ADOLESCENTS' COLLABORATION IN THE CLASSROOM: DO PEER RELATIONSHIPS OR GENDER MATTER?

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Peer collaboration can be a useful tool in a school classroom to help students perform at their best. With whom should students be paired, though? Previous research yields inconsistent findings regarding whether the benefits of peer collaboration depend on the gender or friendship of collaborators. We paired students with a same-gender friend or a nonfriend in their classroom to examine whether friendship and specific dimensions of relationship quality were important for understanding adolescent ($N = 132$ high-school students) boys' and girls' performance on a scientific reasoning task. Dimensions of relationship quality were related to task performance with greater perceived conflict predicting poorer performance. Girls outperformed boys, but the difference was marginal and nonsignificant after accounting for dimensions of relationship quality. Friends' and nonfriends' performance was similar. Results are informative for educators who use collaboration as an instructional technique and for other professionals who work to support the development of effective reasoning and problem-solving skills among adolescents. © 2008 Wiley Periodicals, Inc.

When teachers use peer collaboration in the classroom, the question of how to best pair students to facilitate their performance becomes important. Does it matter whether students are friends? Do boys and girls benefit similarly from collaboration? Researchers have documented general advantages to collaborating with a peer versus working alone for performance on cognitive problem-solving tasks (e.g., scientific reasoning tasks; Fawcett & Garton, 2005; Forman & Cazden, 1985; Tudge, 1992; see Rogoff, 1998, for a review). Collaboration among friends may be particularly advantageous (e.g., Azmitia & Montgomery, 1993). However, teachers may be concerned that friendship will interfere with performance (Hartup, 1996a). Studies that address associations among friendship, gender, and peer collaboration are few in number, yield mixed results, and are based primarily on children and young adolescents. The current study addresses whether the friendship and gender of collaborating pairs of adolescents are associated with performance on a scientific reasoning task. The study also addresses whether dimensions of relationship quality during peers' collaborative interactions are systematically associated with performance, above and beyond any friendship or gender differences. By addressing these two aims, we hope to provide recommendations for teachers who use peer collaboration as an instructional technique and for school professionals who work to support the development of effective reasoning and problem-solving skills in adolescence.

When friends outperform nonfriends on collaborative tasks, researchers often attribute friends' superior performance to qualities of relationships such as their supportiveness (e.g., Azmitia & Montgomery, 1993). Yet, the association between relationship qualities and collaborative performance has not been tested empirically. Relationship qualities such as support and validation differentiate adolescents' friendships from those of younger children (Ginsberg, Gottman, & Parker, 1986).

Thus, adolescence is an ideal developmental period within which to examine the association between relationship quality and collaborative task performance. In addition, compared to children, adolescents spend more time with peers and friends in social settings (Buhrmester, 1996; Csikszentmihalyi & Larson, 1984; Laursen, 1996). Thus, it is important to understand whether characteristics of peers' social relationships (e.g., gender, friendship, relationship quality) are associated with adolescents' reasoning and problem-solving skills.

Vygotskian Theory and Peer Collaboration

When two people collaborate to solve a problem, each brings his or her own perspective to the situation. Vygotskian sociocultural theory predicts that collaboration leads to cognitive growth when partners arrive at a shared or intersubjective understanding of the situation (Bearison, Magzamen, & Filardo, 1986; Gauvain & Rogoff, 1989; Glassman, 1994; Hartup, 1996a; Russell, 1982; Tudge, 1992; Tudge, Winterhoff, & Hogan, 1996). Researchers have begun to address whether friendship of partners is associated with the development of a shared understanding of tasks and performance on such tasks (Azmitia & Montgomery, 1993; Strough, Berg, & Meegan, 2001; Strough & Cheng, 2000; Strough, Swenson, & Cheng, 2001). This focus on friendship comes from research indicating that having a friend is beneficial to adjustment in general (Demir & Urberg, 2004; Dunn, 2004; Hartup, 1996b; Hartup & Stevens, 1997; Ladd & Kochenderfer, 1996). Thus, researchers have begun to consider whether friendship is beneficial for cognitive development in particular (Hartup, 1996a).

Friends may provide a context that promotes cognitive growth. Friends spend more time together than do nonfriends and develop expectations and knowledge of one another (Hartup, 1996b; Zajac & Hartup, 1997) that may come from frequent self-disclosure of secrets and an understanding of the person's strengths and weaknesses. Consequently, friends may challenge each other more than would nonfriends, leading to cognitive, or intrapersonal, conflict arising within the individual (Hartup, 1996a). The resolution of the cognitive conflict and achievement of intersubjectivity may be associated with gaining knowledge or insight, thus indicating that cognitive growth (i.e., learning) has occurred (Hartup, 1996a).

