

## ABSTRACT

Title of dissertation:       THANK YOU FOR BEING A FRIEND: THE RELATIONS BETWEEN  
                                      FRIENDSHIP NETWORK CENTRALITY, READING ACHIEVEMENT,  
                                      AND EXECUTIVE FUNCTIONING IN ELEMENTARY SCHOOL  
                                      STUDENTS

Casey Archer, Doctor of Philosophy, 2022

Dissertation directed by:   Professor David Blazar  
                                      Department of Teaching and Learning, Policy and Leadership

Peer relationships form the bedrock for numerous developmental outcomes, including students' social-emotional wellness, their sense of belonging, their decision-making, and the development of their sense of self. While educators acknowledge the importance of students' social-emotional well-being and their relationship building, these concepts are often thought of as secondary to developing students' academic achievement, particularly considering the oversized role of high-stakes testing in the US educational system. However, the divide between social interactions and academic achievement is not as stark as policymakers may make it seem. Indeed, research by developmental psychologists and education researchers has long documented that having strong peer relationships will allow children to thrive, including on academic development. This three-paper dissertation aims to provide evidence demonstrating the relation between being connected to one's peers, reading achievement, and the development of executive functioning skills for elementary-aged students, including on a sample of primarily English Learners. Throughout all three studies, data were collected as part of Project LEARN, a three-year longitudinal study that measured various components of reading development

alongside executive functioning and other variables, ultimately aiming to compare reading trajectories for elementary-aged English Learners and English Monolinguals.

Paper 1, "Peer Effects on Oral Language Comprehension in Elementary School: A Social Network Analysis" uses student friendship nominations across three semesters ( $N = 414$ ) as well as students' oral comprehension scores. This paper asks, *What is the relation between student centrality (i.e., being connected to one's classroom peers) and change in academic achievement, as measured by oral language skills?* After generating social networks using the friendship nominations, I calculated how central each student was within their classroom friendship network. Using a student fixed effects model comparing students' oral comprehension growth as a function of their classroom centrality, I find that students' predicted oral comprehension growth is significantly greater when students are more central within their classroom network, even after controlling for other reading variables in the model. This paper supports the connection between peer relationships and academics (using oral language as a proxy), suggesting that reading interventions and pedagogy should leverage peer relationships as one way to improve student learning.

Paper 2, "The Differential Relation between Friendship Centrality and Reading Outcomes for English Learners," uses the same data as Paper 1, focusing on whether student centrality differentially predicts reading outcomes for English Learners and English Monolinguals. This paper asks, *a) To what extent does classroom friendship centrality predict reading achievement gains for English Learners?* and *b) To what extent does the relationship between classroom friendship centrality and reading achievement gains differ between English Learners and English Monolinguals?* I used a series of multiple linear regression models, with students nested in homeroom classrooms, to answer the two research questions. First, using a sample of only English Learners ( $N = 160$ ), I find that English Learners are more likely to experience significant gains in oral language comprehension—but not reading comprehension—when they are more central within their

classroom network. Using the full sample of students ( $N = 229$ ), I find that English Monolinguals are significantly more likely to experience gains in reading comprehension when they are more central within their classroom friendship network, but there is no relation between friendship centrality and reading comprehension development for English Learners. This surprising finding, that friendship centrality predicts English Learners' oral language development but not their reading comprehension development, raises pedagogical questions about how best to support English Learners' reading outcomes. More research is needed, with particular attention focused on whether English Learners who are more connected within their classrooms experience similar levels of self-efficacy and sense of belonging as their connected English Monolingual peers.

Paper 3, "Do Executive Functioning Skills Predict Reading Comprehension Growth?" uses students' executive functioning composites—consisting of inhibitory control, cognitive flexibility, and memory scores—and reading comprehension scores in two subsequent semesters. This paper asks, *To what extent do students' growth in executive functioning predict their reading comprehension growth?* Using two methods that aim to limit omitted variable bias—multiple regression with covariate adjustment and propensity score matching—I find that students' growth in executive functioning significantly predicts their reading comprehension growth. This study provides support that interventions targeting students' executive functioning may also contribute to their reading development.

THANK YOU FOR BEING A FRIEND:  
THE RELATIONS BETWEEN FRIENDSHIP NETWORK CENTRALITY, READING ACHIEVEMENT,  
AND EXECUTIVE FUNCTIONING IN ELEMENTARY SCHOOL STUDENTS

by

Casey Archer

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Advisory Committee:

Dissertation Chair: Professor David Blazar  
Professor Claudia Galindo  
Professor Ken Rubin  
Professor Tracy Sweet  
Professor Ana Taboada Barber

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## **Dedication**

Five years ago, in October 2016, I developed a severe case of endocarditis. This heart infection is life threatening, and the outlook was not great for me by the time the doctors figured out what was happening. Thankfully, Arlington has excellent heart surgeons and medical staff, and I progressed that semester from not being able to move or walk, to being able to continue my studies. I dedicate this dissertation to the medical workers who saved my life, as well as the following people who have gotten me across the finish line of this degree program.

First, I have the best, most supportive friends. In no particular order, I could not have survived without the encouragement and support of Sarah, Jamie, Grace, Gracie, Andrew, Theresa, Elaine, Phoebe, Sydney, Katrina, Aaron, Hillar, Liz, Marie, Shannon, Christina, Katherine, Alexis, Becca, Sara, Meredith, Mark, Gail, Jim, JP, and Erin. Whether you were texting me about school, or Big Brother, or memes about corgis, you kept me sane and reminded me that I could succeed. Thank you tremendously.

Second, I have been truly blessed with the most supportive coworkers and employment. AnLar has helped develop my skills as an evaluator since I started as an intern in summer 2018, and they have helped keep me motivated every step of the way. Specifically, I want to thank Sarah and Kathi for always listening and being supportive; Laura and Tate for encouraging me and reading countless drafts; Tara, Becki, Angelique, Ayaka, and Dina for being great friends; and countless coworkers for always reminding me that I could do this. It's not often to find a family at work, but I've got that at AnLar.

This dissertation would absolutely not exist without the support of my colleagues. I spent countless hours writing with Pamela Callahan, Joel Miller, and Nick Stroup over Zoom, both before and throughout the pandemic. They have read every draft and have given me innumerable suggestions and pep talks. I can't wait to sit with Drs. Callahan, Miller, and Stroup in the near future as we relive our battle wounds and celebrate that we made it.

I also would not be here without the support of my advisor, Dr. David Blazar, and the rest of my dissertation committee—Drs. Claudia Galindo, Ken Rubin, Tracy Sweet, and Ana Taboada Barber. David, you read more drafts than you probably ever wanted, and I’m thankful for your encouragement and your feedback. You pushed me to think harder and write better, and I’m so grateful for you. The other committee members have all helped me in unique ways, ranging from supporting me when I was feeling anxious about the dissertation to trusting me to lead your lab, and I’m grateful for all of you. There are also a few professors who particularly challenged me throughout the years, and I am grateful for their support (Drs. Cartwright and Malen).

When I was in the hospital, all of my siblings—April, Ruthann, Michael, Christopher, and Gabby—showed up at a moment’s notice. I also have amazing aunts—Susie, Diane, and Linda—who have also been there with me throughout my life, and I’m thankful for each of you. I love all of you, and I can’t wait to celebrate with each of you in person.

These last two paragraphs can never convey how important the following people are to me, but I’m going to try. This dissertation is as much a success for my parents, Linwood and Lorraine Archer, as it is for me. They raised me to love reading, to be kind, to be inquisitive, and to never give up, and everything that I have is thanks to their love for me. I really do have the best parents I ever could have hoped for, and I would not trade them for anything in the world. They gave up everything to care for me when I was sick, and I know they would do it again. I look forward to calling them every day (usually multiple times per day), whether to talk about Survivor, or Lucie, or what new recipes we found online, and I just think the world of them. This dissertation is for both of you.

Last, I would never be here without the support of my wife, Shamika. She has gone above and beyond for me over the last 6.5 years while I was writing this dissertation, ranging from supporting me financially, caring for me when I was sick, picking up my slack around the house, and just being there with me every day. Being stuck at home doesn’t feel so bad when you have your best friend locked in the house with you, and I can’t imagine

going through 2020 (etc.) without you by my side. I can't wait for all of the adventures we have left, and maybe now I'll actually get to relax with you rather than spending all my free time on school. I owe you everything.

Also, the biggest shout out in the world to my study partner/son/editor, Ricky, and his big sister, Lucie.

To these friends and family, and to those who are no longer with us (Nana, TR, Susan, Ashley, Jeffrey, Lola, Gigi, Mia), I appreciate you more than you ever could know.



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## **Introduction**

Research from multiple disciplinary perspectives has demonstrated that students' peers are associated with social and academic outcomes. Studies indicate, for example, that students who are isolated or rejected within their classroom are more likely to experience negative consequences, including increased aggression (i.e., Ladd & Troop-Gordon, 2003) and greater rates of depression or other internalizing behaviors (i.e., Lereya, Copeland, Costello, & Wolke, 2015). However, being more connected with peers and having supportive friendships can protect against the negative social effects associated with isolation or rejection (i.e., Bowker, Rubin, Burgess, Booth-LaForce, & Rose-Krasnor, 2006). Further, having friends can provide children with academic benefits including the likelihood to explore and understand academic concepts more deeply (i.e., Hartl et al., 2015). Studies also have documented that students imitate the behavior of well-liked peers, which may lead students to mimic study skills, motivation, and classroom participation (i.e., Cooc & Kim, 2016; Hoxby & Weingarth, 2005). Finally, while the social and psychological mechanisms underlying peer effects are debated (Harris, 2010), researchers have provided strong empirical evidence that classroom peers can affect both mathematics and reading test scores (i.e., Gottfried, 2014; Hanushek et al., 2003).

While research has investigated the relation between peers and academic achievement, there are limitations to what is known based—in part—on the typical methodologies employed to date to understand the academic effects of peers. A key feature of this dissertation is that it brings together cross-disciplinary research tools and theoretical frameworks in order to examine components of the logic chain linking peers to increased social and academic outcomes. One line of research, traditionally taken up by economists, uses large-scale administrative datasets to connect characteristics of peers (e.g., percent of students in a classroom who are the same race or ethnicity) to students' own academic achievement (e.g., Angrist & Lang, 2004; Gottfried, 2014; Hanushek, Kain, Markman, & Rivkin, 2003). These studies linking peers to student outcomes have tended to focus on the

average benefit of peers across classes or grades. By using large-scale datasets, economists have causally linked peers to various outcomes, yet there are tradeoffs: the assumptions that large-scale datasets incorporate provide less specific information about which students interact with whom, instead defining “peers” broadly as students in the same class or even grade. These assumptions do not account for the fact that students are most likely to be affected by and associate with students to whom they are similar or share some identity marker, such as gender, race, or even important hobbies (Harris, 2020). Further, the literature exploring English Learners (ELs’) peer relationships—a growing student group that is increasingly of interest to educators and policymakers—is understudied in comparison to other student subgroups (Bellmore, Nishina, & Graham, 2011; Flores-Gonzalez, 2006; Graham & Echols, 2018), and research is needed to understand the ways that language, race, culture, socioeconomic status, or other variables intersect to differentially predict the effect of ELs’ friendships on student achievement.

Last, the relation between two constructs hypothesized to be connected with students’ friendships—reading comprehension and executive functioning—is also crucial to understanding levers to improve child outcomes. There are students with below-average reading comprehension scores even though they exhibit average (or above average) word decoding abilities (Oakhill & Cain, 2017), leading researchers to investigate the connection between executive functioning and reading comprehension. These students with reading comprehension deficits demonstrate lower proficiency in various executive functioning skills, such as inhibition (i.e., Borella, Carretti, & Pelegrina, 2010), working memory (Cain, 2006), and cognitive flexibility (Cartwright et al., 2017). While researchers have investigated the connection between executive functioning and reading comprehension (i.e., Cartwright, 2002; Cartwright et al., 2017; Dahlin, 2011; García-Madruga et al., 2013), the studies use evidence from interventions with small sample sizes that simultaneously develop students’ executive functioning skills and their reading comprehension, leaving questions about which skill develops first or if the skills develop mutually. Strong evidence from a study that more

strongly accounts for omitted variable bias is necessary to substantiate the theoretical claim that executive functioning leads to reading comprehension development.

To fill these gaps in the literature, I draw on rich primary data collected as part of Project LEARN (Taboada Barber et al., 2016), a three-year longitudinal study that investigated reading development and executive functioning among elementary students—particularly English Learners. For this dissertation, 2<sup>nd</sup>- through 5<sup>th</sup>-grade students (N=414) identified who were their closest friends within their homeroom classroom once per semester from Spring 2018 through Spring 2019. Using Social Network Analyses, I calculated how central each student was within their homeroom friendship network. These data were used to predict reading outcomes, informing the relation between student friendship patterns and reading development. The purpose of each dissertation paper is as follows:

- In Paper 1, I create a student fixed-effects model to estimate the effect of being more central within a classroom friendship network on students' English oral language comprehension growth.
- In Paper 2, I use multiple linear regression models to estimate the association of student friendship centrality with both English oral language comprehension growth and English reading comprehension growth. I further investigate the differential relation between friendship centrality and language development for English Learners and English Monolinguals, to uncover whether friendships are equally predictive of achievement regardless of language status.
- In Paper 3, I use multiple linear regression as well as propensity score matching to estimate the relation between students' change in executive functioning and change in reading comprehension.

