, a total of six students had refused to participate in the study. All their data was deleted, including their previously filled out data. In addition, 13 students did not fill out the questionnaire at wave 1, 19 students at wave 2, and 17 students at wave 3. This leaves us with 550, 551, and 553 participants at wave 4, wave 5, and wave 6 respectively.

Figures

Figure 1

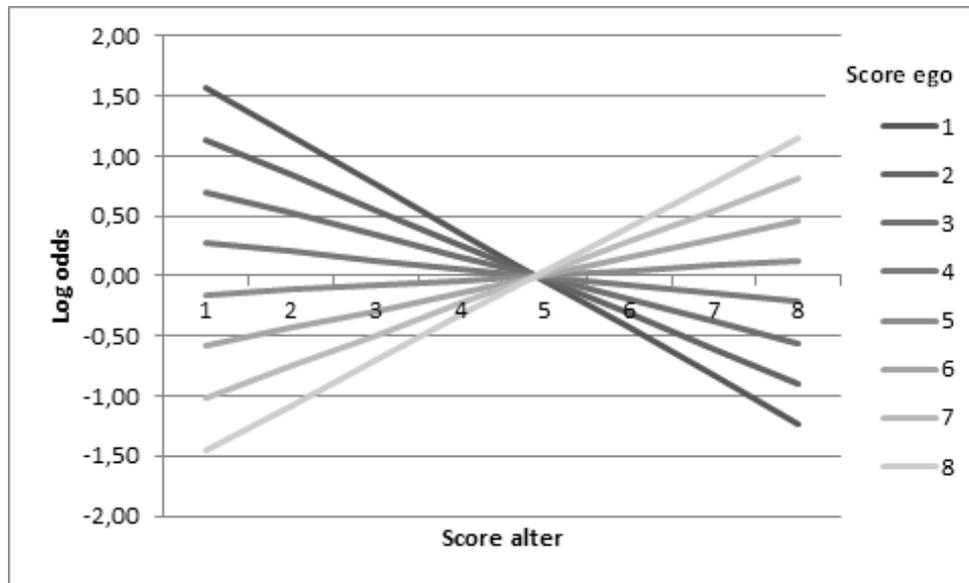
Ego/alter selection in the first year regarding students' grades on the language cluster: log odds that ego (an individual) nominates alter (a peer) given the achievement scores of ego and alter.



Note. Calculations based on Ripley et al. (2015). Ego refers to an individual student (the nominator) whereas alter refers to his/her peers (the nominees).

Figure 2

Ego/alter selection in the second year regarding students' average grades: log odds that ego (an individual) nominates alter (a peer) given the achievement scores of ego and alter.



Note. Calculations based on Ripley et al. (2015). Ego refers to an individual student (the nominator) whereas alter refers to his/her peers (the nominees).

Tables

Table 1

Explanation of Some Basic Parameters in the RSiena Model

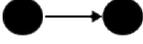
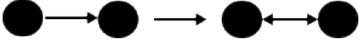
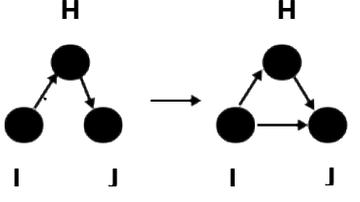
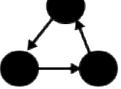
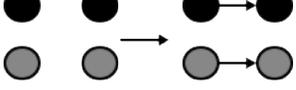
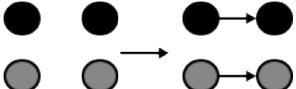
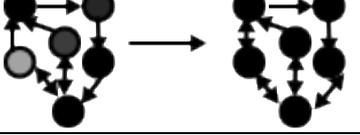
<i>Effect</i>	<i>RSiena effect name</i>	<i>Explanation</i>	<i>Graphical representation</i>
Outdegree	density	The basis tendency to form relationships (nominate others)	
Reciprocity	recip	The tendency toward reciprocation of received nominations	
Transitive triplets	transTrip	Transitive closure ($i \rightarrow h \rightarrow j; i \rightarrow j$): Intermediary h adds proportionally to the tendency to form relation $i \rightarrow j$. (Friends of friends become friends)	
3-cycles	cycle3	Nonhierarchical cycles of generalized reciprocity	
Same gender	sameX	Relations occur more often between actors with the same gender	
Grade alter (alter effect)	altX	Actors with higher grades have a higher indegree (more received nominations)	
Grade ego (ego effect)	egoX	Actors with higher grades have a higher outdegree (more given nominations)	
Grade ego * Grade alter (selection effect)	egoX * altX	Relations occur more often between students with the same grades	
Average alter (influence effect)	avAlt	The tendency of students to get grades similar to those of friends	

