

# *Sibling Influences on Math Achievement*

by Madison B. Poisall, B.S., Mia C. Daucourt, M.S., and Sara A. Hart, Ph.D.

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**Abstract:** Many scholars have conducted studies to understand the overall role more knowledgeable others play in children's academic achievement. According to Bandura's (1977) social learning theory, individuals learn by observing and imitating the behaviors of those around them, including their older siblings. The present study examined the older sibling-younger sibling relationship in an academic context by investigating how younger siblings' math achievement, measured by the Elementary Mathematics Student Assessment (EMSA), was linked to older sibling's warmth, academic socialization, and academic support behaviors. The sample was drawn from the Parent Experiences, Attitudes, and Learning in Math (PEALM) study, a parent-report, questionnaire-based study, which included 66 children who ranged from kindergarten to third grade. Pearson correlations showed that all three variables were negatively associated with younger siblings' math achievement. Then, two regression models demonstrated that the separate sibling scales did not significantly predict younger siblings' math achievement, but a composite scale comprised of all three component measures of sibling influences did. These findings show that siblings play an overall negative role in younger siblings' math achievement, but no one aspect of the older sibling-younger sibling relationship is driving this relation.

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The sibling relationship is thought to be one of the most pervasive and longest-standing relationships in a person's life (Sanders, 2004). Throughout their early and middle childhood, siblings spend a majority of their time together, and in turn, develop a unique relationship with one another. Because of the sheer amount of time spent together as well as their places in the family structure, older and younger siblings are found to influence one another throughout their developmental years. One area of sibling influence is the realm of academics. There has been limited prior research on older sibling influences on younger sibling's academic achievement. Historically, most research on the predictors of academic achievement has centered on the parent-child relationship. For example, Uddin (2011) found that parental warmth and acceptance were positively related to their child's academic achievement. Thus, in the current study, I aimed to determine if this positive association extended to the sibling relationship as well. Additionally, rather than zeroing in on a specific domain, the literature that does exist on sibling influences tends to look at academic achievement in general ways (i.e., GPA). For example, Eccles et al. (1997) found that children with older brothers who

provided support for academic achievement had higher GPAs. Moreover, the same study also found that higher GPA for the younger sibling was related to positive behavioral regulation by an older sibling.

With respect to math achievement in particular, Bouchev & Harter (2004) found that students' perceptions of significant individuals in their lives in terms of the domains of math and science, do in fact predict students' own performance and self-perceptions. As math skills are a globally in-demand skillset, the results of this study could potentially hold future implications for the math field as a whole to determine some of the factors that drive math achievement differences in children. Accordingly, the present study will be filling an important gap in the literature looking at the significant early influences on children's math achievement by narrowing the broader focus on general academic achievement to investigate math achievement, specifically. Moreover, to the best of my knowledge, in addition to the lack of research on the role of siblings in math achievement, no prior studies have investigated the sibling support constructs that I examined in the present study, namely sibling warmth, sibling academic socialization, and sibling

academic support behaviors. Thus, my investigation will provide important novel insight into the facets of the sibling relationship that matter for children's math achievement.

My research questions are as follows: 1.) Is there a correlation between younger siblings' math achievement and each of the three older sibling subscales: sibling warmth, sibling academic socialization, and sibling academic support? 2.) What is the total contribution of the three subscales to younger children's math achievement? 3a.) Which of the three subscales is the driving association between older sibling influences and younger siblings' math achievement? 3b.) What is the overall role of older siblings in younger siblings' academic achievement? Based on the work of Eccles et al. (1997) and Bouchey et al., (2010), which found positive relations between positive older sibling variables and their younger siblings' academic achievement, I hypothesize that there will be a positive correlation between younger siblings' math achievement and each of the older sibling subscales (sibling warmth, sibling academic socialization, and sibling academic support). Because they are exploratory in nature, I do not have a priori hypotheses for the second and third research questions examining the overall role and comparative strength of older sibling influences on younger siblings' math achievement and the role of each specific sibling influence.

### **Theoretical Framework**

A prominent and well-known theory in psychology is Bandura's theory of social learning, which posits that individuals learn through observation, modeling, and imitation (Bandura, 1977). Assuming that older and younger siblings spend much of their adolescent and school-aged years together, it would be appropriate to also assume that a younger sibling who observes their older sibling engaging in positive school-related behaviors (e.g., finishing homework on time) and exhibiting positive attitudes toward school would, in turn, imitate the older sibling's school-related behaviors and attitudes. This modeling can extend to most facets of the siblings' lives. The present study specifically examines older siblings' modeling of academic-related behaviors, such as studying and finishing homework on time and how they are associated with children's math achievement.