This three-paper dissertation contributes to the research literature by using longitudinal student-generated friendship data to predict student reading achievement over time, including on a sample of students that consists largely of English Learners. Rather than employing assumptions about which students were friends, these student-generated friendship nominations allow for more specific understandings about how being connected to one's classroom peers can predict student reading achievement over time. The combination of student friendship data collected over time with modeling techniques that aim to limit selection and omitted variables biases builds on the strengths of both the economics and social network analysis literatures on peers. The final paper in this dissertation further explores linkages between the two key student outcomes explored: children's executive functioning skills (i.e., the skills associated with goal setting and planning ahead) and their reading development. Both are thought to relate to students' peer networks, either as predictors or outcomes, and substantiating the connection between executive functioning and reading comprehension will further guide intervention development associated with children's relationships, reading development, and executive functioning skills.

It has long been understood that friendships are important for students' social development (for a review, see Bukowski, Laursen, & Rubin, 2018). These papers provide evidence that friendships are also important for students' academic development, including for English Learners, a growing student group of interest to teachers and policy makers. Implications for instructional practice and policy development are discussed in each paper. Ultimately, I make the case throughout this dissertation that student friendships may support achievement, and further work should explore interventions that strengthen student friendship networks as one way of improving reading outcomes.

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**Peer Effects on Oral Language Comprehension in Elementary School:  
A Social Network Analysis**

**Paper 1**

Theoretical and empirical work from developmental frameworks describe specific avenues through which peers influence one's own attitudes, behaviors, and beliefs. To what extent do these peer influences subsequently benefit academic performance?

A sizeable body of research from multiple disciplinary perspectives has linked characteristics of students' peers to a variety of social and academic outcomes. For example, studies indicate that students who are isolated or rejected within their classroom's social groups demonstrate an increased likelihood of negative short- and long-term outcomes, including increased aggression (e.g., Ladd & Troop-Gordon, 2003), increased misbehaviors in school (Snyder et al., 2004), and greater rates of depression or other internalizing behaviors later in life (e.g., Lereya et al., 2015). In contrast, having strong peer support systems and friendships can protect against negative social effects of isolation or rejection (Bowker et al., 2006), which in turn provides children with academic benefits including the opportunity to explore and understand academic concepts more deeply (Hartl et al., 2015). Economists have built on this work from developmental psychologists by showing how access to peers with a common identity marker (e.g., English language learner status, race/ethnicity, gender) can further affect both mathematics and reading test scores (Gottfried, 2014; Hanushek et al., 2003). At the same time, this latter work generally is unable to identify the social and psychological mechanisms driving these relationships (Harris, 2010).

Together, the theoretical and empirical "peer effects" literature suggest that peers can serve as a catalyst to behaviors and beliefs that can lead to academic success. At the same time, because the literature often has developed from distinct disciplinary frames and traditions – namely from developmental psychologists and from economists – that have conceptualized peers in different ways and also have tended to focus on different sets of outcomes, gaps in the literature remain. While the peer effects literature to date has made important discoveries about the effects of various components of schooling on student achievement, such as how the achievement of one's classroom peers can affect one's own

learning, the studies by nature focus on classroom averages (e.g., average reading ability) and/or demographic percentages as predictors. These studies assume all students have equal effects on each other merely by being in the same classroom, which contradicts the finding that kids are most likely to be influenced by those with whom they relate and interact frequently (Harris, 2010).

This study contributes to our understanding of the benefits of student peers by utilizing student-level data that were generated by the students themselves, rather than by making assumptions that students in the same classroom or grade interact frequently. The prior literature connecting peers to academic outcomes primarily uses large-scale datasets, with peers operationally defined as students in the same school, grade level, or classroom. The present study addresses this limitation by utilizing student friendship nominations, such that students' friends are identified and used to predict student outcomes. Additionally, this study utilizes student panel data collected across three semesters to connect exogenous changes in network centrality to changes in reading achievement. Furthermore, the existing studies connecting peer social networks to reading outcomes either utilize a pre- and post-design to measure change, or rely on students' grades, which are not largely incomparable across contexts. Student friendship data, which are often challenging to collect due to concerns related to student privacy as well as the ethics of asking students who their friends are (and are not), provide a unique dataset with which to investigate connections among friendship networks and reading outcomes.

## **Motivation and Theoretical Frameworks:**

### **Interdisciplinary Perspectives on Why Peers and Friends Matter**

This section presents empirical and theoretical work documenting connections between peers or friendships and academics. Additionally, this section contains a brief discussion of Social Network Analyses, the primary methodological tool used in this study.

Prior work has explored the ways in which groups can impact classroom engagement, motivation, and academic success. Further, group processes as well as dyadic relationships are associated with language development, particularly for younger children. For this study, group dynamics, dyadic relationships/friendships, and language development form the theoretical framework connecting friendship networks to reading outcomes.

Given the complexity of relationships and group dynamics, it is important to distinguish among a few key terms that are used throughout this paper. In line with previous literature, 'peers' refers to other children within the same schools, grades, or classrooms (see Kindermann & Gest, 2018). 'Peer' does not assume any close relationships between two children; one's peers are merely the students in a similar setting, and it can be assumed that children interact with their peers regularly through school or classroom activities. Among one's peers, children form 'friends,' and these are others with whom children develop mutual trusting and caring relationships (i.e., Bagwell & Bukowski, 2019; Bagwell & Schmidt, 2011; Laursen & Hartup, 2002). By definition, friendships are reciprocated relationships in which both children feel an affinity towards each other. However, it is possible for one child to believe a friendship exists while the other does not reciprocate these feelings. In this instance, one child perceives another child is a friend, while the other child merely considers them a peer. Given the egocentric (i.e., student-driven) data collection metrics, in which students identify who their friends are, these directed, non-reciprocated friendships are possible and common in the data. From the perspective of the child declaring their friends, this friendship is a reality; thus, these non-reciprocated friendships are still considered 'friends' in this paper. Compiling all students into a social network, in which all students are linked to their identified friends, results in 'student friendship networks.' These networks consist of all children in a classroom, with friends (or perceived friends) linked by ties. Students who did not identify each other as friends are not linked in these student friendship networks, but by nature of being a part of the classroom roster, these children are co-located in the network as peers. These underlying student

friendship networks are represented using sociograms in a 2-dimensional plane (see Figure 1).

### **Peers, engagement, and academics**

Peers have important effects on others' growth. Social Cognitive theory (Bandura, 1986; Hinde & Stevenson-Hinde, 1987) posits that peers influence each other's behaviors, attitudes, and beliefs after observing how others behave as well as the consequences of those particular behaviors. If peers notice that behaviors or beliefs are rewarded, then they become more likely to endorse or subscribe to those particular actions. Within a classroom, children may be more likely to model the behaviors of students who are popular or well liked in an attempt to gain social standing themselves (Cillessen & Rose, 2005; Rambaran et al., 2017). Others have added to that framework, noting that if peers perceive rewards for behaviors or beliefs, then they become more likely to hold those beliefs or mimic those actions, especially pertaining to students' self-efficacy and motivation (Chen & Pajares, 2010; Grigg et al., 2018; Usher et al., 2019).

Popular peers are also more likely to influence the norms of behavior within a classroom (Bukowski, Brendgen, & Vitaro, 2007). This process, known as peer socialization, can affect the behaviors and attitudes that guide a classroom atmosphere, such as motivation, engagement, or even achievement. Peers at the top of the social hierarchy set expectations that others follow, possibly in an attempt to ascend in the hierarchy or to avoid rejection (Rodkin & Ryan, 2012). Popular students who promote behaviors that are associated with academic success (such as participation in class, studiousness, etc.) may lead to different academic outcomes than in classes where the popular students promote behaviors that negatively impact academic engagement.

Students' perceptions of belonging can also have impacts on academic outcomes. Students who feel that they belong at school are more likely to put effort into their schoolwork and enjoy being in the classroom (Goodenow, 1993). Additionally, feelings of

belonging have been associated with student achievement for early adolescents (Roeser, Midgley, & Urdan, 1996). Among adolescents, participating in school activities is associated with increased feelings of school belonging (Dotterer, McHale, & Crouter, 2007), particularly for Latinx students (Brown & Evans, 2002). Additionally, developing feelings of school belonging significantly mediated the connection between having friends in school activities and increases in academic achievement, suggesting school belonging is an intermediary step that develops after establishing friends in activities (Knifsend et al., 2018). However, few studies have examined this relationship for students in the early elementary school grades, in which students experience the most growth in reading understanding.

Social isolation can have detrimental effects on students' socio-emotional development. Lereya et al. (2015) demonstrated that students who do not have friends over long periods are more likely to develop internalizing problems, such as depression or anxiety. These students may also be less engaged within the classroom, since internalizing problems can lead students to disassociate and not focus. In contrast, having friends is associated with greater academic engagement (Wentzel & Caldwell, 1997), which might explain why students who feel more connected within their classroom network experience greater academic growth over time. Again, much of the extant literature focuses on students in secondary schools, at times when socialization is crucial to students' transition from childhood to adolescence and early adulthood. However, this dissertation would shed light on the extent to which these relationships exist for pre-adolescent students in the elementary grades.

### **Language Development and Peers**

This study utilizes oral language comprehension as an indicator of academic success. Reading comprehension underlies achievement across the curriculum, including mathematics (Grimm, 2008), science (Reed et al., 2017), and social studies (Vaughn et al., 2013). Oral language is a significant longitudinal predictor of reading achievement

(Babayigit et al., 2020; Silverman et al., 2020). Thus, identifying contributors to oral language comprehension has implications for achievement across the curriculum. Further, oral language comprehension is associated with success on high-stakes testing, particularly for younger students (Nyman, 2013). This study utilizes one such understudied variable, student centrality within friendship networks, because of the role that peer interactions and friendships have for children's oral language development (Kory-Westlund & Breazeal, 2019; Swain et al., 2002).

Research has demonstrated that peers can be leveraged to improve each other's reading skills in the elementary grades. The Peer Assisted Learning Strategies (PALS) instructional technique involves pairing students together who can coach each other and develop their reading levels (Fuchs et al., 2000). Randomized control trials have demonstrated that PALS improves students' word decoding and oral language comprehension (Lemons et al., 2014). This intervention utilizes the social contagion model, whereby peers learn from each other and mimic each other's reading behaviors (Cooc & Kim, 2016). Thus, interventions capitalizing on peer behaviors, support, and capacity to work together can lead to reading developments for elementary students.

Given the research, I hypothesize that greater opportunities for peer interactions, as well as increased efficacy and sense of belonging developed through greater social connectedness with friends, will foster children's oral language development. Specifically, students will show increased growth in oral comprehension in semesters when they are more central within their classroom friendship networks, after controlling for prior achievement.

### **Peer Effects Methodology**

While researchers have examined peer effects using various lenses, the conclusions linking peers and academic outcomes are limited based on the quality of existing data. One reason for limited conclusions linking students' peers to academic performance is the way in



which peers have been operationalized by researchers from various disciplines. One line of research, traditionally employed by economists, uses large-scale administrative datasets to connect characteristics of peers (e.g., the percent of students in a classroom who are the same race or ethnicity) to students' own academic achievement (e.g., Angrist & Lang, 2004; Gottfried, 2014; Hanushek et al., 2003). Although students in the same classroom or grade are peers in the broader sense, administrative data cannot capture which students are interacting or who considers themselves friends. Using large-scale datasets to reach conclusions about the effect of peers on various outcomes is limited given that students are most likely to affect others with whom they share an affinity or identity marker (Harris, 2010). Children—or adults—do not weigh all “peers” equally when making decisions about behaviors. While peers are broadly defined, these studies do not allow researchers to consider the influence of students' friendships on their achievement.

A second methodological approach asks students to declare who their friends are or with whom they interact. This approach allows researchers to create “social networks” that are thought to provide more valid representations of the underlying classroom or grade-level relationships within a closed system of students (e.g., Carolan, 2014). Researchers can analyze these networks to provide clearer quantitative representations about the connections between friendships and academic outcomes. However, empirical analysis in education policy studies has focused on *creating* social networks, rather than *connecting* them to student outcomes.

Developmental psychologists have utilized sociometric tools throughout the twentieth century to study group relationships and dynamics empirically (see Cillessen & Bukowski, 2018 for a review). These tools allow researchers to have a primary focus on peer status and various social/ecological phenomena related to friendships and peer networks such as aggression (e.g., Parkhurst & Hopmeyer, 1998), rejection (e.g., Parker & Asher, 1987), or popularity (e.g., Cillessen & Mayeux, 2004). Researchers can use sociometric tools and social network analyses to quantify various components of the networks and incorporate the

measures into traditional statistical models to predict outcomes. These methods provide specific information about which students are interacting with whom, which can strengthen claims made about the effect of one's peers on outcomes, rather than defining peers broadly as those students who share a classroom or school (Daly, 2010). Further, these methods allow researchers to study the effect of friendships on identified outcomes, since students can identify which of their peers they consider friends. While sociometric tools allow researchers to collect fine-grained student-level data on who one's friends are, children's friendships (and their accompanying friendship nominations) are often in flux and can vary wildly over time. However, within elementary students' classroom networks, children often retain stable friendship networks (Cooc & Kim, 2016; Ryan & Shim, 2012).