Friendship, Gender, and Problem-Solving Performance

From a theoretical standpoint, then, collaboration between friends is expected to be more beneficial than collaboration between nonfriends. From an educator's standpoint, however, teachers are concerned that friendship will interfere with performance (Hartup, 1996a). For instance, if friends work together, teachers may anticipate off-task conversations that interfere with completing the assignment. Given the mismatch between theory and the perspective of educators, research is needed to address whether friendship is beneficial to performance when peers collaborate.

Research on children and adolescents is equivocal as to whether friendship is beneficial, or is differentially beneficial, for boys versus girls. A study of children (5–10 years old) indicated that, for boys, friends performed significantly worse than nonfriends on a scientific reasoning task, but that, for girls, friends performed significantly better than nonfriends (Kutnick & Kington, 2005). Other researchers have found that for boys (2nd and 6th graders), friends performed better than did nonfriends (Newcomb & Brady, 1982).

Among adolescents (8th graders) friendship was more beneficial to boys than to girls (Strough et al., 2001); girls outperformed boys on a classroom collaborative task (i.e., performing a skit in Spanish), regardless of friendship. On a difficult scientific reasoning task, adolescent friends (5th graders) were more likely than acquaintances to challenge one another, and friends performed better than nonfriends, although only on the difficult version of the task (Azmitia & Montgomery, 1993). Thus, empirical research examining collaborative task performance as a function of friendship and gender among children and adolescents yields inconsistent results.

Relationship Quality and Problem-Solving Performance

Dimensions of relationship quality may be useful in disentangling inconsistent findings regarding friendship and collaborative performance. For socio-emotional development, friendship quality is more important than simply having a friend (Berndt, 1996; Hartup, 1996b; Hartup & Stevens, 1997). Applying this to cognitive development and a collaborative problem-solving situation, dimensions of relationship quality during a collaborative interaction may be useful in predicting the likelihood that the interaction is beneficial for performance, irrespective of friendship. For example, supportive peers who validate each other's thoughts and opinions might more easily achieve an intersubjective understanding of a task that facilitates performance.

Greater support, validation, intimacy (willingness to reveal thoughts and feelings; Laursen, 1996), and loyalty (commitment to the relationship; Laursen, 1996) characterize high-quality peer relationships (Ginsberg et al., 1986; Savin-Williams & Berndt, 1990; Sullivan, 1953). During adolescence, support and loyalty become increasingly important (Laursen, 1996; Savin-Williams & Berndt, 1990). Thus, these dimensions of relationship quality may distinguish friends' relationships from those of nonfriend acquaintances.

When working on a collaborative task, friends may be more likely than nonfriends to perceive that their partners provide support and validation. The prevalence of conflict would not be expected to differ between friends and nonfriends (Newcomb & Bagwell, 1995). However, friends are more likely to strive to resolve conflicts that do occur (Laursen, 1996; Newcomb & Bagwell, 1995). Thus, perceptions of conflict resolution would be expected to be greater among friends than nonfriends. In addition, conflict resolution is thought to facilitate cognitive growth and performance on cognitive problem-solving tasks whereas unresolved conflict may have detrimental consequences for performance (Azmitia, 1996; Strough et al., 2001).

Dimensions of relationship quality also may be useful in understanding whether gender and friendship interact to influence performance. When boys' and girls' friendships are compared, girls typically report greater validation and caring, help and guidance, and closeness and security (Bukowski, Hoza, & Boivin, 1994; Parker & Asher, 1993; Schneider, Wiener, & Murphy, 1994). This research suggests that collaborating with a friend could be more beneficial to girls than to boys. Furthermore, validation, support, and conflict resolution may facilitate performance, regardless of the friendship and gender of collaborative partners.

Research Questions and Hypotheses

The current study addressed two main research questions. First, we examined whether the friendship and gender of collaborating peers was systematically associated with their performance on a scientific reasoning task. Based on prior research, we hypothesized that friends would outperform nonfriends, and girls would outperform boys. We explored whether friendship differences were more pronounced for girls than for boys. Second, we examined whether dimensions of relationship quality during a collaborative interaction were systematically associated with performance, above and beyond any differences associated with friendship, gender, or their interaction. We expected that higher ratings of support, validation, and conflict resolution and lower ratings of conflict would be associated with better performance.