Table 2

Descriptive statistics of students' school grades in their first and second year, the averages of these school grades, and the averages per cluster (N≈600).

	First year						Second year					
	W1		W2		W3		W4		W5		W6	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Dutch	7.16	.93	7.10	.84	6.99	.95	6.75	.92	6.57	.89	6.57	.85
English	7.37	1.28	7.00	1.23	6.93	1.24	6.81	1.29	6.97	1.11	6.64	1.12
history	6.77	1.12	6.30	1.23	6.52	1.15	6.22	1.05	6.62	.99	6.58	.97
geography	6.91	1.12	6.47	1.15	6.47	1.03	6.40	1.10	6.74	1.09	6.54	1.06
mathematics	7.01	1.20	6.84	1.24	6.83	1.33	6.50	1.32	6.63	1.33	6.82	1.44
biology	7.21	1.03	7.08	1.06	6.81	1.21	6.84	1.07	6.58	1.14	6.86	1.09
Average total (GPA)	7.00	.74	6.75	.82	6.68	.89	6.56	.73	6.72	.69	6.64	.74
Average languages	7.26	.92	7.05	.88	6.96	.97	6.78	.87	6.77	.80	6.60	.82
Average social	6.84	.92	6.38	1.04	6.49	.92	6.31	.84	6.68	.82	6.57	.84
Average science	7.11	.95	6.96	.98	6.82	1.12	6.64	1.02	6.61	1.05	6.83	1.07

Note. School grades are measured on a scale from 1 to 10 and grades below 5.5 are considered unsatisfactory.

Table 3

Categories for school grades and per wave the number of students that have average grades falling into a specific category.

Category	Grades	First year			Second year		
		W1	W2	W3	W4	W5	W6
1	< 5.0	7	53	72	4	23	60
2	5.0 – 5.4	4	40	38	32	31	45
3	5.5 – 5.9	24	55	59	75	62	60
4	6.0 – 6.4	84	105	69	106	90	62
5	6.5 – 6.9	126	121	86	148	91	66
6	7.0 – 7.4	147	80	67	106	110	72
7	7.5 – 7.9	122	77	78	41	76	79
8	≥ 8.0	73	56	116	19	48	86

Note. School grades below 5.5 (categories 1 and 2) are considered unsatisfactory. Students get grades for about 13 subjects. For transition to the next year/grade, an overall maximum of three unsatisfactory grade points on these 13 subjects is allowed.

Table 4

Sample and change descriptives for the 27 first year and the 24 second year classes (N≈600).