### **Social Network Analyses**

This study makes use of Social Network Analyses as a way to operationalize students' positions within their classroom friendship network. Social Network Analysis (SNA) is a statistical procedure used to quantify the underlying social networks of contained groups (Carolan, 2014; Daly, 2010). Researchers analyze a closed group of individuals and the social ties among them in order to reproduce a visual image of the network and analyze the network using various quantitative methods (Carolan, 2014). Social network analysis enables researchers to model the influence that social processes (i.e., relationships, group dynamics) have on other variables (Daly, 2010; Davison, 2019). For example, social network analyses would allow researchers to answer questions such as: is being more or less connected with others in the network associated with other outcomes? Do individual measures predict whether a pair of students will become friends? To what extent does the structure of a group network predict whether the group overall will demonstrate increases in other outcomes? While SNA is becoming more common across research fields, it is currently underutilized in education research (Daly, 2010).

Within SNA, actors (i.e., students) are the individuals forming relationships. The ties (i.e., connections) among actors can vary; examples include interactions, relationships, advice-seeking, or any other sort of connection among the network participants (Carolan, 2014). The actors can also vary among specific individuals, groups of individuals, or institutions (Carolan, 2014). Network information can be used in conjunction with peer effects models to give researchers a better understanding of the social processes taking place within classrooms or schools. Furthermore, these social relationships can be used to leverage student outcomes in educational systems. Therefore, understanding social network analyses may lead to improved educational outcomes for students when policy is informed by this research (Daly, 2010).

In addition, social network models allow researchers to gain a broader perspective of how one's social environment can shape one's own attributes and outcomes. Whereas peer effects models can account for how dyadic (i.e., two-student) relationships may lend some predictive power to various educational outcomes, such as test scores or delinquent behaviors, incorporating social network information into statistical models can develop a greater understanding of the structure of a network and one's own position within that social group (Burk et al., 2007). Creating social network models allows researchers to predict how relationships might change or evolve over time, as well as how other actors may influence one's actions or character traits (Burk et al., 2007).

To my knowledge, only two studies to date have used student social networks to predict academic achievement in the general population<sup>1</sup> (Cooc & Kim, 2016; van Rijsewijk et al., 2018), focusing on short-term reading outcomes or classroom grades. Cooc and Kim (2016) asked second- and third-grade children to identify which classroom peers they read with, using those nominations to identify peers. The average reading level of students' identified reading peers was used as a predictor for students' own reading achievement.

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<sup>1</sup> A third study (Elreda et al., 2016) uses social network analysis to predict achievement but focuses on English Learners. This study is discussed in Paper 2.

Ultimately, peers' reading scores predicted one's own reading scores; however, the predictor was nonsignificant when controlling for a student's own reading score. Thus, the authors demonstrated homophily of peers, whereby peers predict one's own reading achievement as a result of peers being similar to themselves (and having similar reading achievement). This study improved on prior peer effects studies by incorporating study-level peer nominations rather than assuming all students in the same classrooms were peers of each other. Additionally, the study used a classroom fixed effects model to control for non-observed teaching differences. However, the primary focus of this study was on peers' reading levels, demonstrating students are likely to read with others who are of similar reading achievement. The study also did not collect peer nominations from multiple time points, instead assuming that students' reading peers would be consistent across semesters. The current study builds on their fixed effects model but also captures data across time points to leverage variation in students' position in the classroom friendship network over time.

A second study (van Rijsewijk et al., 2018) demonstrated a connection in student network centrality and academic achievement. Using early adolescents (with a mean age of 13 years) in a school in the Netherlands, participants identified which of their peers they were likely to ask for help if they needed it. Classrooms with less dense help networks were associated with decreased academic achievement. Further, individuals who were more central within the help network were more likely to be high-achieving individuals. This study demonstrated that classroom climate was an important predictor for classroom-level achievement, and that students with more access to help from peers were more likely to achieve. While the study is similar to the present study, it uses one time point to assess the correlation between student network centrality and achievement. The authors acknowledge that more factors may be at play than just students' access to social capital, and they claim that one limitation was their inability to have longitudinal data to compare changes in network status over time.

More research garnered from student self-created friendship networks is necessary to understand the extent to which these social networks are associated with changes in various academic outcomes, and whether the relations among constructs are maintained over time. Additionally, the findings from the extant studies can be strengthened using longitudinal data, in which student centrality is utilized as the independent variable. That analytic model will allow for an understanding of how student changes in network centrality can predict student changes in reading achievement over time. Finally, and most importantly, neither study asks the children to identify their friends; rather, they identify with whom they read or to whom they seek guidance. The current study contributes to the literature by providing evidence about the impact of friendships (or perceived friendships) on academics. While research has documented various important effects of friendships on social-emotional or developmental outcomes, this study will supplement those findings by examining academic effects of friends for elementary-aged children.

### **Present Study**

The hypothesized logic model connecting friendships with reading achievement relies on developmental processes associated with peer relationships as well as classroom dynamics supporting student learning and engagement. There are positive effects on students' well-being that are associated with being connected to peers, including an increased sense of belonging (e.g., Dotterer, McHale, & Crouter, 2007; Goodenow, 1993; Roeser, Midgley, & Urdan, 1996) and an increased perception of self-worth (Hiatt, Laursen, Mooney, & Rubin, 2015), as well as a decreased chance of depression or other internalizing behaviors (Lereya et al., 2015). Due to these benefits, children who are more connected to peers are better able to enjoy being in the classroom and to participate in classroom activities. In turn, these students are better able to engage with the instructional activities (Hartl et al., 2015) and therefore are more adept at learning the classroom content. Outside

of the instructional activities, students who are more connected with peers are engaging more frequently with others, which involves increased opportunities to communicate and support their oral language skill development. Given the correlation between oral language comprehension and reading comprehension (e.g., Babayigit et al., 2020; Silverman et al., 2020), these children are developing their propensity to both produce and understand the English language. Further, within classroom networks that are characterized by many dense social connections, students are most likely to repeat behaviors of those students who are considered well-liked or popular (e.g., Cillessen & Rose, 2005; Rambaran et al., 2017), and if these students are also more likely to participate in the classroom and display study skills, others who are connected to them will similarly display these behaviors and therefore develop their own language skills. Ultimately, friendships allow children to meaningfully engage with each other and the classroom content, bolstering their oral language skills over time.

According to this theory of action, students' connectivity with peers in their homeroom classroom will lead to increased language outcomes. Specifically, having more friends will improve social-emotional outcomes, including sense of belonging and self-worth. Additionally, students with greater support within the classroom will be more able to focus on the classroom material, thereby increasing their aptitude for learning. Further, students who are more connected will communicate more frequently with others, both during and outside of instructional activities, which will provide these students with greater opportunities to develop their oral language skills. A combination of the social-emotional components and the greater ability to develop language skills will allow students with greater connectivity with peers to experience greater oral language outcomes over time.

To examine whether student friendship networks have predictive power for student achievement, this study examines the relationship between student-created friendship networks and changes in academic outcomes over three semesters. The following research

question, focused on peer friendship networks among students nested in homeroom classrooms, will guide this study:

What is the relation between student centrality (i.e., being connected to one's classroom peers) and change in academic achievement, as measured by oral language skills?

To answer this question, I leverage a longitudinal dataset collected as part of a larger study that investigated various cognitive and language predictors of reading comprehension. This study builds from the strengths of prior work by drawing on social network data collected over time, paired with student fixed effects modeling strategies aimed at limiting sources of omitted variables bias when linking peer networks to academic outcomes. To understand the extent to which being central to one's network (i.e., well-connected, as opposed to residing on the periphery of the network with few to no friends) predicts academic achievement, I leverage data from a larger study investigating reading development among elementary students. Over three semesters, 2<sup>nd</sup>- through 5<sup>th</sup>-grade students indicate which students from within their homeroom classroom are their closest friends. I use these data to create classroom friendship networks and to empirically measure each student's network centrality. I used a student fixed effects model to leverage exogenous changes in network centrality and the associated changes in students' oral comprehension reading scores.

### **Method**

This study is part of a larger longitudinal study, Project LEARN (Taboada Barber et al., 2016), examining elementary-aged English Learners' and English Monolinguals' reading development that occurred from fall 2016 through spring 2019. The present study incorporates data from twenty-four 2<sup>nd</sup>- to 5<sup>th</sup>-grade classrooms in public schools in a mid-Atlantic US state across the transition from their 2017-2018 to 2018-2019 school years. In

the three semesters (spring 2018, fall 2018, and spring 2019), students were asked to name their top five friends within their classroom. I use Social Network Analyses to quantify students' centrality within their peer friendship network as a predictor for reading achievement over time, hypothesizing that greater centrality within peer friendship networks would be associated with greater cognitive, linguistic, and academic growth over time. Given that data were collected across three semesters, I use panel data to examine whether changes in friendship networks can explain differences in reading growth.

Five public schools in the mid-Atlantic US were part of the larger study and comprised the current sample. These schools had higher-than-average populations of English Learners (ELs) compared to the overall state population, which allowed for more powered analyses of ELs' development over time. Parents or legal guardians of students provided annual informed consent for their student to participate in the study; students who did not receive informed consent across both years of the present study were removed from the sample. This study was approved by the university institutional review board, and participants were treated in accordance with the ethical principles of the American Psychological Association.

## **Participants**

In spring 2018, participants were 2<sup>nd</sup>-through 5<sup>th</sup>-grade students from the five elementary schools. The full sample of students who participated in the whole-class assessments in Spring 2018 included 765 students. To be included in the present study, students had to have complete social network data across all three time points ( $n = 414$ ). Appendix 1 compares the students in the analytic sample with the full sample of students in the longitudinal study in Spring 2018. Of note, the students who comprise the analytic sample are more likely to be Hispanic, an English Learner, and/or to receive free or



reduced-price lunch than the full analytic sample. This differential affects the external validity of the results and is discussed in the limitations section.

Students in this sample were evenly distributed across grades 2 through 5 in the spring of 2018, with an average age of 9.20 years. A slightly greater number of participants were male (52.9%) than female (44.7%), although gender data were missing for some students (2.4%). Most of the students were Hispanic (73.7%) or Black (21.3%). Most students were eligible for free or reduced-price lunch in either year of the study (87.0%), and most students were identified by the school district as English Learners in either year of the study (70.5%). Table 1 provides complete descriptive data on the full sample of students in the present study.

Table 1  
*Descriptive Statistics for the Sample*

<i>Variable</i>	<i>n</i>	<i>M (SD) or %</i>
Grade, SY 2017-2018		
Second	102	24.6%
Third	109	26.3%
Fourth	106	25.6%
Fifth	97	23.4%
Age, Fall 2017	396	9.20 (1.17)
Gender		
Male	219	52.9%
Female	185	44.7%
Missing	10	2.4%
Race/Ethnicity		
Hispanic	305	73.7%
Black / African American	88	21.3%
White	3	0.7%
Asian	2	0.5%
Native Hawaiian / Pacific Islander	1	0.2%
Multi-Racial	5	1.2%
Missing	10	2.4%
SES, Fall 2017		
Eligible for Free or Reduced-Price Lunch	360	87.0%
Not eligible	38	9.2%
Missing	16	3.9%
English Learner, either SY 17-18 or SY 18-19		
Yes	292	70.5%
No	121	29.2%
Missing	1	0.2%
Student has IEP, either SY 17-18 or SY 18-19		
Yes	22	5.3%
No	381	92.0%
Missing	11	2.7%

Note: Table 1 displays descriptive data on the 414 students in the sample.

## Measures

Students were assessed using a battery of assessments twice per semester—once was an individual assessment and once was in a whole-class setting. For individual assessments, a Research Assistant (RA) led the child to a quiet spot in the school for a one-hour assessment protocol, consisting of a research battery of thirteen various assessments

each semester. For whole-class assessments, one or two RAs administered three whole-class assessments to the students participating in the study within their classrooms. Any students not participating were allowed to read or meet with their teacher during that one-hour block. For both the individual and whole-class assessments, RAs were trained each semester on administering and scoring the assessments. RAs were required to pass fidelity checks with the PI, co-PIs, or other lab staff each semester.

The outcome variable (i.e., oral language comprehension) was administered as part of the individual assessment battery, and the independent variable of interest (i.e., student friendship network centrality) was assessed as part of the whole-class assessment. Other covariates (e.g., word decoding, reading comprehension, and vocabulary) were collected as part of the individual assessments.

The following sections describe the operational definitions of each of the key variables used in this study.

**Friendship centrality.** The primary independent variable for the present study was student centrality within classroom-based friendship networks, which aims to characterize how 'central', or crucial, each child is within the constructed social network (Carolan, 2014). While there are many different ways to define centrality, this study utilizes two methods: closeness and in-degree. Closeness involves creating a sociogram that displays student connections, using the students' friendship nominations, and measuring how central each student is within that network. In contrast, in-degree is a count of the number of friendship nominations each student received.

The following subsections describe the two centrality measures in detail, including how they are calculated and what constructs they highlight.