METHODS

Participants

Participants were 132 adolescents (58 boys, 74 girls) who attended one of two public high schools in North Central West Virginia. A power analysis conducted using SamplePower (version 2.0, SPSS, Chicago, IL) indicated that $N = 132$ was sufficient power (.91) to detect a medium

effect size for seven predictors. The average age of the adolescents was 15.36 years (range $= 14-17$ years). Demographic characteristics of the sample reflected the geographic area from which the sample was drawn; the majority of participants (89.4%) were Caucasian/White. Other racial groups represented were African-American (3.0%), Hispanic (3.0%), Asian American (0.8%), and mixed-race or American Indian (3.0%). Participants reported their current grade point average (GPA) on the four-point scale used in their schools (mean $[M] = 2.99$, standard deviation $[SD] = .70$).

Inclusion Criteria. To be eligible for inclusion, adolescents were required to have at least one mutually nominated same-gender friend in their classroom (e.g., John nominates Joe as a friend, and Joe nominates John). To establish eligibility for inclusion, we used the friendship nomination procedure used by Strough et al. (2001) and asked participants to identify both good and best friends among their classmates. Of the 195 students who consented to participate, 78% met the inclusion criterion of having at least one reciprocal (mutually nominated) friend in the classroom.

Experimental Groups. Individuals who had a mutually nominated friend in the classroom were randomly assigned to either the friend or nonfriend condition. An individual who was randomly assigned to the nonfriend condition (15 boy dyads, 17 girl dyads) was paired with a classmate not indicated by him/her to be a friend (and the assigned partner also did not nominate the individual). An individual assigned to the friend condition (14 boy dyads, 20 girl dyads) was paired with a mutually nominated friend. If none of the individual's mutually nominated friends were available to be paired (due to already being paired with other classmates), the individual was then assigned to work with a nonfriend (this occurred in fewer than 10 cases).

Procedure

Data from the current study are from a larger study of adolescent problem solving. Only those procedures and materials relevant to the current research questions are reported here.

Participants completed all components of the study in their school classrooms. After assenting to participate and obtaining parental consent, participants completed the first part of the study, which included a demographics questionnaire and the friendship nomination procedure. Within $1-2$ days of completing the friendship nomination procedure, students who met study inclusion criteria (see above) were randomly paired with a friend or nonfriend classmate and completed the remainder of the study procedures.

Partners were paired to discuss two scientific reasoning tasks. Following 5 minutes of discussion for each reasoning problem, partners were separated and participants then individually completed answer sheets and indicated their own responses to the problems without further input from the partner. Our approach of collecting data from individual students following peer interaction was designed to mimic situations in which adolescents receive input from others but then make individual decisions (e.g., after collaborating on a classroom assignment or homework, the person turns in individual work to the teacher). Following completion of the reasoning task answer sheets, participants completed the situation-specific relationship quality measure. We then conducted a raffle to award small prizes to students for their participation.

Materials

Situation-Specific Relationship Quality. We developed a 21-item measure of the quality of peers' relationships during their collaborative interaction by modifying Parker and Asher's (1993) 41-item Friendship Quality Questionnaire (FQQ). Parker and Asher used confirmatory factor analysis to create a measure of the quality of children's best friendships consisting of six subscales:

Validation and Caring ($\alpha = .90$), Conflict Resolution ($\alpha = .73$), Conflict and Betrayal ($\alpha = .84$), Help and Guidance ($\alpha = .90$), Companionship and Recreation ($\alpha = .75$), and Intimate Exchange ($\alpha = .86$).

In adapting the FQQ to create our Situation-Specific Relationship Quality (SSRQ) measure, we retained items relevant for describing a collaborative interaction and rephrased items to describe aspects of peers' relationships while working together on the task (e.g., "We count on each other for good ideas on how to get things done" was rephrased "We counted on each other for good ideas about what to do for the tasks"). We also deleted items irrelevant to adolescents (e.g., "We always play together at recess"). In total, we retained and modified 21 items from the FQQ to compose our SSRQ measure. Participants used a 5-point Likert-type scale (0 = not at all true to 4 = really true) to indicate the degree to which each of 21 statements described the relationship with their partner while collaborating on the tasks. Participants individually completed this measure following the interaction with their assigned partner.