By virtue of growing up with the same parents and in the same household (in most cases), and sharing approximately 50% of the same genes, siblings are already more similar than non-siblings (Scarr & Grajek, 1982). It is also natural for an older sibling to hold power in their relationship with their younger sibling simply due to the difference in age and experience (Lindell & Campione-Barr, 2017). Older siblings have also historically been regarded as agents of socialization. It is from the older sibling that the younger sibling may learn not only social norms but academic norms as well (Wang, Degol & Amemiya, 2019). Keeping this in mind, it is possible to see the potential connections between the social learning theory and older siblings having influence on their younger siblings in many aspects of life including and especially the academic domain.

In addition to the role of Bandura's social learning theory (1977) in sibling modeling and similarity, there are additional theories that may elucidate the role of sibling interactions in children's math achievement. The sibling deidentification theory claims that siblings may wish to differentiate from one another in order to protect themselves from rivalry and social comparison within the family (Whiteman, McHale, & Crouter, 2007). A direct divergence from the social learning theory, sibling deidentification would suggest in this context that in order to stand out from their older sibling, a younger sibling would be likely to focus his or her efforts and behaviors on domains that are in opposition to the domain in which their sibling excels. For example, if the older sibling performs well academically, the younger sibling may reject the idea of also doing well academically, choosing instead to focus his or her time more on sports or musical pursuits as a way of differentiating him or herself. Acknowledging the fact that these two theories provide different explanations for the academic achievement of siblings, the results of the present study may be able to assist with determining which of these theories may be more at play in the context of sibling influences on math achievement. If the sibling deidentification theory is supported in my analyses, I would expect a negative association between the older sibling variables and the younger sibling's math achievement. If Bandura's social learning theory is supported, I would expect a positive association between the older sibling variables and younger siblings' math achievement.

Finally, according to Bronfenbrenner's bioecological model of human development (Bronfenbrenner & Ceci, 1994), interactions occurring within a child's microsystem or their immediate surroundings and connections, are some of the most salient and influential interactions the child can observe (Wang et al., 2019), as the individuals existing in this microsystem are of much personal significance to the child. Significant individuals in the microsystem are usually identified as parents, teachers, close friends, and most important to the present study, siblings. Moreover, older siblings may display parent-like corrective behaviors like helping parents enforce family rules and setting an example for younger siblings (Amato, 1989), which could further emphasize the role model status of the older sibling in the younger sibling's eyes. Seeing their older sibling as someone who enforces the rules and who they should listen to, may help to affirm the feeling of wanting to imitate an older sibling's behaviors. This may manifest as a statistically significant, positive association between older siblings' academic support behaviors and younger siblings' math achievement. Further, research centering around the family in times of distress, change, or parental separation has noted that older siblings will oftentimes take on multiple roles (i.e., mentor, teacher, caregiver) in place of the parents in some instances (Wang et al., 2019). Having an older sibling take on a caregiver-type role or even a role with more authority that establishes important academic ideals may help affirm to the younger sibling to see the older sibling as a role model and potentially result in significant links between older siblings' parent-like behaviors, like sibling academic support and socialization and younger siblings' math achievement.

### **Sibling Warmth**

In line with Bandura's (1997) social learning theory, Rowe & Gulley (1992), posited that siblings with a warmer relationship may, in fact, be more willing to imitate each other's behavior because of the emotional closeness that comes from the warmth of a sibling relationship. In fact, the more time siblings spend together and the more positive their relationship, the more likely they are to behave similarly (Rowe and Gulley, 1992). For the present study, sibling warmth was defined following Sander's

defining features of sibling warmth, which include closeness, intimacy, and companionship between siblings (Sanders, 2004). Examples of sibling warmth in the context of the present study include telling the child you love them and spending quality time with the child. Previous research on parenting has shown that mothers' school involvement has a positive association with their child's academic achievement when the relationship between mother and child is characterized by warmth (Simpkins et al., 2006). Evidence also suggests that children's modeling and imitative behaviors are particularly influenced by those who are similar to them, hold power, and provide a degree of warmth (Wang, Degol & Amemiya, 2019). Thus, it is also likely that a warm relationship with an older sibling will be conducive to younger siblings' general achievement, and specifically their math achievement, which I tested here. Previous work has also found that sibling warmth and support is related to variables that have been shown to be important for academic achievement, such as self-esteem and self-worth (Amato, 1989), which may also create a positive connection between older sibling warmth and younger siblings' math achievement.