*Closeness.* Carolan (2014) defines closeness as a function of the average distance between a particular node and all of the other nodes in the network. In other words, how connected is each student, on average, to each of the other students in the closed network. Thus:

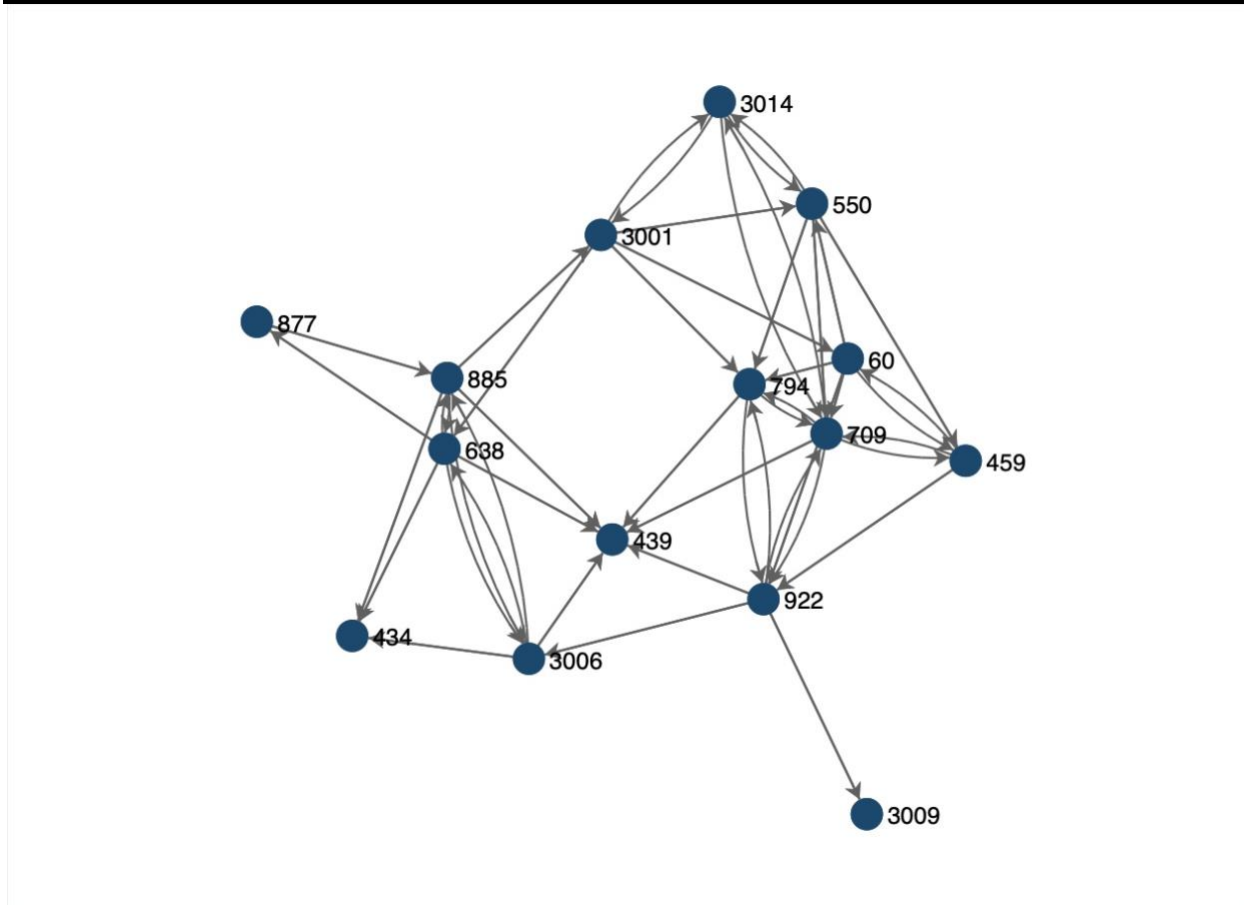
$$Closeness_i = \sum \frac{1}{d(N_i, N_j)}$$

where  $d$  is the distance between Node  $i$  and every other Node  $j$  in the model (Carolan, 2014). Using closeness centrality, a node (i.e., student) that is more central within the network has higher closeness than other nodes.

In the fall and spring of each school year, students were provided with a complete roster from their homeroom class. The assessor asked, "Who are your best friends in your class? Circle up to five friends." Students were reminded that they could circle zero, one, two, three, four, or five friends from their class. They were instructed not to circle themselves.

Based on students' responses, directed social networks were created for each classroom at each of the three time points. Using the igraph R package (version 1.2.4.2), sociograms mapped students' social position on a latent space. Students who were more connected to their classroom networks based on the friendship nominations they indicated and received are positioned towards the center of the sociogram, and their less-connected peers appear on the periphery. See Figure 1 for a sample sociogram displaying the friendship network generated for one of the classrooms. Following Cruz et al. (2012), Elreda et al. (2016), and Li & Stone (2018), who also asked participants about who their 'best friends' or 'friends' were, I refer to the underlying social network as the 'classroom friendship network' throughout this dissertation. While not all identified relationships were reciprocated friendships, the friendship nominations allow me to capture students' perceived friendship networks that exist in each classroom.

Figure 1  
*Class Sociogram demonstrating the Friendship Network for a Sample Class*



Note: Figure 1 displays a sociogram that maps friendship nominations among students in a particular classroom in spring 2018. Each student is represented by a node, with numbers indicating the student ID. Students closer to the center of the network, such as student 794, have increased centrality scores because they are more connected to their classroom peers. Student 3009, who was only nominated by one peer as a friend (and who nominated no friends of their own) would have the smallest centrality score from among this classroom network. The sociogram was created using the *nwcommands* Stata package (Grund, 2015).

Students' closeness at each time point was calculated using Carolan's (2014) definition. Students who were more central to their class friendship network using the closeness definition had higher scores than their less-connected peers. Closeness centrality uses both friendship nominations that a student *makes* (i.e., who do they think are their friends?) as well as friendship nominations that a student *receives* (i.e., who thinks of me as their friend?). Therefore, closeness centrality incorporates information about a student's

perception of their standing within the social network (i.e., do I think that I have lots of friends in this class?) as well as how others perceive that particular student. Students with increased closeness scores believe they are connected to other central students in the classroom, and other students reciprocate those nominations. Students with lower closeness scores are less likely to name central students as their friends, and/or central students are less likely to nominate them. These students are less likely to be friends with well-connected peers, or they are more likely to only be connected to peers at the periphery of the social network.

*In-degree.* In contrast, in-degree centrality only utilizes friendship nominations that each student receives, with the idea that students who receive more friendship nominations are more central to their network (e.g., Philip, 2010). A student's own nominations for whom they believe are their friends do not affect their own in-degree, whereas closeness centrality by definition is affected by the nominations that a particular student makes. In essence, in-degree does not allow students to affect their own centrality score. This measure highlights how others perceive a student, and it does not allow one's own perception (or lack thereof) of connectedness or comfortability with peers to affect one's score. Because of the differences in the underlying constructs that in-degree and closeness measure, it is not expected that these measures would be highly correlated with each other.

As with other social network variables, there are different ways to operationalize the variable (Daly, 2010). The simplest involves using a simple count of the number of students who nominated a particular student; however, students from larger classes could have more students nominate them by nature of a larger pool of students. In order to prevent network size from affecting students' scores, in this study in-degree centrality was operationalized as the number of nominations a student received, divided by the possible number of students in the network who could have nominated that student (i.e.,  $N - 1$ , where  $N$  is the number of students in the classroom). Like closeness centrality, larger values of in-degree centrality indicate a student is more central in their friendship network.

Table 2 contains descriptive statistics for the primary variables in the study, and Table 3 presents the correlation matrix of the study variables.

Table 2  
*Descriptive Statistics for the Study Variables*

Variable	<i>M</i>	SD	Reliability <sup>2</sup>
Centrality (Closeness)	0.0198	.01	N/A
Centrality (In-Degree)	0.26	0.14	N/A
Oral language comprehension	15.43	4.45	0.78–0.83
Word decoding	47.58	11.19	0.94–0.98
Reading comprehension	26.12	8.12	0.94–0.98
Vocabulary	25.47	4.46	0.77–0.78

Note: Table 2 displays the sample mean (*M*), standard deviation (*SD*), and reliability for each of the variables in the model. The units for all reading measures are the number of questions correct on the WJ-IV assessment.

**Oral language comprehension.** Students' oral language comprehension was assessed using the Woodcock-Johnson-IV Tests of Achievement (WJ-IV; Schrank et al., 2014) Oral Comprehension subtest during individual assessment sessions. This test provides students with short, orally-presented passages, and students must complete the passages using an appropriate word or phrase (e.g., "Without a doubt, his novels are more complex than the novels of many contemporary \_\_\_\_\_.\" A correct response would be *authors*.). Students' scores are the correct number of items out of 33. Split-half reliability coefficients<sup>3</sup> for children ages 6-10 range from 0.78 to 0.83 (McGrew et al., 2014).

**Letter-Word decoding.** The individually administered Letter-Word Identification subtest of the WJ-IV (Schrank, Mather, & McGrew, 2014) measured students' abilities to

<sup>2</sup> The reliability for the sociometric variables is challenging to assess accurately due to the changing social context of groups (Maassen et al., 2004). In other words, researchers measuring the reliability or stability of measures struggle to ascertain whether differences in reporting are due to measurement error or to slight changes in the groups being studied (Maassen et al., 2004). Cillessen, Bukowski, and Haselager (2000) found that Cohen's  $\kappa$  for sociometric measurements vary between .01 and .44, and sociometric variables are particularly consistent for popular or rejected children.

<sup>3</sup> Split-half reliability involves splitting an assessment into two equivalent halves, each of which measures the same construct or set of constructs. Then, the reliability in student scores on the first and second halves of the assessment are calculated.

decode letters and words. This test required students to read a list of English letters or words presented in print. Students' scores are the correct number of items out of 78. Split-half reliability coefficients for children ages 6-10 range from 0.94 to 0.98 (McGrew et al., 2014).

**Reading comprehension.** The individually administered WJ-IV Passage Comprehension subtest (Schrack et al., 2014) indicated reading comprehension. This subtest consists of three item types: identifying which rebus (picture symbol) matches an actual picture, identifying a picture that corresponds to 1-3 words, and silently reading short passages and completing blanks in the passages with appropriate words. Students' scores are the correct number of items out of 52. Split-half reliability coefficients for children ages 6-10 range from 0.89 to 0.98 (McGrew et al., 2014).

**Vocabulary.** Students' English vocabulary was measured using the WJ-IV Picture Vocabulary subtest (Schrack et al., 2014). Students were presented with a picture, and they were asked to name the picture using the appropriate English vocabulary word. Students' scores are the correct number of items out of 54. Split-half reliability coefficients for children ages 6-10 range from 0.77 to 0.78 (McGrew et al., 2014).



Table 3  
Correlation Matrix of Study Variables

	Centrality (Closeness)	Centrality (In-Degree)	Oral Comprehension	Reading Comprehension	Letter-Word Decoding	Vocabulary
Centrality (Closeness)	-----					
Centrality (In-Degree)	0.09**	-----				
Oral Comprehension	-0.06	0.06	-----			
Reading Comprehension	-0.02	-0.00	0.47***	-----		
Letter-Word Decoding	-0.07*	0.10**	0.57***	0.62***	-----	
Vocabulary	-0.09**	0.00	0.74***	0.48***	0.59***	-----

Note: Table 3 displays pairwise correlations for each of the variables in the model.

\* $p < .05$

\*\* $p < .01$

\*\*\* $p < .001$

Of note, the two measures of centrality have a weak correlation ( $r = 0.09$ ), providing evidence that the measures are capturing different components of centrality. This correlation aligns with previous literature finding only a moderate correlation on average between in-degree and closeness for studies using symmetric networks (i.e., if either student nominates the other, a tie exists; Valenti et al., 2008). Given that this study uses directed social networks (i.e., one student can nominate another, but the tie may not be reciprocated) as opposed to symmetric networks, one would expect a correlation between in-degree and closeness that is much closer to 0. The lack of a relation between the two centrality measures indicates that one's in-degree does not explain variation in one's closeness; therefore, students with high closeness centrality may or may not be the same students who made and received lots of nominations themselves.

The weak correlation between the variables strengthens claims that they are validly measuring different components related to friendship. Closeness centrality utilizes friendship nominations that students make as well as friendship nominations that students receive, measuring both the extent to which a student is connected to their peers and the extent to which a student feels they belong within the network. In contrast, in-degree centrality only indicates the proportion of students in one's class who nominated a particular student as a friend. Students' perceptions of their own belonging do not factor into in-degree measures; instead, in-degree provides evidence about how many of one's peers consider a particular child is a friend. The distinction between the two operational definitions of centrality will be important when understanding the model results, since they are illuminating different components of the friendship network centrality.

### **Data Analysis**

This study examines links between students' friendship network centrality and oral language proficiency. A primary concern when estimating these links is that student network centrality is not exogenous; student centrality is related to many factors that students have control over (e.g., determining who to befriend) and demographic factors (e.g., gender,

race, etc.). In addition to time invariant factors, such as gender (Grard et al., 2018), students' network centrality is a factor of changing variables, such as students' disposition or interests. These variables need to be properly incorporated into the models to avoid confounding estimates of student friendship network centrality with other factors.