We conducted an exploratory principal components factor analysis of the SSRQ data to identify underlying dimensions of peer relationships during a collaborative interaction. We used exploratory analysis rather than confirmatory analysis because we had modified and reduced the number of items (compared to the 41-item FQQ). Varimax rotation indicated three independent components with eigenvalues >1: Support and Conflict resolution (40.4% of the total variance), Validation (15.5% of the total variance), and Conflict (6.3% of the total variance). Table 1 lists all items according to the factor on which they loaded the highest.

We created three subscale scores by averaging the ratings of all the items that loaded highly ($\geq .40$) on a given subscale, as identified by the principal components analysis. Coefficient alpha is listed for each subscale in Table 1. Scores for each subscale ranged from 0 to 4. We used the three subscale scores (Support and Conflict Resolution, Validation, Conflict) in analyses as indicators of SSRQ.

Scientific Reasoning Tasks. Participants collaborated with a partner to discuss two scientific reasoning tasks adapted from previous research (Azmitia & Montgomery, 1993; Kuhn & Brannock, 1977). Because Azmitia and Montgomery found differences between friends and nonfriends only on the most difficult version of their scientific reasoning tasks, we used the difficult version in our study. For the first task, labeled the *pizza problem,* participants determined which ingredient on a pizza was the cause of several people becoming sick. Task materials included depiction of six scenarios in which a different combination of six ingredients was on each pizza. Pictures that accompanied each list of ingredients indicated whether the person who ate the pizza was sick or healthy. The outcome (sick vs. healthy) also was given in written form. For the second task, labeled the *plant problem*, participants determined the cause of death of several plants. Task materials depicted six scenarios in which plants received different combinations of the following characteristics: the amount and frequency of water and the type of plant food given to the plant, the type of sunlight to which the plant was exposed, the size of the plant's pot, and the type of music played to the plant. The health of the plant was given in pictorial and written form.

For each scenario there was a causal variable that was perfectly correlated with the negative outcome (i.e., the causal variable was present in all instances of the negative outcome and never present in instances of the positive outcome). Two additional variables were partially correlated with the negative outcome (i.e., the variables were present in some but not all instances of the negative outcome, but also were not present in any of the positive outcomes).

After a period of discussion about the two problems, participants individually wrote answers to several questions. Participants identified the variable they thought was the cause of the people getting sick or of the plants dying. They then explained why they thought this variable was the cause.

Table 1

Situation-Specific Relationship Quality Questionnaire (SSRQ) Items and Subscales

Item	Item Loading
Support and Conflict Resolution (11 items, $\alpha = .93$)	
Partner helped me with things so that we could get the tasks done quicker	.850
We counted on each other for ideas on how to get the tasks done	.813
I was able to ask partner for help and advice when I was having trouble figuring out something about the tasks	.783
We came up with good ideas on ways to do things for the tasks	.781
I could count on partner for good ideas about what to do for the tasks	.739
I could talk to partner if mad about something that happened while we worked on the task	.728
Partner cared about my feelings while working on the task together	.716
We made up easily when we disagreed about the tasks	.716
We got over our arguments really quickly	.654
If mad at each other while working on the tasks, we were able to talk about how to get over it	.644
Partner apologized if hurt my feelings while working on the tasks	.555
Validation (5 items, $\alpha = .84$)	
Partner told me I was good at things while working on the tasks	.803
Partner told me I was pretty smart	.710
We made each other feel important and special while working with each other on the tasks	.676
Partner made me feel good about my ideas for the tasks	.581
We got mad at each other a lot while we worked on the tasks	.415
Conflict (5 items, $\alpha = .81$)	
We fought while working on the tasks	.821
We bugged each other while working on the tasks	.777
Partner did not listen to me while working on the tasks	.773
Partner said mean things about me while we were working on the task	.757
We argued a lot while working on the task	.567

Note. Coefficient alpha is for the subscale score. The subscale score is the average value of the item ratings. Item loadings are from a principal components analysis with varimax rotation.

Finally, they indicated whether they believed any other variable was a cause of the outcome and, if so, explained why they thought this.

From their written responses, we assessed two aspects of participants' performance on the reasoning tasks: (1) accuracy of their responses regarding the causal variable, and (2) the justification for the link between the variables and the outcome (adapted from Azmitia & Montgomery, 1993; Kuhn & Brannock, 1977). Greater accuracy and justification scores indicated better performance.