<i>Sample</i>	W1	W2	W3	<i>Sample</i>	W4	W5	W6
Network density indicators				Network density indicators			
Average degree	5.25 (1.41)	5.68 (1.21)	5.55 (1.37)	Average degree	5.38 (1.39)	5.25 (1.27)	4.67 (1.18)
Missing fraction	2.6%	2.2%	2.4%	Missing fraction	1.7%	0.6%	1.7%
Other network indicators				Other network indicators			
Reciprocity	61% (.08)	61% (.09)	61% (.09)	Reciprocity	60% (.11)	58% (.11)	57% (.10)
Transitivity	63% (.08)	64% (.07)	64% (.08)	Transitivity	63% (.09)	63% (.11)	62% (.11)
Same sex	86% (.09)	83% (.10)	84% (.09)	Same sex	80% (.10)	79% (.09)	81% (.07)
Control variables				Control variables			
Homework	4.69 (1.32)	4.45 (1.52)	4.43 (1.45)	Homework	4.58 (1.53)	4.55 (1.64)	4.46 (1.76)
Satisfaction with school	3.46 (.68)	3.41 (.72)	3.20 (.84)	Satisfaction with school	3.10 (.81)	3.07 (.84)	3.00 (.84)
Network autocorrelation				Network autocorrelation			
Geary's <i>C</i> achievement	.96 (.18)	.94 (.22)	.94 (.19)	Geary's <i>C</i> achievement	.84 (.11)	1.00 (.13)	.95 (.23)
<i>Change</i>	W1-W2	W2-W3		<i>Change</i>	W4-W5	W5-W6	
Friendship indicators				Friendship indicators			
Jaccard index (stability)	50% (.08)	52% (.09)		Jaccard index (stability)	56% (.11)	52% (.09)	
Hamming distance	85.30%	82.59%		Hamming distance	75.8%	79.33%	
(change)	(38.35)	(40.07)		(change)	(42.23)	(43.44)	
No. of friendships dissolved	1013	1296		No. of friendships dissolved	995	1190	
No. of friendships emerged	1316	1202		No. of friendships emerged	940	783	
No. of friendships maintained	2248	2268		No. of friendships maintained	2131	1181	
Changes in achievement (average)				Changes in achievement (average)			
No. of steps down	763	541		No. of steps down	346	529	
No. of steps up	180	667		No. of steps up	401	547	
Actors that remain stable	22.5% (.14)	17.2% (.11)		Actors that remain stable	17.5% (.11)	13.0% (.09)	

Note. Standard deviations are placed between brackets. Reciprocity was calculated as $2M/(2M+A)$, where M = mutual friendship and A = asymmetric friendship; Transitivity was calculated as N of transitive triplets divided by N of 2-paths (potentially transitive triplets); See for more information on the calculation of the different network indices Veenstra and Steglich (2012).

Table 5

Meta-analysis results on friendship and academic achievement for the 27 first year classes (N≈600).

	Average		Language		Social		Science	
	Mean est.	SE						
<i>Network dynamics: Friendship</i>								
Constant friendship rate (period 1)	8.01	.63	8.78	.82	7.69	.47	8.78	.82
Constant friendship rate (period 2)	8.25	.84	7.67	.66	7.67	.66	7.67	.66
Outdegree (density)	-2.44 ^{***}	.07	-2.65 ^{***}	.16	-2.58 ^{***}	.15	-2.65 ^{***}	.16
Reciprocity	1.77 ^{***}	.12	1.64 ^{***}	.12	1.64 ^{***}	.12	1.64 ^{***}	.12
Transitive triplets	.37 ^{***}	.03	.37 ^{***}	.02	.37 ^{***}	.02	.37 ^{***}	.02
Transitive reciprocated triplets	-.13 ^{***}	.03	-.12 ^{***}	.03	-.12 ^{***}	.03	-.12 ^{***}	.03
3-cycles	-.28 ^{***}	.03	-.27 ^{***}	.03	-.27 ^{***}	.03	-.27 ^{***}	.03
Same gender	.88 ^{***}	.09	.86 ^{***}	.07	.85 ^{***}	.07	.86 ^{***}	.07
Grade alter	.04 ^{**}	.02	.07 ^{**}	.03	.06 ^{**}	.02	.07 ^{**}	.03
Grade ego	-.08	.07	-.07	.07	-.03	.04	-.07	.07
Grade ego * Grade alter	.07	.06	.05 ^{***}	.02	.04 ^{**}	.01	.05 ^{**}	.02
<i>Behavior dynamics: Achievement</i>								
Rate grade (period 1)	9.80	1.70	6.89	.84	6.89	.84	6.89	.84
Rate grade (period 2)	7.95	1.17	9.91	1.36	9.96	1.44	9.91	1.36
Linear shape	.02	.03	.00	.05	.04	.04	.00	.05
Quadratic shape	-.02 [*]	.01	.00	.01	-.01	.01	.00	.01
Effect of friends' grades (average alter)	.06	.04	-.28	.24	-.01	.04	-.28	.24
Effect from gender (1=boy)	-.03	.03	-.07	.04	-.07	.04	-.07	.04
Effect from homework	.02	.01	.00	.02	-.01	.02	.00	.02
Effect from satisfaction with school	.03	.02	-.02	.03	-.02	.03	-.02	.03

Note. * p-value <.05. ** p-value <.01. *** p-value <.001 (two-tailed tests). Students in the pre-vocational track with practical orientation did not have history and geography courses, so these classrooms were not included in the analyses concerning the social cluster.