To address these concerns, I leverage the longitudinal data and specify a student fixed effects model. These models absorb the within-student variation in key independent and dependent variables that is time-invariant (Hanushek et al., 2003) – such as innate ability to form friendship networks and student demographic factors related to friendship formation – by using student panel data to measure how changes in the independent variable (i.e., friendship network centrality) are associated with changes in the dependent variable (i.e., oral language achievement). Using this statistical model, students serve as their own controls. The student fixed effects model uses the following equation:

$$oral\ comp_{i,jkt} = \beta_1 centrality_{i,jkt} + \alpha_i + u_{ijk},$$

where the oral comprehension score of individual  $i$  in class  $j$  at school  $k$  at time  $t$  is predicted as a function of centrality measures<sup>4</sup>.  $\alpha$  is a vector of the unobserved time invariant student fixed effects, and  $u$  represents the error term. I account for nesting of students within classes (and schools) by clustering standard errors at the class level, thereby accounting for non-independence of observations within classrooms. This clustering method allows for unobserved similarities among students within the same classroom that would be related to both the student friendship networks and reading outcomes. For example, a classroom in which the teacher purposely utilizes student friendship networks when differentiating reading instruction may have less of a relationship between network centrality and reading growth since the teacher may be exploiting friendships to drive

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<sup>4</sup> Appendices 1 and 2 also contain estimates for reading controls, including students' measures of English language vocabulary, reading comprehension, and letter-word decoding. These estimates have not been incorporated into the primary model since student fixed effects models inherently incorporate time variant measures, such as students' mastery of various components of the English language.

academic achievement. The students in this class may have residuals that differ in magnitude from the full sample of students, and thus their residuals need to be clustered together to incorporate similarities among this smaller group of students.

I fit three regression models using the two identified measures of centrality (e.g., closeness and in-degree) as the independent variables. Using two different measures allows comparisons to be made about whether and how centrality measures differ in predicting student achievement growth over time. In the student fixed effects models, I fit one model each, using either closeness or in-degree as the independent variable. Then, the final model incorporates both centrality measures. Each model uses data from the three different time points.

To examine the effect of omitted variable bias, I ran additional student fixed effects models that incorporated other time-varying student-level variables, such as letter-word decoding, vocabulary, and reading comprehension (see Appendices 2 and 3). The purpose of these additional models is to ensure that additional controls do not result in instability of the coefficients of the primary independent variable (i.e., friendship network centrality). By adding additional covariates yet not greatly impacting the estimates for centrality, these models provide greater evidence that the student fixed effects models are properly specified and that no lurking variables are biasing the effect sizes.

Complete social network data were collected for 414 students within 24 classrooms. Between 5 and 13 percent of students were missing reading variables at each time point (Taboada Barber et al., 2020), due to transferring schools or being absent from school the day the individual assessments were conducted. Missing data can be problematic for social network analysis (Neal, 2008; Rogers & Kincaid, 1982), since missing data can distort the shape of the predicted network. For example, if data are missing for a key student in a network, such as a student who connects or brokers various portions of the network, the data may be mapped as two completely exclusive cliques. When mapping networks, more complete data help to demonstrate accurately the connections that exist among students.

Thus, efforts were taken to incorporate students in the dataset if there was enough evidence to represent those students' relationships, either through their own or other students' friendship nominations. Students were only excluded from their classroom friendship network if they met the following criteria: a) they were absent on the day their classroom data were collected, and b) fewer than two students nominated them as friends.

Missing data on the covariates (i.e., reading comprehension, letter-word decoding, vocabulary) were imputed using multiple imputation by chained equations in Stata (see Azur et al., 2011). I conducted twenty imputations, which exceeds the guidance of using at least the number of imputations to match the percentage of missing data (i.e., 13 imputations to cover the 13% missingness in this study; White, Royston, & Wood, 2011). Following the multiple imputations, sensitivity analyses were conducted to ensure the imputation was successful and did not introduce biases (Rezvan, Lee, & Simpson, 2015).

## **Results**

Two series of models were run to measure if students' changing friendship network centrality was connected with their oral reading comprehension growth. The main results are presented in Tables 4 and 5, which display the fitted student fixed effects models—either using closeness (Table 4) or in-degree (Table 5). Statistically significant predictor variables are indicated. Each series includes a null model as well as two versions of a final model: one using the variables' original scales, and another using standard deviation units. Additionally, models incorporating students' other reading measures (i.e., reading comprehension, vocabulary, and word decoding) as covariates are presented in Appendices 2 through 4.

### **Closeness Centrality**

The student fixed effects models include closeness as a measure of friendship network centrality, providing evidence about whether student centrality (measured using

closeness) can predict academic achievement growth (see Table 4). The closeness-only model significantly predicts oral comprehension growth over time ( $F(1,402) = 8.48, p = .004$ ). According to the model, a 1-SD increase in centrality was associated with a .08-SD increase in oral language comprehension. All standard deviation unit predictions are presented in the standardized version of the full model in Table 4.

Further, closeness centrality is a significant predictor even after controlling for in-degree (see Full Model) and other reading covariates (see Appendix 4). Controlling for students' in-degree, a 1-SD increase in closeness is associated with a 0.09-SD increase in oral comprehension. In this full model that controls for in-degree, students who are more connected with their peers as a result of having increased out-degree (i.e., they nominate more students as friends) or being closer towards the center of the classroom friendship network are expected to increase their oral comprehension above what they experience when less-connected to their peers. This predicted increase in oral comprehension as a result of increased closeness (but not in-degree) is explored in the discussion section.

Table 4

*Student Fixed Effects Model Predicting Oral Comprehension Growth using Closeness Centrality*

	Closeness only (Standardized)		In-Degree only (Standardized)		Full Model (Standardized)	
	<i>Estimate</i> (s.e.)	<i>t</i>	<i>Estimate</i> (s.e.)	<i>t</i>	<i>Estimate</i> (s.e.)	<i>t</i>
Centrality (Closeness)	0.08** (.03)	2.91	—	—	0.09** (0.03)	3.15
Centrality (In-Degree)	—	—	-0.05 (0.04)	-1.39	-0.06 (0.04)	-1.70
Constant	-0.04* (.02)	-2.13	-0.04 (.02)	-1.88	-0.03 (0.02)	-1.84
<i>N</i>	414	—	407	—	407	—
<i>F</i>	8.48**	—	1.93	—	5.94**	—

Note: Table 4 displays the student fixed effects models predicting students' oral language comprehension scores. The models present estimates in standard deviation units. Student fixed effects are absorbed in the models. Robust standard errors clustered at the classroom level are in parentheses.

\* $p < .05$

\*\* $p < .01$

\*\*\* $p < .001$

### **In-Degree Centrality**

The student fixed effect model also measured student centrality using in-degree. As demonstrated in Table 4, centrality in the in-degree-only model (using in-degree proportion) was not a significant predictor of oral comprehension ( $\beta = -0.05, p = .17$ ). This relation was also demonstrated in the full model: a 1-SD increase in in-degree proportion was not a significant predictor of oral comprehension, after controlling for closeness ( $\beta = -0.06, p = .09$ ). These estimates were not statistically significant. Overall, in-degree centrality did not significantly predict students' semester-over-semester changes in oral comprehension.

Implications for these models, and for the differences in the findings of the two measures of centrality, are discussed in the next section.

## Discussion

Research has demonstrated that peer relationships are both associated with and lead to improvements in a variety of outcomes that are associated with success in school; however, developing connections among children is largely considered a secondary goal in schools in comparison with improving academic outcomes. Being well-connected with peers can improve students' sense of belonging in the classroom, which is associated with putting more effort into schoolwork (Goodenow, 1993) and even increased academic success (Roeser, Midgley, & Urdan, 1996). Students' classroom and school peers, broadly defined as those students who share a teacher or who attend the same school, can predict student achievement (Gottfried, 2014; Hanushek, Kain, Markman, & Rivkin, 2003; Rapaso & Goncalves, 2020). However, homing in on the specific peers who students identify as friends can provide more relevant information about the extent to which teachers and schools can leverage student friendship networks to develop academic achievement. This study incorporated students' friendship nominations to develop classroom friendship networks and determine the extent to which students' friendship network centrality is associated with academic growth, in order to provide specific evidence that peer relationships are significant predictors of achievement. Because of the importance of language comprehension to all school content areas, I used language achievement as an outcome variable to explore whether social network analyses could link student centrality to achievement growth.

Language comprehension—whether for written or oral language—is crucial for academic success, and this paper provides support that it is intricately connected to students' peer relationships. Students' ability to process and understand language provides the foundation for many fundamental skills (Einarsdóttir et al., 2016). Oral language skills, in particular, can be important predictors of later reading outcomes (Catts et al., 2001; Hulme & Snowling, 2009). Additionally, oral language skills can be as effective as written reading comprehension tests in determining student performance on high-stakes tests (Whitley, 2019). Given the importance of language comprehension to high-stakes testing,



districts are in constant need of strategies to strengthen students' achievement. Those strategies become more worthwhile for budget-constrained districts when they are both inexpensive and effective. This study examines one potential mechanism—student friendship networks—which are empirically connected with academic achievement growth in the student fixed effects models.

Students' friends may supplement student academic growth, particularly for oral comprehension. When elementary students were more connected to their classroom network, they were more likely to have increased oral comprehension test scores, above and beyond growth explained by their reading comprehension, letter-word decoding, and vocabulary understanding. While the effect size of this increase was small—a 1-standard deviation increase in centrality was associated with a 0.09 standard deviation increase in oral language comprehension—this finding suggests the importance that friends can have on students' language development, which positively impacts academic growth. Based merely on friendship connectedness, a student at the median of oral language comprehension but 1-SD above the mean in terms of network centrality could be expected to perform at the 54<sup>th</sup> percentile after a semester. These estimated effect sizes are moderate in comparison with other education interventions (see Kraft, 2020), and the estimated effect size is aligned with other peer effect studies that find small to moderate effect sizes of peers on academics (e.g., Angrist & Lang, 2004; Cooc & Kim, 2016; Lefgren, 2004). However, the estimated effect size in this study is smaller than other larger detected effect sizes using longitudinal data (e.g., Hanushek et al., 2001; Henderson et al., 1978; Hoxby, 2000). Paired with other instructional supports, such as high-quality teachers, effective curriculum, and other school supports, highly connected children could experience increased reading achievement over time.

This growth works in conjunction with academic growth students experience in schools as a result of instruction. Understanding how teachers can strengthen students' friendship networks is outside of the scope of this study, but there are interventions to

increase student connections in the classroom (e.g., Cranley Gallagher, 2013; Krone & Yu, 2019), and these interventions could provide a relatively inexpensive approach with many positive effects that more dense friendship networks have on students, including increased engagement (Liem & Martin, 2011), self-efficacy (Graber et al., 2016), happiness / well-being (Troop-Gordon et al., 2019), and self-esteem (Antonopoulou et al., 2019), as well as academic growth.

There were discrepancies in the results of the two series of student fixed effects models. Specifically, students had significant increases in oral comprehension when they had increased network closeness, yet in-degree did not significantly predict growth in oral comprehension. The component that separates the two measures is one's out-degree, or the number of friends that a student claims to have in their network. Because in-degree is not a significant predictor of academic growth and given that in-degree and closeness are only weakly correlated in this dataset, it appears that the difference in the two models is largely being driven by one's out-degree. Thus, students who are nominating more friends have greater closeness measures, and those are the students who are experiencing larger academic gains. In that sense, closeness may be a proxy for students' beliefs of connectedness with their peers, as well as how supported and comfortable students feel in their homerooms. Future research should explore differences in belonging, motivation, and engagement for students who have different levels of out-degree, particularly when there are differences in the extent to which friendship nominations are reciprocated by their peers.

Additionally, future research can continue to explore the mechanisms explaining why friendship matters for both academic achievement and oral language comprehension, but prior theoretical and empirical work offer preliminary hypotheses. Students who are more central in their classroom friendship networks are the most likely to feel a sense of belonging at school (Osterman, 2000). This sense of belonging is particularly relevant for students who are nominating many students as friends, as they are demonstrating beliefs

that they are connected with peers. Additionally, having friends can provide a protective buffer against negative academic consequences, such as school dropout (Wentzel et al., 2018), or against internalizing (Burgess et al., 2006) or externalizing behaviors (Bowker & Spencer, 2010). Longitudinal studies can untangle which constructs are at play as students experience changes in their social connectedness, as well as changes in academic achievement. Further, classroom-level connectedness may be an important factor—for example, do classrooms with a well-connected network of students and few (or no) students on the periphery experience greater academic achievement gains, on average, than classes with greater variability in connectedness? Future research can explore these differences in classroom networks and their associated differences in outcomes.

These results provide promising evidence that friendships have important predictive power for language growth and academic achievement, but there are some limitations to this study. The student population is not representative of the general US public school population; English Learners were heavily oversampled in the study. Because peers are theorized to be a major resource for the academic and social development of ELs (see Bukowski, Laursen, & Rubin, 2018), it is possible that the same pattern may not be observed in students who are English Monolinguals (EM) in US schools. Additionally, these findings should not be interpreted as friendship networks having causal impact on language growth. While fixed effects models control for time-invariant predictors, and the panel data allow students to serve as their own comparisons, there are other changing factors that could explain the observed increases in oral language comprehension, such as student self-efficacy or students' connectedness with family members. As social network analyses continue to develop, more rigorous causal frameworks can test the causal nature of friends on academic achievement.