For *accuracy,* a perfect score (5 points) indicated that the participant identified the correct causal variable and mentioned no other variable. Participants earned 4 points for responses that mentioned the causal variable and one or both of the partially correlated variables, but only 3 points if one or both of the partially correlated variables was identified, without mention of the causal variable. Participants earned 2 points if an incorrect variable was mentioned along with the correct causal variable; 1 point was earned if an incorrect variable was mentioned along with one or both of the partially correlated variables. Responses earned 0 points if a participant did not identify any variables, or if only incorrect variables were mentioned.

For *justification,* responses earned a score between 0 and 3 based on the extent to which responses reflected scientific reasoning. A perfect score (3 points) indicated that the participant

linked the causal variable to both the positive and negative outcomes (e.g., "The three people who got sick ate mushrooms and the three people who didn't get sick did not eat mushrooms."). Participants earned 2 points for responses if explanations linked the variables to either the positive or negative outcome, but not both. One point was earned if circular reasoning was used (e.g., "The plants in medium sized pots died because the plants in the medium pots were dead."). Responses earned 0 points if explanations included unrelated variables or were based on personal experience (e.g., "The onions caused them to be sick because onions make a lot of people sick.").

The first author completed scoring of the accuracy and justification of responses to the reasoning problems after establishing reliability with another scorer. To establish reliability of scoring, the first author trained an undergraduate research assistant in the use of the scoring scheme using the data of five individuals. Following training, both researchers scored the responses of 35 individuals. The interscorer reliability of the two scorers, as indicated by kappa coefficients, was .85 for accuracy scores and .80 for justification scores for the pizza problem, and .83 for accuracy scores and .87 for justification scores for the plant problem.

RESULTS

Preliminary Analyses

Data Reduction. We computed Spearman correlation coefficients to assess the extent to which reasoning on the two problems (pizza, plant) was similar. The correlations for accuracy scores ($r[129] = .52$) and justification scores ($r[127] = .71$) were significant and positive, $p < .05$, indicating that reasoning scores were similar on the two problems. Thus, to reduce the number of data analyses, we summed the respective scores (accuracy, justification) for the two problems to create two total scores: *accuracy* and *justification*. We used these total scores in subsequent analyses.

Manipulation Check. To determine if our SSRQ measure distinguished among the friend and nonfriend groups, we conducted a 2 (group: friend, nonfriend) × 2 (gender: girls, boys) multivariate analysis of variance (MANOVA) with the three SSRQ subscales (Support and Conflict Resolution, Validation, Conflict) as the dependent variables. We expected that friends would have higher ratings of validation and support and conflict resolution compared to nonfriends, and that these differences might be more pronounced among girls. The MANOVA indicated main effects of friendship (Wilks' $\Lambda = .94$, $F(3,126) = 2.85$, $p < .05$) and gender (Wilks' $\Lambda = .88$, $F(3,126) = 5.56$ $p < .05$) on the linear combination of the dependent variables. The interaction between friendship and gender was not significant.

The main effect of friendship was localized to the Support and Conflict Resolution variable, $F(1,128) = 8.34$, $p < .05$, $\eta_p^2 = .06$. Friends' ratings ($M = 2.58$, $SD = .98$) of Support and Conflict Resolution were significantly higher than nonfriends' ratings ($M = 2.02$, $SD = 1.05$). The difference between friends' ($M = 1.29$, $SD = .92$) and nonfriends' ($M = .99$, $SD = .85$) ratings of Validation was marginal, $F(1,128) = 2.93$, $p = .09$, partial $\eta_p^2 = .02$. Ratings of Conflict did not differ significantly for friends and nonfriends. Overall, these results indicated that our manipulation successfully created experimental groups that differed in dimensions of relationship quality posited to be important for understanding collaborative task performance, namely Support and Conflict Resolution.

The main effect of gender was localized to two variables, Support and Conflict Resolution [$F(1,128) = 15.38$, $p < .05$, $\eta_p^2 = .11$] and Validation [$F(1,128) = 4.80$, $p < .05$, $\eta_p^2 = .04$]. Girls ($M = 2.61$, $SD = 1.01$) rated Support and Conflict Resolution higher than did boys ($M = 1.92$, $SD = .97$). Girls ($M = 1.30$, $SD = .92$) also rated Validation higher than did boys ($M = .95$, $SD = .83$). Gender differences in ratings of Conflict were not significantly different. Thus, in both friend and nonfriend dyads, girls' ratings of positive relationship qualities differed significantly from boys' ratings.