### **Sibling Academic Socialization**

Prior research has also shown that having a more academically involved parent is associated with higher positive academic outcomes for the child (Lam & Ducreux, 2013). This parental involvement can be roughly translated to the parent exhibiting some sort of academic support behavior with their child, which is meant to bolster children's achievement outcomes. If this is the case in terms of the parent-child relationship, it could potentially also be a factor in the sibling relationship, and I investigated this possibility in the present study by assessing the association between sibling academic support behaviors and sibling academic socialization and younger siblings' math achievement.

Academic support behaviors are behaviors performed around the child that help influence their motivation to do well in school (Zippert & Rittle-Johnson, 2020). Examples of this include helping the child with their homework, talking to the child about doing well in school, and encouraging the child to study. Milevsky & Levitt (2005) found that children in grades 5-8 with higher levels of support

from their brothers showed more positive school attitudes overall. Although their outcome was not directly measuring academic achievement, like I did in the present study, the fact that they found a positive link between sibling support behaviors and sibling academic-related outcomes means that the same link may exist with academic achievement as well. Additionally, supportive and accepting interactions are thought to enhance school outcomes for adolescents (Wentzel, 1994). As such, younger siblings who receive academic support from their older sibling may also experience enhanced school outcomes, which I tested in the realm of mathematics in my current investigation.

The third and final construct that was examined in the present study is sibling academic socialization. Academic socialization is the process by which a child's academic behaviors and attitudes are shaped by a significant person in their life, in this case a sibling (Taylor et al., 2004). Examples of this include talking to the child about liking school and discussing with the child how they can do well in school. Parents may academically socialize their children by setting expectations for academic performance and providing a supportive home environment (Taylor et al., 2004), and the present study intended to determine if this level of socialization within the sibling relationship could help children's academic success in math.

## **Method**

### *Participants*

The sample used in this study was drawn from an earlier questionnaire-based study that investigated parental and home-based influences on children's math achievement called the Parent Experiences, Attitudes, and Learning in Math (PEALM) Questionnaire. The overall sample is made up of 124 students in grades K-4 from Florida schools in Leon, Bay, and Hillsborough counties. Of those 124, only 66 students had older sibling measures, meaning the other 58 participants either did not have siblings, only had younger siblings, or did not complete the sibling measures. In terms of race, four participants reported as American Indian, 24 as Asian, zero as Hawaiian, 104 as Black, 372 as White, and four as Other. 236 participants were female and 220 were male. These variables can be seen in Table 1. Three control variables were utilized, gender, age, and socioeconomic status, in order to control for their

effects on the outcome. For the PEALM project, questionnaire data was collected by up to two primary caregivers of the children who participated in the Research on Experiences, Attitudes, and Learning in Math (REALM) study. The REALM study studied the influence of teacher math attitudes and math ability on the students in their classrooms. The sample included 599 kindergarten through third grade students from 25 different schools in one state in the United States. PEALM recruited the caregivers of the children enrolled in the REALM study to fill out a voluntary questionnaire about themselves, their home, and their children. In the case of two-parent households, mothers and fathers were asked to fill out separate identical PEALM questionnaires. Parents were then asked to return the questionnaires in a pre-addressed and stamped envelope and were compensated for their participation in PEALM and completion of the questionnaire with a \$30 online gift card. For this study, I used questionnaire data on siblings, socioeconomic status, race, age, and sex drawn from the questionnaire portion of PEALM, and linked it to the children's math achievement data collected by teachers in schools through REALM based on deidentified student identification numbers.

### *Measures*

Within PEALM, a researcher-created, 24-item measure used parent report to assess older sibling influences. Seven of the items were then used to create three scales that represented sibling warmth, sibling academic socialization, and sibling academic support behaviors. Parents were asked to rate the behaviors of their child's older sibling on a 4-point Likert scale.

Sibling warmth was measured by two items (e.g., "spend quality time alone with your child" and "tell your child they love him/her"), which was summed to represent total level of sibling warmth, with a maximum for each item of 4 = very often and a minimum of 0 = not at all.