Furthermore, friendship quality was not measured in this study, and the quality of relationships is important in explaining one's sense of belonging. For example, friendship quality is correlated with students having increased self-worth (Hiatt, Laursen, Mooney, &

Rubin, 2015), and friendship quality is also predictive of students having fewer internalizing problems (Rubin et al., 2004). Because not all friendships are equal in quality (e.g., Bagwell & Bukowski, 2018), future studies should incorporate quality when comparing students' connectedness over time, using measures such as Bukowski, Hoza, and Boivin's (1994) Friendship Qualities Scales.

Last, it is important to note that children's social networks are not limited to their homeroom classrooms. While elementary students spend a majority of their school time engaging with peers in their classrooms, students' networks consist of children from across classes, grades, and even schools. This study used classroom rosters to define social networks, but children may have more support from individuals outside of these classes. It is possible that their sense of belonging and self-worth may be driven by those connections in addition to the friendships formed within a classroom.

These results are exploratory, and future work should continue to investigate the explanatory power that friends and peer effects can have on academic achievement. However, the significant results provide preliminary evidence that friends *are* an important resource that schools can utilize to leverage student growth. I do not suggest that effective teachers, evidence-based curriculum, or supportive learning environments are unimportant in the American education system for student growth; however, peers have been overlooked as a pillar that can support increases in academic achievement. Fostering a sense of community and developing friendship connections among children, particularly in elementary school classrooms in which students spend most of the school day with the same group of children, can support student growth—developmentally and socially, but also academically.

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## Appendices

### Appendix 1

*Table comparing full Project Learn sample (in spring 2018) to analytic sample*

	Full Sample, Spring 2018	Analytic Sample	P-value
Grade, SY 2017-2018	24.3%	24.6%	.520
Second	23.3%	26.3%	
Third	29.2%	25.6%	
Fourth	23.3%	23.4%	
Fifth			
Age, Fall 2017	9.23 (1.17)	9.20 (1.17)	.668
Gender			With missing: < .001  Without missing: .454
Male	47.2%	52.9%	
Female	43.8%	44.7%	
Missing	9.0%	2.4%	
Ethnicity			With missing: < .001  Without missing: .008
Hispanic	60.8%	73.7%	
Black / African	23.5%	21.3%	
American	2.8%	0.7%	
White	1.6%	0.5%	
Asian	0.1%	0.2%	
Native			
Hawaiian /			
Pacific	2.2%	1.2%	
Islander	9.0%	2.4%	
Multi-Racial			
Missing			
SES, Fall 2017			With missing: < .001  Without missing: .005
Eligible for	76.9%	87.0%	
Free or			
Reduced-Price	14.1%	9.2%	
Lunch	9.0%	3.9%	
Not eligible			Without missing: < .001
Missing			
English Learner, either SY 17-18 or SY 18-19	54.5%	70.5%	
Yes	36.5%	29.2%	
No	9.0%	0.2%	Without missing: < .001
Missing			

Student has IEP, either SY 17-18 or SY 18-19	3.9%	5.3%	With missing: < .001
Yes	87.1%	92.0%	
No	9.0%	2.7%	Without missing: .387
Missing			

Note: Chi-square tests of homogeneity were conducted for each set of categorical variables to test whether the analytic sample varies from the full sample. For the continuous variable, age, a two-sample t-test for independent means compared the two groups. For the categorical variables, 9.0% of the students did not have demographic data due to students being absent when individual testing was conducted, or from missing district-level data. Statistical testing was conducted using 'missing' as a category; however, since these students would not be incorporated in any models (due to missing other variables), the statistical test that excluded missing values gives a better representation of the difference between the full and analytic samples.

## Appendix 2

*Student Fixed Effects Model with Reading Covariates using Closeness Centrality*

	Model with Covariates		Model with Covariates (Standardized)	
	<i>Estimate</i> ( <i>s.e.</i> )	<i>t</i>	<i>Estimate in SD</i> ( <i>s.e.</i> )	<i>t</i>
Centrality (Closeness)	30.41** (10.78)	2.82	0.07** (.03)	2.82
Reading Comprehension	-0.00 (.01)	-0.24	-.00 (.02)	-0.24
Vocabulary	0.13* (.06)	2.29	0.13* (.05)	2.29
Letter-Word Decoding	0.16*** (.03)	5.99	0.42*** (.07)	5.99
Constant	4.18** (1.54)	2.72	.03 (.02)	1.46
<i>N</i>	414	—	414	—
<i>F</i>	16.72***	—	17.78***	—

Note: Appendix 2 displays the student fixed effects models predicting students' oral language comprehension scores, utilizing closeness centrality and reading covariates. The full standardized version presents estimates in standard deviation units. Student fixed effects are absorbed in the models. Robust standard errors clustered at the classroom level are in parentheses.

\* $p < .05$

\*\* $p < .01$

\*\*\* $p < .001$



## Appendix 3

*Student Fixed Effects Model with Reading Covariates using In-degree Centrality*

	Model with Covariates		Model with Covariates (Standardized)	
	<i>Estimate (s.e.)</i>	<i>t</i>	<i>Estimate in SD (s.e.)</i>	<i>t</i>
Centrality (In-degree)	-0.79 (1.06)	-0.75	-0.03 (.03)	-0.75
Reading Comprehension	-0.00 (.01)	-0.37	-0.01 (.02)	-0.37
Vocabulary	0.16** (.06)	2.67	0.15** (.06)	2.67
Letter-Word Decoding	0.16*** (.03)	5.75	0.43*** (.08)	5.75
Constant	4.06* (1.68)	2.42	0.03 (.02)	1.62
<i>N</i>	407	—	407	—
<i>F</i>	14.90***	—	14.90***	—

Note: Appendix 3 displays the student fixed effects models predicting students' oral language comprehension scores, utilizing in-degree and reading covariates. The full standardized version presents estimates in standard deviation units. Student fixed effects are absorbed in the models. Robust standard errors clustered at the classroom level are in parentheses.

\* $p < .05$

\*\* $p < .01$

\*\*\* $p < .001$

## Appendix 4

*Student Fixed Effects Model with Reading Covariates using Closeness and In-Degree Centrality*

	Full Model with Covariates (Standardized)	
	<i>Estimate</i> ( <i>s.e.</i> )	<i>t</i>
Centrality (Closeness)	0.09** (0.03)	3.29
Centrality (In-Degree)	−0.04 (0.03)	−1.19
Reading Comprehension	−0.01 (0.02)	−0.52
Vocabulary	0.14* (0.06)	2.30
Letter-Word Decoding	0.47*** (0.08)	6.14
Constant	0.04 (0.02)	1.62
<i>N</i>	406	—
<i>F</i>	15.14***	—

Note: Appendix 4 displays the student fixed effects models predicting students' oral language comprehension scores, utilizing closeness centrality, in-degree, and reading covariates. The full standardized version presents estimates in standard deviation units. Student fixed effects are absorbed in the model. Robust standard errors clustered at the classroom level are in parentheses.

\* $p < .05$

\*\* $p < .01$

\*\*\* $p < .001$

## **Paper 2**

### **The Differential Relation between Friendship Centrality and Reading Outcomes for English Learners**

Longstanding lines of research highlight gaps in academic outcomes between English Learners (ELs) and English Monolinguals (EMs). As such, considerable attention has been paid to interventions that may close these gaps (e.g., Cardoza & Brown, 2020; Carlo et al., 2008). Among other resources, leveraging peers is hypothesized to be an important way to improve ELs' social and academic skill development and close achievement gaps (Chen, Lee, & Chen, 2018; Graham & Echols, 2018), due in part to the large role that peer socialization plays in ELs' English language development and overall well-being. The interaction among language status, culture, and/or race and ethnicity may leave ELs particularly susceptible to exclusion or even victimization (e.g., Nansel et al., 2001).

Research has begun to identify whether social relationships can specifically benefit ELs' learning. For example, within their classroom networks, ELs with a higher proportion of non-EL friends<sup>5</sup> are more likely to experience year-over-year growth in English Language Arts standardized tests (Elreda et al., 2016). While there is preliminary support that friendships matter for ELs' academic achievement, research exploring peer relationships in US public schools for ELs, as well as various ethnic and racial groups, is relatively underexplored (Graham & Echols, 2018). Further, research is necessary to understand the predictive value of classroom social networks on achievement for ELs, and whether and how teachers can leverage social relationships to support student learning. This research can

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<sup>5</sup> As in Paper 1, "friends" refers to reciprocated relationships between two individuals, characterized by trust, caring, and respect (i.e., Bagwell & Bukowski, 2018; Laursen & Hartup, 2002). "Peers" are others who are in the same classroom, grade, or school, regardless of whether each pair of individuals considers themselves friends (see Kindermann & Gest, 2018). While friends are reciprocated relationships, one individual can perceive another is a friend, and in the mind of that individual, the friendship exists. Because of the egocentric (i.e., student-driven) measures used to capture friendships, these perceived friendships are still part of the underlying friendship network because the perceived tie affects the structure of the network. If all friendship ties were mapped among a classroom of students, this would form the friendship social network among all peers in the class. Those children who are most connected to their peers in this friendship network would be considered the most 'central,' and would therefore have the greatest centrality within the network.

provide evidence of the extent to which connecting to peers may be particularly important for ELs' academic outcomes.

To examine the connection between students' social networks and academic growth, and whether that relation is connected to student language status, this study explores the following research questions:

- To what extent does classroom friendship centrality predict reading achievement gains for English Learners?
- To what extent does the relationship between classroom friendship centrality and reading achievement gains differ between English Learners and English Monolinguals?

To answer these questions, I use a statistical modeling technique, known as social network analyses, which allows researchers to determine the extent to which people within a social network are important, or central, to the network overall. Data come from five elementary schools in the Mideastern United States. These schools have high proportions of English Learners (the students are primarily Latinx and are first- through third-generation immigrants). Students were in 2<sup>nd</sup>- through 5<sup>th</sup>-grade when data collection began, and data were collected over the course of three academic semesters. Students were asked at each time point to name their best friends in their classroom, and these data were analyzed using social network analyses in conjunction with longitudinal reading data.

The following section details what is known about ELs, peer relationships, friendships, and their connections to language development.

## **Literature Review**

### **Why Peers and Friends Matter for Learning**

The relation between peer relationships in the classroom and learning is multifaceted. Social interactions affect the ways children think about themselves and their belonging within the classroom environment. The dynamic and complex social interactions

may result in children becoming either isolated or rejected by their peers, and in turn, at increased risk of internalizing behaviors such as depression (Lereya et al., 2015). These children are also more likely to display aggressive behaviors (Ladd & Troop-Gordon, 2003) and to be impulsive or inattentive in school (Snyder et al., 2004). In contrast, those children who have strong relationships with their peers, including those who are “central” (i.e. well connected with many other children) in their social network, may be protected against the negative outcomes associated with being isolated or rejected (Bowker et al., 2006).

Children with friends in their classroom environments may display behaviors and develop motivations that are associated with academic success. Having friends in general is associated with increased motivation and self-efficacy (Bagci, 2018; Nelson & DeBacker, 2008), both of which are contributing factors to academic achievement (Niehaus et al., 2012; Usher et al., 2019). Further, having strong friend groups is associated with students exploring academic concepts more deeply in the classroom and having a greater understanding of the content (Hartl et al., 2015).

Popular or well-liked children may affect classroom norms in ways that can strengthen or inhibit learning. Children are more likely to assume the behaviors of these well-liked or popular children (Cillessen & Rose, 2005; Rambaran et al., 2017), particularly when these well-liked or popular children share common identity markers with themselves, such as race, gender, language status, or other factors (Harris, 2010). As a result, the behaviors of those children may be influential in establishing a classroom environment that sustains learning and inquiry. Peer effects have empirical support, both for developmental and academic outcomes (Bukowski et al., 2018; Harris, 2010), and researchers have used large-scale datasets to connect peers with increases in both mathematics and reading test scores (Gottfried, 2014; Hanushek et al., 2003).

In addition to factors related to popularity or likeability, learning is associated with children’s access to resources. Specifically, children are more likely to succeed academically

when resources are available to help them achieve, and friendships afford children the opportunity to access resources. When they form friendships, children build the capacity to increase their social capital, or the potential resources that an individual can access through their social connections, such as knowledge, physical capital, or other forms of support (Bourdieu, 1986), since their friends may have access to resources or other individuals. Indeed, states with increased social capital (as measured by civic engagement) have been linked to improved student outcomes, due in part to the social capital opportunities afforded to residents (Braatz & Putnam, 1996). Similarly, schools with increased parental involvement are associated with increased academic achievement, even after controlling for school socioeconomic status (Park et al., 2017). Friendships allow children to expand the resources available to them, including human capital available through friends' families. These connections may provide children with greater social or academic support, which can translate into increased opportunities to learn.

### **Classroom Social Networks and English Learners**

While friends are important for all children, research and theory suggest they may be particularly important for English Learners. Because some ELs may not speak English outside of the school setting, school is an important location for these children to develop their oral English skills. Furthermore, English oral language abilities are an important predictor of reading achievement and comprehension (Babayigit et al., 2020; Silverman et al., 2020). Students' interactions with their peers thus provide opportunities for language development (Kory-Westlund & Breazeal, 2019; Swain et al., 2002).