Academic Performance. To examine whether our experimental groups were equivalent in prior academic achievement, we conducted a 2 (group: friend, nonfriend) × 2 (gender: girls, boys) ANOVA with self-reported GPA as the dependent variable. Self-reported GPA did not differ significantly between friends ($M = 2.97$, $SD = .71$) and nonfriends ($M = 3.01$, $SD = .68$) or between boys ($M = 2.89$, $SD = .83$) and girls ($M = 3.07$, $SD = .56$). The interaction between friendship and gender also was nonsignificant.

To determine whether individual differences in students' academic achievement were associated with their performance on the scientific reasoning task, we examined correlations among self-reported GPA and accuracy and justification scores. Higher self-reported GPA was associated with greater accuracy scores [$r(129) = .25$, $p < .05$] and greater justification scores [$r(127) = .18$, $p < .05$] on the scientific reasoning tasks. Thus, we included self-reported GPA in the primary analyses (reported below).

Friendship, Gender, Relationship Quality, and Problem-Solving Performance

To address the two research questions of the study, we conducted two hierarchical regression analyses (one for accuracy scores and one for justification scores). The first step of each hierarchical regression addressed the first research question: whether the friendship and gender of collaborating peers was systematically associated with their performance on a scientific reasoning task. We expected that friends would perform better than nonfriends and that girls would perform better than boys. We explored the potential interaction between friendship and gender. The second step of each hierarchical regression addressed the second research question: whether the quality of the relationship between peers during the interaction was systematically associated with performance (above and beyond any differences associated with friendship and gender).

To conduct the hierarchical regression analyses, we used the SPSS (version 15.0; SPSS, Chicago, IL) general linear model procedure. In each hierarchical regression, gender and friendship were categorical predictors and the three dimensions of relationship quality were continuous predictors. Given that preliminary analyses (described above) indicated that GPA was associated with justification and accuracy scores, we also examined GPA as a continuous predictor. Due to the number of predictors, a Bonferroni correction was applied and alpha was set at .032 when testing the contribution of individual predictors.

Accuracy. In the hierarchical regression model predicting accuracy scores, friendship, gender, their interaction, and GPA were entered on the first step. The overall model was nonsignificant; GPA was, however, significantly associated with accuracy scores (see Table 2 for mean scores and Table 3 for regression model results). Thus, in contrast to our hypothesis, accuracy scores did not differ significantly as a function of friendship, gender, or their interaction.

In the second step, the three dimensions of situation-specific relationship quality were entered into the hierarchical model predicting accuracy scores. The overall model was nonsignificant; higher reported GPA remained significantly associated with greater accuracy. In contrast to our hypotheses, none of the dimensions of SSRQ were associated with accuracy scores (see Table 3).

Justification. In the first step of the hierarchical regression analysis predicting justification scores, the overall model was significant, $F(4,122) = 3.14$, $p < .05$. In accord with our prediction, girls' justification scores were greater than those of boys; but the difference was marginal ($p = .05$; see Table 3). In contrast to our predictions, neither friendship nor the Friendship × Gender interaction was significantly associated with justification scores (see Tables 2 and 3). GPA was not significantly associated with justification scores.

Table 2

Mean (M) Accuracy and Justification Scores (and Standard Deviations [SD]) for the Scientific Reasoning Tasks by Group

	Friends		Nonfriends		Total	
	M	*SD*	*M*	*SD*	*M*	*SD*
Accuracy Scores						
Boys	8.88	(2.58)	9.03	(2.04)	8.96	(2.29)
Girls	9.05	(1.99)	9.33	(1.80)	9.18	(1.90)
Total	8.98	(2.22)	9.19	(1.91)	9.08	(2.06)
Justification Scores						
Boys	2.00	(2.51)	2.14	(2.42)	2.07[a]	(2.44)
Girls	2.35	(2.15)	3.66	(2.38)	2.93[b]	(2.33)
Total	2.21	(2.29)	2.93	(2.50)	2.56	(2.41)

Note. Superscripts indicate mean differences, $p = .05$.