Sibling academic socialization was measured by two items (e.g., "talk to your child about liking school" and "talk to your child about doing well in school"), which was summed to represent total level of sibling academic socialization, with a maximum for each item of 4 = very often and a minimum of 0 = not at all.

Sibling academic support behaviors was measured by two items (e.g., “help your child with homework” and “help your child understand concepts he/she doesn’t understand”), which was summed to represent total level of sibling academic support behaviors, with a maximum for each item of 4 = very often and a minimum of 0 = not at all.

Finally, I also calculated and created an overall sibling influence score for each of the three subscales by adding the three scale scores together.

The child’s math achievement was measured using the Elementary Mathematics Student Assessment (EMSA), which consists of a 16-item math test that is designed to align with Common Core Standards of Mathematics. The EMSA assesses number sequence, word problems, and computation, which also varies in content and number of items for each grade-level. Math test scores were gathered using a two-parameter logistic model based on item-response theory. The expected a posteriori (EAP) method was utilized to estimate the person ability in each grade level. These ability estimates were then mapped onto a single scale by the Stocking-Lord method for vertical equating (Kolen & Brennan, 2014), which allows comparison of scores between grades. A student’s EMSA score for each wave was operationalized as a theta score, with high scores indicating high levels of math achievement and lower scores indicating lower levels of math achievement. The test proved to be reliable across all four grade levels (kindergarten  $\alpha = .77$ , 1st grade  $\alpha = .79$ , 2nd grade  $\alpha = .82$ , 3rd grade  $\alpha = .87$ ).

### Analysis Plan

I used R version 3.5.3 (R Core Team, 2020) to first run descriptive statistics, looking specifically at mean, standard deviation, minimum and maximum values, skew, and kurtosis to determine if all variables were normally distributed. As a second step, a regression was run to remove all variance due to age, sex, and SES and the resulting predicted values were used for all analyses. Next, I ran each bivariate association separately using a Pearson correlation with younger siblings’ math achievement and each of the sibling influence variables. Then, I ran a regression with sibling warmth, sibling academic socialization, and sibling academic support behaviors as predictors of younger siblings’ math achievement they explained as a whole. Finally, I ran a regression for a measure

representing total sibling influences predicting younger siblings’ math achievement.

## Results

### Descriptive Statistics

I examined the overall composition of my sample in terms of the age, race, and sex of the participants. Race was split into selectable categories including American Indian or Alaska Native, Asian, Native Hawaiian, or Other Pacific Islander, Black or African American, White, and Other. These demographic details are presented in Table 2.

### Correlations

Pearson correlations were conducted to determine the strength, direction, and significance of the relation between each of the three sibling scales and the younger siblings’ math achievement. Contrary to my expectations, sibling warmth and sibling academic support behaviors were found to be negatively correlated with younger siblings’ math achievement ( $r(64) = -.31, p = .012$ ;  $r(64) = -.29, p = .018$ ). This can be seen in Table 3.

Sibling academic socialization was also found to be negatively correlated with younger siblings’ math achievement, but the relation was not statistically significant ( $r(64) = -0.20, p = .107$ ). When looking at the correlation between the total sibling influence scale, which combined all three of the aforementioned subscales, and younger siblings’ math achievement, a statistically significant negative correlation was found,  $r(64) = -.338, p = .016$ .

### Multiple Regression Analysis

A multiple regression analysis was conducted to determine if sibling warmth, sibling academic socialization, and sibling academic support behaviors predicted younger sibling math achievement. The results of the regression, shown in Table 4, showed that the three subscales explained 11.6% of the variance in younger siblings’ math achievement ( $R^2 = 0.12, F(3, 64) = 2.72, p = .052$ ). When all three predictors were included in the model, sibling warmth ( $\beta = -.02, t(62) = -1.48, p = .144$ ), sibling academic socialization ( $\beta = .003, t(62) = .27, p = .789$ ), and sibling academic support behaviors ( $\beta = -.02, t(62) = -1.22, p = .227$ ) did not statistically predict math achievement.

A regression analysis was also conducted to determine if the total sibling influence scale made up of all three sibling support measures predicted younger sibling math achievement. The results showed that the total scale explained 11.4% of the variance in younger siblings' math achievement ( $R^2 = 0.11$ ,  $F(1, 64) = 8.24$ ,  $p = .006$ ). When this single predictor was included in the model, it statistically significantly predicted younger siblings' math achievement ( $\beta = -.01$ ,  $t(64) = -2.87$ ),  $p = .056$ ).