Knowledge about ELs' friends may provide information about ELs' English language development and, ultimately, ELs' abilities to perform well on English language tests. Empirical evidence has demonstrated that interacting with English Monolinguals has more predictive power for ELs' English oral language proficiency than other variables associated with verbal skill development, such as time spent in the US and maternal education (Carhill-

Poza, 2015). Additionally, ELs who report a greater proportion of their friends are non-ELs were more likely than other ELs to demonstrate gains in middle school standardized tests (Elreda et al., 2016), potentially due to more opportunities to practice the language as well as the increased sense of belonging in the school. For Latinx students in particular, who represent a plurality of ELs in US public schools (NCES, 2020), feelings of belonging at school were directly related to the strength of their friendships (Delgado et al., 2016). In other words, Latinx students who believed they had stronger friendships also had heightened perceptions of feeling they belong in their school community, which is associated with academic success (Allen & Bowles, 2012; Juvonen, 2006). Friendships thus are associated with many developmental predictors for academic outcomes.

Research supports the benefits of ELs having both similar and dissimilar friends, including other students who are also learning the English language, and other students of the same ethnic/racial groups. Among marginalized groups including ELs and immigrant students, students with stronger friendships—both same-race and inter-race—are less likely to drop out of school than other student groups (Delgado et al., 2016). Immigrant children with greater propensity to build social capital, acquired through building connections with any of their peers, are more likely to succeed academically, regardless of whether their friends are also immigrants (Ryabov, 2009). Ultimately, building relationships among peers can provide them with greater likelihood to succeed on a variety of outcomes, including academics.

### **Learning and Policy Considerations and English Learners**

There are also unique policy concerns that differentially impact English Learners in US schools. ELs are responsible for learning the same content as their grade-level peers, but learning presents an increased challenge given that ELs must navigate the new content, usually presented in English, while also learning the English language. While statewide “English-only” education policies currently only exist in Arizona (Jacobson, 2020), ELs are



often denied supplemental support that might come in the form of instruction or resources in their native language, even though native language literacy as well as access to content delivered in students' native language are associated with higher student achievement (García-Vazquez et al., 1997; Ramirez et al., 1991; Thomas & Collier, 2003).

Additionally, structural components may present ELs with challenges in the schools. Districts and schools with high proportions of ELs are more likely to have relatively inexperienced teachers (Dabach, 2015), often who do not have specific training on how to tailor instruction to ELs. While some states with high-EL populations, such as California, have recently mandated that teachers receive training during their preparation programs on supporting ELs, these policies can have unintended consequences in relegating ELs to only new teachers (Dabach, 2015). States with newer waves of immigrant populations, such as North Carolina, do not have similar statewide policies aimed at supporting ELs, leaving teachers in these states feeling unprepared to meet ELs' specific learning needs (O'Neal et al., 2008). Moreover, even among teachers with specialized degrees or certificates, there is still a pervasive perception among teachers that they are unprepared to guarantee success for ELs (Gándara et al., 2005). ELs are less likely to graduate than other students, due in part to state graduation requirements mandating students pass high-stakes assessments (Center on Education Policy, 2006). Districts with high-EL populations—both urban and rural—are more likely to report having insufficient materials or even school facilities necessary to teach students (Gándara & Maxwell-Jolly, 2006). Given these challenges, much work remains to be done to determine ways to support ELs—academically and socially.

### **Hypotheses and Directions for Research**

While the extant literature provides insight into how peers can serve as an important resource for ELs' social and academic development, there are several gaps. Like the broader peer effects literature, existing research connecting ELs' peers to test scores tends to use administrative datasets that, by the nature of the available data, make assumptions about

who one's peers are. For example, researchers have focused on the percentage of same-race peers, or percentage of students who passed previous standardized tests, and linked these measures to students' own academic achievement (e.g., Angrist & Lang, 2004; Gottfried, 2014; Hanushek, Kain, Markman, & Rivkin, 2003). Those studies contribute important findings to the broad peer effects literature, by measuring the impact of class- or grade-level average characteristics on student achievement, but they do not incorporate data about which students actually are interacting with and influencing each other regularly, which can be measured using student-level friendship or relationship data within classrooms or grades. An alternative approach proposed by some (and used in this study) is to use student-created "social networks," which are thought to provide more valid representations of the underlying classroom networks (e.g., Carolan, 2014). A second limitation of the current literature base is that these sorts of rich social networks rarely are connected to educational outcomes. Research in this arena is sparse in general, and the narrower literature exploring links between ELs' peers and their outcomes is understudied in comparison to other student subgroups (Bellmore, Nishina, & Graham, 2011; Flores-Gonzalez, 2005; Graham & Echols, 2018).

At present, Elreda et al. (2016) is the only study that uses social network analyses to predict academic outcomes for ELs, yet the study only includes as a predictor variable the percentage of one's nominated friends who are non-ELs. While that study explores whether ELs with higher percentages of English Monolingual friends are more likely to improve their own English language skills, its findings beg the question of whether overall student centrality and acceptance—rather than just acceptance by EMs—can similarly improve outcomes for ELs. In other words, are ELs who are well connected within their classroom networks still likely to improve language outcomes, even if their connections are primarily with other ELs? Even though theoretical research on children in general links student acceptance (one component of student social networks) and school belonging with academic progress (e.g., Allen, Kern, Vella-Brodrick, Hattie, & Waters, 2018; Kindermann, 2007;

Kindermann, 2016), few studies have examined the explicit connection among these constructs for ELs. More research is necessary to investigate whether peer relationships factor significantly into ELs' academic outcomes.

Prior literature offers a hypothesized theory of action explaining why friendships may affect ELs' academic outcomes. As discussed in Paper 1, there are many reasons why friendships matter for academic outcomes for children in general, including developing one's sense of belonging (e.g., Dotterer, McHale, & Crouter, 2007; Goodenow, 1993; Roeser, Midgley, & Urdan, 1996), one's ability to interact with and learn the content (Hartl et al., 2015), and one's oral language skills through increased opportunities to socialize with others. Beyond these reasons, however, ELs are particularly likely to benefit from having friends in the classroom, primarily because many ELs only interact in English when in the classroom or with their friends. As a result, peer and friend interactions develop ELs' oral language comprehension (Kory-Westlund & Breazeal, 2019; Swain et al., 2002). Having increased opportunities to interact with peers is associated with greater English language growth (Carhill-Poza, 2015), so it stands to reason that those students with greater connections with peers will demonstrate increased development. Given the increased predictive ability of friendships to protect against dropping out of school later in their career (Delgado et al., 2016), it seems likely that having friends within the earlier grades may particularly offer a propensity for ELs to succeed and develop their language skills.

In sum, I hypothesize that the effect size of being well-connected within the classroom friendship network will be even greater for ELs than within the general student population. Those students who are most connected (i.e., those with greater friendship network centrality) will experience the benefits of greater self-worth, increased feelings of belonging, greater access to social capital, and more opportunities to practice the English language, all of which will translate into greater oral language development and, ultimately, greater reading comprehension development. For these reasons, the hypothesized

estimated effect of friendship centrality for ELs will be larger than the estimated effect of friendship centrality in the general elementary student population.

### **Methods**

This study is part of a larger longitudinal study examining elementary-aged English Learners' and English Speakers' reading development. The full project took place from Fall 2016 to Spring 2019. The present study encompasses data collected from Spring 2018 through the end of the project. In Spring 2018, participants were 2<sup>nd</sup>-through 5<sup>th</sup>-grade students from five public elementary schools. The full sample of students who participated in the whole-class assessments in Spring 2018 included 765 students. To be included in the present study, students had to have social network data in the full semester of the project (Spring 2019). The final sample consisted of 232 students. (See Table 1 for a comparison between the full analytic sample and the ELs-only sample used for Models 1 and 2.)

Students were assessed twice per semester—once was an individual assessment and once was in a whole-class setting. For individual assessments, a Research Assistant (RA) led the child to a quiet spot in the school for a one-hour assessment battery, consisting of thirteen short standardized assessments each semester. For whole-class assessments, one or two RAs administered three whole-class assessments to the students participating in the study within their classrooms. Any students not participating were allowed to read or meet with their teacher during that one-hour block. For both the individual and whole-class assessments, RAs were trained each semester on administering and scoring the assessments. RAs were required to pass semesterly fidelity checks with the study authors.

The outcome variables (i.e., oral language comprehension, reading comprehension) were administered as part of the individual assessment battery, and the independent variable of interest (i.e., student network centrality) was assessed as part of the whole-class assessment. Students' English language status and their gender were part of an administrative dataset collected by the school district.

## **Participants**

Five public schools in the mid-Atlantic US were part of the larger study and comprised the current sample. These schools had higher-than-average proportions of ELs compared to the overall state population, which allowed for greater statistical power to examine the reading and cognitive development of ELs over time. Parents or legal guardians of students provided annual informed consent for their child to participate in the study; students who did not receive informed consent across both years of the present study were removed from the sample. This study was approved by the university institutional review board, and participants were treated in accordance with the ethical principles of the American Psychological Association.

Students in this analytic sample were evenly distributed across grades 3 through 5 in the spring of 2019, with an average age of 9.7 years. A slightly greater number of participants were male (50.9%) than female (47.8%), although gender data were missing for some students (1.3%). Most of the students were Hispanic (78.5%) or Black (17.8%). Most students were eligible for free or reduced-price lunch in either year of the study (88.4%), and most students were identified by the school district as English Learners in either year of the study (73.3%). Table 1 provides complete descriptive data on the full sample of students in the present study, including the subsamples that were limited to only ELs.

Table 1  
*Descriptive statistics for the sample*

Variable	ELs-only sample		Full analytic sample	
	<i>n</i>	<i>M (SD) or %</i>	<i>n</i>	<i>M (SD) or %</i>
Grade, SY 2018-2019				
Third	60	35.3%	77	33.2%
Fourth	60	35.3%	76	32.8%
Fifth	50	29.4%	79	34.1%
Age, Fall 2019	167	9.65 (0.90)	229	9.7 (0.89)
Gender				
Male	88	51.8%	118	50.9%
Female	82	48.2%	111	47.8%
Missing	0	0.0%	3	1.3%
Ethnicity				
Hispanic	170	100.0%	182	78.5%
Black / African American	0	0.0%	41	17.8%
White	0	0.0%	4	1.7%
Asian	0	0.0%	2	0.9%
Missing	0	0.0%	3	1.3%
SES, Fall 2017				
Eligible for Free or Reduced-Price Lunch	161	94.7%	205	88.4%
Not eligible	9	5.3%	24	10.3%
Missing	0	0.0%	3	1.3%
English Learner, either SY 17-18 or SY 18-19				
Yes	170	100.0%	170	73.3%
No	0	0.0%	62	26.7%
Student has IEP, either SY 17-18 or SY 18-19				
Yes	13	7.6%	16	6.9%
No	157	92.4%	216	93.1%

## Measures

Social Network Analysis (SNA) is a statistical procedure used to quantify the underlying social networks of contained groups (Carolan, 2014; Daly, 2010). Researchers analyze a closed group of individuals and the social ties among them in order to reproduce a visual image of the network and analyze the network using various quantitative methods (Carolan, 2014). While SNA is becoming more common across research fields, it is currently underutilized in education research (Daly, 2010). Network information can be used in

conjunction with peer effects models to give researchers a better understanding of the social processes taking place within classrooms or schools. Furthermore, these social relationships can be used to leverage student outcomes in educational systems. Therefore, understanding social network analyses may lead to improved educational outcomes for students when policy is informed by this research (Daly, 2010).

Social network models allow researchers to gain a broader perspective of how one's social environment can shape one's own attributes and outcomes. Incorporating social network information into statistical models can develop a greater understanding of the structure of a network and one's own position within that social group (Burk et al., 2007). Creating social network models allows researchers to predict how relationships might change or evolve over time, as well as how other actors may influence one's actions or character traits (Burk et al., 2007).

**Friendship Centrality.** The primary independent variable for the present study was a student's friendship centrality, which aims to classify how important each actor, or child, is to the network as a whole (Carolan, 2014). While there are many ways to define centrality, this study utilizes closeness. Following other researchers who also asked students to identify their closest friends (i.e., Cruz et al., 2012; Elreda et al., 2016; Li & Stone, 2018), I use the term "friendship network" throughout this study to refer to the underlying social network connecting peers via their indicated friendships. While not all indicated relationships are reciprocated, these friendship networks contain both the actualized and perceived friendships among the classroom peers.

Carolan (2014) defines centrality as a function of the average distance between a particular node and all of the other nodes in the network. Thus:

$$Centrality_i = \sum \frac{1}{d(N_i, N_j)}$$

where  $d$  is the distance between Node  $i$  and every other Node  $j$  in the model (Carolan, 2014). This particular measurement of centrality is referred to as 'closeness,' and a node that is more central within the network has higher closeness than other nodes.