Table 3

Results of Hierarchical Regression Models Predicting Accuracy and Justification Scores from Friendship, Gender, Grade Point Average, and Average Ratings of Situation-Specific Relationship Quality

Analyses Predicting Accuracy	R^2	ΔR^2	ΔF	sr^2
Model 1	.06			
Friendship				−.05
Gender				−.03
Friendship × Gender				−.01
GPA				.24***
Model 2	.08	.02	.78	
Friendship				−.02
Gender				−.05
Friendship × Gender				−.02
GPA				.25***
Support and Conflict Resolution				−.04
Validation				−.06
Conflict				−.04
Analyses Predicting Justification				
Model 1	.09**			
Friendship				−.15
Gender				−.18*
Friendship × Gender				.11
GPA				.14
Model 2	.15**	.05*	2.52*	
Friendship				−.16
Gender				−.12
Friendship × Gender				.13
GPA				.10
Support and Conflict Resolution				.00
Validation				.12
Conflict				−.19***

Note. * $p \leq .06$; ** $p < .05$; *** $p < .032$.

When the three dimensions of SSRQ were entered in the second step, the overall regression model was significant [F (7,119) = 2.94, $p < .05$] and R^2 change (.05) was marginal [F (3, 119) = 2.52, $p = .06$]. Perceived conflict was the only variable significantly associated with justification scores; greater perceived conflict during the interaction with one's partner was associated with poorer justification for responses (see Table 3).

Discussion

The goal of this study was to address whether it is important to consider friendship, gender, and relationship quality when adolescents collaborate in the classroom. At least for the type of collaborative task we examined, the friendship of peer partners appears to be of little consequence, and gender appears to be of only marginal importance when individual performance is assessed immediately following collaboration. What does appear to be important for understanding task performance is the extent to which adolescents perceive that their interaction with an assigned classmate was characterized by conflict. The implications of these findings for research and practice are discussed below.

Friendship, Gender, and Problem-Solving Performance

In understanding why friendship differences in task performance were not found, it may be important to consider the difficulty (or lack thereof) of the task for the adolescents in our study. Among early adolescents, benefits of friendship are found only on the most difficult version of a scientific reasoning task (Azmitia & Montgomery, 1993). Although we used the difficult version of Azmitia and Montgomery's reasoning task, our adolescents were high-school students (M age = 15 years, 4 months) who were older than participants in previous research (M age = 11 years, 5 months). For high-school students, the tasks appear to have been relatively easy: 85% of adolescents received the highest accuracy score for the pizza problem and 77% for the plant problem, suggesting a ceiling effect. These percentages exceed the 57% accuracy reported by Azmitia and Montgomery for early adolescents.

Whereas accuracy scores suggest that high-school-age adolescents rather easily solved the tasks, justification scores indicated that they did not always understand the logical rationale for their answers. Only 32% and 21% of participants earned perfect justification scores on the pizza and plant problems, respectively. As discussed below, qualities of peers' relationships were useful in understanding why justification scores were relatively low even though, in general, accuracy scores were relatively high.

There was some indication that girls outperformed boys by earning higher justification scores. However, the difference was marginal and the effect size was small. In addition, and in contrast to our hypotheses, our results did not indicate a significant interaction between friendship and gender on problem-solving performance (cf., Kutnick & Kington, 2005; Strough et al., 2001). Although our findings for gender did not support our hypotheses, they are consistent with meta-analyses indicating gender similarities in various skills and behaviors during adolescence (Hyde, 2005).

Relationship Quality and Problem-Solving Performance

Relationship quality was associated with adolescents' justification scores on the reasoning task. Greater perceived conflict during the collaborative interaction was associated with lower justification scores. Lower justification scores indicated poorer scientific reasoning skills. When interactions were marked by conflict, adolescents may have failed to learn *why* the answer was correct, and thus earned lower justification scores. Conflict may have been disruptive such that students did not effectively use their time and lost focus on the task.

Qualities of partners' relationships during the interaction were not associated with accuracy scores. The best predictor of accuracy scores was students' reports of their GPAs. GPA was associated with accuracy scores even after friendship, gender, and relationship quality were taken into consideration. In contrast, for justification scores, GPA was a significant correlate, but was not a significant predictor after accounting for friendship, gender, and relationship quality. Together, these findings suggest that the relative roles of students' prior achievement and qualities of their relationships during a collaborative interaction may differ depending on the performance index. Whereas prior achievement (as assessed by self-reported GPA) was associated with accuracy in identifying the correct response, adolescents' perceptions of conflict during the interaction with their assigned partner was relatively more important for predicting the extent to which they were able to express the logical rationale justifying their responses.