### Discussion

The present study adds a unique perspective to the prior literature by looking at the sibling relationship on academic achievement (as opposed to the parent-child relationship) as well as focusing on a specific domain of academic achievement in math. The results of the Pearson correlation showed that in contrast with my initial hypothesis, there was a negative correlation between the three sibling support behaviors and younger siblings' math achievement. This finding could support the sibling deidentification theory (Whiteman, McHale, & Crouter, 2007) in which in order to avoid comparison and rivalry, the younger sibling would deidentify himself or herself from an older sibling who demonstrated their own focus on academics.

The multiple regression analysis that was run showed that none of the three sibling support behaviors significantly predicted younger siblings' math achievement separately. However, the single combined measure of sibling influences did emerge as statistically significant. Due to the fact that each scale only had two items, the composite measure may have allowed more variability to be picked up on, thus leading to it appearing as statistically significant. This could mean that overall sibling influences should be considered instead of separating them out or that more items should be added to the scales.

The present study has a few potential limitations, the first being the number of participants, as I had to exclude some because there was no achievement data available, and I didn't have the outcome needed to analyze. I also did not have data from participants that did not have any siblings or only had younger siblings. However, I focused on older siblings because their support has been shown to influence younger siblings' general academic achievement (Ryherd, 2011) significantly and positively. The

control variables gender, age, and socioeconomic status that were used to residualize the outcome, can also explain the smaller sample size because children who did not have data for these variables were dropped. The COVID-19 pandemic also limited the number of participants that were able to participate in the REALM study, so the collection of math achievement data was cut short. Future studies should utilize a larger participant pool to determine if the results would change. Social desirability bias is another limitation common to questionnaire-based studies and may have had an influence on the results of the present study by participants answering in way they believed to be more socially acceptable as opposed to what their actual response would be (Gordon, 1987).

The findings of this study may have implications in the math education of children with older siblings and could be used as a tool to better cultivate an effective learning environment. Since the results showed negative associations between older sibling academic support and younger sibling math achievement, this may suggest to parents to limit sibling interaction in terms of academics and helping with school. Math is an important and growing field and those hoping to educate their children in the math domain could potentially use the results of this study to best fit the needs of their child and their education.

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Tables

Table 1

*Frequencies of Categorical Variables*

Variable	N	Percent
<b>Race</b>		
American Indian	4	.81%
Asian	24	4.8%
Hawaiian	0	0
Black	104	21%
White	372	75%
Other	4	.81%
<b>Sex</b>		
Female	236	51.8%
Male	220	48.2%

Table 2

*Descriptive Statistics*

Variable	Mean	SD	Min.	Max	Skew	Kurtosis
<b>Single items</b>						
Quality time	2.93	0.93	1	4	-.28	-1.04
Love	2.85	1.24	0	4	-.67	-.80
Liking school	2.31	1.18	0	4	-.26	-.70
Doing well in school	2.49	1.18	0	4	-.41	-.72
Homework help	2.20	1.13	0	4	.03	-.92
Help understanding	2.51	1.03	0	4	-.42	-.27
Age in months	98.5	16.83	14	133	-1.39	5.41
Sibling academic support behaviors	4.70	1.96	0	8	-.07	-.84
Sibling academic socialization	4.79	2.19	0	8	-.27	-.50
Sibling warmth	5.77	1.85	1	8	-.42	-.87
Composite sibling measure	16.21	5.06	3	24	-.29	-.73

## Sibling Influences on Math Achievement

Table 3

*Correlation Results*

Measure	1	2	3	4
1. Sibling academic support behaviors	-			
2. Sibling academic socialization	.65	-		
3. Sibling warmth	.55	.60	-	
4. Composite sibling measure	.79	.70	.95	-
5. Predictor	-.29	-.20	-.31	-.34

Table 4

*Regression Results*

Intercept	Estimate	SE	<i>t</i> -value	<i>p</i> -value
Sibling warmth	-.020	.014	-1.48	.144
Sibling academic socialization	.003	.012	.269	.789
Sibling academic support behaviors	-.016	.013	-1.22	.227
Composite sibling total	-.011	.004	-2.87	.006

*Note.* Estimate reflects the unstandardized beta coefficient.