Table 6

Meta-analysis results on friendship and academic achievement for the 24 second year classes (N≈550).

	Average		Language		Social		Science	
	Mean est.	SE						
<i>Network dynamics: Friendship</i>								
Constant friendship rate (period 1)	7.13	.73	6.90	.72	6.38	.63	6.56	.63
Constant friendship rate (period 2)	6.81	.59	6.82	.67	7.29	.67	8.15	1.08
Outdegree (density)	-2.50 ^{***}	.10	-2.41 ^{***}	.08	-2.72 ^{***}	.22	-2.28 ^{***}	.05
Reciprocity	1.46 ^{***}	.11	1.45 ^{***}	.11	1.52 ^{***}	.12	1.45 ^{***}	.09
Transitive triplets	.36 ^{***}	.03	.38 ^{***}	.03	.44 ^{***}	.08	.38 ^{***}	.04
Transitive reciprocated triplets	-.03	.04	-.02	.05	-.02	.08	-.01	.04
3-cycles	-.32 ^{***}	.03	-.33 ^{***}	.03	-.37 ^{***}	.05	-.29 ^{***}	.03
Same gender	.81 ^{***}	.10	.72 ^{***}	.07	.67 ^{***}	.07	.75 ^{***}	.08
Grade alter	.03	.03	.04 [*]	.02	.06	.09	-.02	.02
Grade ego	.00	.11	-.10	.07	-.10	.11	-.04	.04
Grade ego * Grade alter	.11 [*]	.06	.04 [*]	.02	.01	.05	.02	.01
<i>Behavior dynamics: Achievement</i>								
Rate grade (period 1)	8.97	2.29	11.22	1.72	10.58	3.65	10.32	2.41
Rate grade (period 2)	7.80	1.36	12.36	1.81	18.68	2.83	13.42	1.68
Linear shape	.06 ^{***}	.02	.00	.03	.06 ^{**}	.02	.13 ^{***}	.03
Quadratic shape	-.03 ^{***}	.01	.00	.01	-.01	.01	.03 ^{***}	.01
Effect of friends' grades (average alter)	.09 ^{***}	.02	.09 ^{***}	.03	.09 [*]	.04	.10 ^{***}	.02
Effect from gender (1=boy)	-.02	.02	.00	.03	.02	.04	.05	.07
Effect from homework	-.01	.01	-.02	.01	.01	.01	-.01	.01
Effect from satisfaction with school	.00	.02	.00	.02	.01	.02	.01	.02

Note. ^{*} p-value <.05. ^{**} p-value <.01. ^{***} p-value < .001 (two-tailed tests). Students in the pre-vocational track with practical orientation did not have history and geography courses, so these classrooms were not included in the analyses concerning the social cluster.

Table 7

Ego-alter influence table in the eighth grade regarding students' average grades: log odds that ego's grades (individual student) are influenced by alter's grades (peers) given the achievement scores of ego and alter.

Alter/ Ego	1	2	3	4	5	6	7	8
1	-1.04	-.95	-.86	-.77	-.68	-.59	-.50	-.41
2	-.78	-.69	-.60	-.51	-.42	-.33	-.24	-.15
3	-.57	-.48	-.39	-.30	-.21	-.12	-.03	.06
4	-.43	-.34	-.25	-.16	-.07	.02	.11	.20
5	-.35	-.26	-.17	-.08	.01	.10	.19	.28
6	-.32	-.23	-.14	-.05	.04	.13	.22	.31
7	-.36	-.27	-.18	-.09	.00	.09	.18	.27
8	-.45	-.36	-.27	-.18	-.09	.00	.09	.18

Note. Calculations based on Ripley et al. (2015). Ego refers to an individual student (the nominator) whereas alter refers to his/her peers (the nominees).

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