Limitations of the Current Study

Our study has several limitations. First, our measure of self-reported perceived conflict does not address whether conflict reflects that partners failed to reach consensus about a "correct answer" for the task or that partners engaged in interpersonal conflict unrelated to the task. Conflict regarding the task (i.e., cognitive conflict) is thought to benefit cognitive development, if it is resolved (e.g., Bearison et al., 1986; Gauvain & Rogoff, 1989; Hartup, 1996a; Russell, 1982; Tudge, 1992; Tudge et al., 1996). Social conflict (i.e., difficulty working with a specific person) is associated with poorer performance if it is not resolved (Strough et al., 2001). Second, we measured performance immediately following collaboration. Theorists suggest that collaborative benefits require a period of "fermentation" and are not immediately apparent (Azmitia, 1996). Third, the friends with whom students were paired were not necessarily their very best friends, and all students in the nonfriend group were acquainted classmates. Differences between friends and nonfriends in perceived qualities of relationships were significant, but the effect sizes were small. Differences in qualities of relationships and task performance may be more pronounced when best friends are compared to strangers. Finally, although the size of our sample provided sufficient power to detect medium effects, larger samples would provide greater power to detect small effects. Future research that addresses these limitations is necessary to understand more completely the meaning of the associations between friendship, gender, relationship quality, and task performance that we report.

Recommendations for Future Research

An important question to address in future research is the extent to which friends support cognitive development that occurs both inside and outside of the classroom. Friends are in a unique position to facilitate (or undermine) each other's cognitive growth when their relationships endure over time. Yet, research on friendship and cognitive development remains understudied in comparison to research on friendship and socio-emotional development.

Future research also could be aimed at understanding whether an optimal pairing of peers for classroom assignments exists. For example, same-gender friend pairs could be compared to other-gender friend pairs. During adolescence, other-gender friendships become more frequent (Buhrmester & Furman, 1986; Sullivan, 1953). Yet, adolescents are more likely to select same-gender peers than other-gender peers as partners for school projects (Strough et al., 2001; Strough & Covatto, 2002). A comparison of collaboration between same- and other-gender friends could address why this occurs. Such a comparison also would provide important information in light of recent increases in the prevalence of same-gender classrooms (Gray & Wilson, 2006; Shapka & Keating, 2003).

To further understand optimal pairings and potential benefits of classroom collaborations, investigations of "friendless" students should be conducted. In our study, to avoid experimental confounds, adolescents who did not have any friends in the classroom did not qualify for inclusion. Yet, when collaboration is used as an instructional technique, all students are included. Students who do not have many (or any) friends may find it particularly challenging to deal with the social demands of working with a peer to solve a problem or complete a task. When structured correctly, however, collaboration in the classroom may be a means of integrating "friendless" students and promoting positive peer relationships (see Aronson, 1978; Johnson, Johnson, & Smith, 2007).

Applications for School Professionals

These findings have implications for the use of collaboration in high-school classrooms. Teachers are sometimes hesitant to pair students with friends (Hartup, 1996b). Our findings suggest that a focus on qualities of collaborators' interactions may be relatively more important than friendship per se. More specifically, teachers may wish to avoid pairing a student with a classmate with whom they have a history of not getting along because conflict was associated with poorer task performance. If such a scenario cannot be avoided, students may benefit if teachers monitor and intervene to reduce conflict. Such monitoring may be particularly important when the task requires understanding the underlying logic of a solution, not just correct identification of an answer.

Our findings also have implications for school psychologists by suggesting that the potential "pay off" of conflict resolution interventions may be wide-ranging. Conflict-resolution interventions often are aimed at improving students' social development and peer relationships, or reducing the incidence of violence in schools (e.g., Bell, Coleman, Anderson, Whelan, & Wilder, 2000; Benson & Benson, 1993). Our findings highlight the potential implications of such interventions for promoting cognitive development. Namely, assisting students in developing their conflict resolution skills may promote the development of logical reasoning. Interventions that teach students conflict resolution skills may increase the likelihood of experiencing cognitive growth when adolescents encounter disagreements with peers and friends inside and outside the classroom.

Conclusions

During an average school day, adolescents may be faced with many problems to solve. Understanding the circumstances under which adolescents effectively solve their problems is important for teachers, parents, and/or other individuals who work with adolescents. Our study suggests that, at least for the type of task we examined, neither the gender of adolescents nor the type of relationship between partners (friends vs. nonfriends) was significantly associated with their performance, but conflict may be detrimental to some aspects of task performance. Research that builds on these findings is needed to better understand how peer collaboration can best be used in the classroom to facilitate students' performance and to determine whether friends provide a supportive context for boys and girls' cognitive development.

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