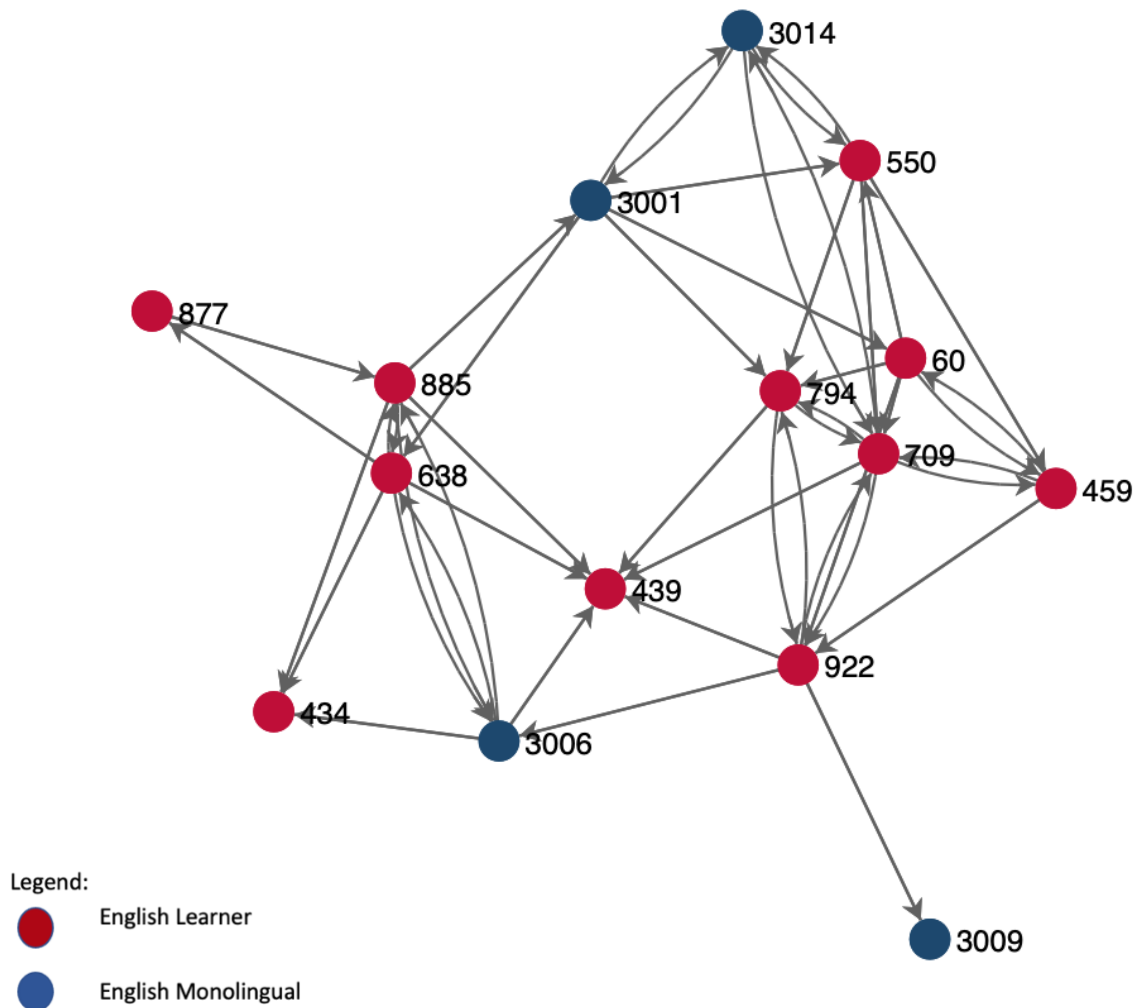
In the whole-class assessment, students were provided with a complete roster from their homeroom class. The assessor asked, "Who are your best friends in your class? Circle up to five friends." Students were reminded that they could circle zero, one, two, three, four, or five friends from their class. They were instructed not to circle themselves. Children were constrained by which other children were on their class roster. Because the longitudinal study used purposive sampling aimed at ensuring a large proportion of ELs in the sample, most children were interacting with and therefore nominating ELs. The large proportion of ELs in the sample affects generalizability, as discussed in the Limitations section.

Based on students' responses, directed social networks were created for each classroom at each of the three time points. Using the *igraph* R package (version 1.2.4.2), sociograms mapped students' social position on a latent space. Students who were more connected to their classroom networks based on the friendship nominations they indicated and received are positioned towards the center of the sociogram, and their less-connected peers appear on the periphery. Centrality scores were created using the full sample of students utilized in Paper 1, regardless of whether the students remained in the analytic sample used in this paper. Keeping these calculations from Paper 1 ensured that social networks were created using the full group of peers in the classroom. See Figure 1 for a sample sociogram displaying one of the social networks from one of the classrooms.



Figure 1

*Class sociogram demonstrating friendship network for a sample class, shaded by EL status*



Note: Figure 1 displays a sociogram that maps friendship nominations among students in a particular classroom at Time 1. Each student is represented by a node, with numbers indicating the student ID. Students closer to the center of the network, such as student 794, have increased friendship centrality scores because they are more connected to their classroom peers. Student 3009, who was only nominated by one peer as a friend (and who nominated no friends of their own), would have the smallest friendship centrality score from among this classroom network. The sociogram was created using the *nwcommands* Stata package (Gorund, 2015). Nodes are shaded according to whether the student was identified as an English Learner or an English Monolingual.

Students' centrality at each time point was calculated using Carolan's (2014) operationalization of closeness. Students who were more central to their class had higher scores than their less-connected peers. Because the social network was focused on friendships within the classroom, the primary independent variable is referred to as friendship centrality, or friendship closeness, throughout this study.

**Oral language comprehension.** Students' oral language comprehension was assessed using the Woodcock-Johnson-IV Tests of Achievement (WJ-IV; Schrank et al., 2014) Oral Comprehension subtest during individual assessment sessions. This test provides students with short, orally presented passages, and students must complete the passages using an appropriate word or phrase (e.g., "Without a doubt, his novels are more complex than the novels of many contemporary \_\_\_\_\_.\" A correct response would be *authors*.). Students' scores are the correct number of items out of 33. The Woodcock-Johnson IV tests have been widely used in education research, and analyses of other datasets show strong reliability indices. Split-half reliability coefficients on the oral language comprehension score for children ages 6-10 range from 0.78 to 0.83 (McGrew et al., 2014).

**Reading comprehension.** The individually administered WJ-IV Passage Comprehension subtest (Schrank et al., 2014) measured reading comprehension. This subtest consists of three item types: identifying which rebus (picture symbol) matches an actual picture, identifying a picture that corresponds to 1-3 words, and silently reading short passages and completing blanks in the passages with appropriate words. Students' scores are the correct number of items out of 52. In other datasets, split-half reliability coefficients for children ages 6-10 range from 0.89 to 0.98 (McGrew et al., 2014).

**Demographic variables.** Students' English Language status was determined by the school district through the WIDA assessment. Students who did not score above a particular threshold, determined by grade level, were identified by the district as an EL and were eligible for English as a Second Language support. For the present study, students were labeled as English Learners if they were classified as an EL during either of the two years

from which data were used for this study. The school district also indicated students' gender through the administrative dataset. The gender values were indicated by parents when students enrolled the student in the district, unless the district updated any gender identities by parent or student request.

Table 2  
*Descriptive statistics for the study variables*

<i>Variable</i>	<i>M</i>	<i>SD</i>	<i>Min</i>	<i>Max</i>	<i>N</i>
Friendship centrality (Closeness)	0.02	0.01	0.003	0.053	232
Oral language comprehension (Time 6)	15.9	4.3	4	27	224
Oral language comprehension (Time 5)	15.4	4.2	3	28	232
Reading comprehension (Time 6)	27.0	5.6	10	39	232
Reading comprehension (Time 5)	25.4	5.2	9	39	232
Centrality * EL Status Interaction	0.01	.01	0	.053	232

Note: Table 2 displays the sample mean (M) and standard deviation (SD) for each of the variables in the model. The units for all of the reading measures are the number of questions correct on the WJ-IV. This table does not include gender or EL status, which were included in Table 1.

## **Data Analysis**

Linear regression models were run to explore the various research questions. Each model uses a reading achievement outcome measured in Spring 2019. The primary independent variable for the models is student friendship centrality, measured using closeness during the same semester as the achievement outcome measure. Additionally, Models 3 and 4 include an interaction term between student friendship centrality and English language status; this interaction term indicates the extent to which there is a differential predictive value of friendship closeness for ELs versus EMs. All estimated coefficients indicate the predicted increase in reading comprehension (oral or written) that is associated with a 1-unit change in the independent variables, after controlling for the other variables in the model. The models control for the students' Fall 2018 score on the same achievement measure as the model outcome variable, a dummy-coded variable for whether

a student is female, and students' English language status (for Models 3 and 4). Controlling for prior achievement allows the model to account for student-level variables that might otherwise introduce bias into the coefficients. For example, by controlling for initial reading achievement, the models will account for student factors that are associated with individual achievement, such as motivation, socioeconomic status, parent education level, etc., allowing the equation to model student growth (see Ballou, Sanders, and Wright, 2004).

The students were nested in 26 classrooms; the robust error terms for the models are clustered by class to account for class-level dependencies. All non-demographic variables were standardized by subtracting the grand mean (i.e., all students for whom data were collected) and dividing by the overall standard deviation. Standardization allows for comparisons across variables, as well as for ease of interpretation. The table below displays the variables used in each model, as well as the research questions that guide the models. The fitted regression equations follow Table 3.

Table 3  
*Research questions associated with each model*

	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Model 4</i>
Research Question	To what extent does classroom friendship centrality predict reading achievement gains for English Learners?		To what extent does the relationship between classroom network centrality and reading achievement gains differ between ELs and English Monolinguals?	
Outcome Variable	Low-stakes oral comprehension test	Low-stakes reading comprehension test	Low-stakes oral comprehension test	Low-stakes reading comprehension test
Independent Variables	Network centrality		Network centrality, and the interaction between network centrality and English language status	
Covariates	Prior oral comprehension, gender, socioeconomic status, grade	Prior reading comprehension, gender, socioeconomic status, grade	Prior oral comprehension, English language status, gender, socioeconomic status, grade	Prior reading comprehension, English language status, gender, socioeconomic status, grade
Sample	Students identified as ELs		All students in the sample	

Note: Gender is operationalized using a dummy-coded variable indicating whether a student identifies as female. Socioeconomic status is operationalized using a dummy-coded variable indicating whether a student qualifies for free- or reduced-price lunch. Grade level is operationalized using a series of dummy-coded variables indicating whether a student is in second, third, fourth, or fifth grade.

Model 1:

$$\begin{aligned} & \text{Oral comprehension}_{final_i} \\ &= \beta_1 * \text{Friendship centrality}_i + \beta_2 * \text{Oral comprehension}_{initial_i} + \beta_3 * \text{Demographics}_i \\ &+ \varepsilon_{ij} \end{aligned}$$

Model 2:

$$\begin{aligned} & \text{Reading comprehension}_{final_i} \\ &= \beta_4 * \text{Friendship centrality}_i + \beta_5 * \text{Reading comprehension}_{initial_i} + \beta_6 * \text{Demographics}_i \\ &+ \varepsilon_{ij} \end{aligned}$$

Model 3:

$$\begin{aligned} & \text{Oral comprehension}_{final_i} \\ &= \beta_7 * \text{Friendship centrality}_i + \beta_8 * \text{Friendship centrality}_i * \text{EL status}_i + \beta_9 \\ & * \text{Oral comprehension}_{initial_i} + \beta_{10} * \text{Demographics}_i + \beta_{11} * \text{EL status}_i + \varepsilon_{ij} \end{aligned}$$

Model 4:

$$\begin{aligned} & \text{Reading comprehension}_{final_i} \\ &= \beta_{12} * \text{Friendship centrality}_i + \beta_{13} * \text{Friendship centrality}_i * \text{EL status}_i + \beta_{14} \\ & * \text{Reading comprehension}_{initial_i} + \beta_{15} * \text{Demographics}_i + \beta_{16} * \text{EL Status}_i + \varepsilon_{ij} \end{aligned}$$

For each model,  $\beta$ s represent the estimated coefficients for each indicated variable using student  $i$ . Each model includes a vector of student demographics variables, including a dummy-coded variable for whether a student is a female, whether the student is eligible for free or reduced-price lunch, and the students' grade. The coefficients for these models are not reported in the tables below and serve as control variables to ensure children are being compared to similar students. However, the coefficients are included for reference in Appendices 1 through 4. Each model's error term,  $\varepsilon$ , is clustered by class  $j$ .

## Results

### Oral Language Comprehension, English Learners

I created models to determine whether the relation between centrality and achievement holds for English Learners. The first model predicted English oral language comprehension using students' measures of classroom friendship centrality (see Table 4).

This model provided further evidence that students' friendship centrality is associated with English oral language growth over time. In aggregate, the final model significantly predicts oral language growth ( $F(6, 24) = 112.06, p < .0001$ ). Controlling for the other variables, a 1-standard deviation (SD) increase in centrality was associated with a 0.12-SD increase in oral language comprehension, after controlling for the other variables. Students' prior oral comprehension was significantly related to their Spring 2019 oral comprehension ( $t(26) = 20.60, p < .001$ ).

Table 4

*Regression model predicting standardized oral comprehension growth using friendship centrality for English Learners*

<i>Variable</i>	<i>Estimate (s.e.)</i>	<i>t-value</i>	<i>p-value</i>
Friendship Centrality (Closeness)	0.12 (0.04)	2.85	.009
Prior oral comprehension (Fall 2018)	0.85 (.04)	20.60	< .0001
Constant	−0.10 (0.22)	−0.45	0.655
<i>N</i>	160		
<i>F</i> (6, 24)	112.06		< .0001
<i>R</i> -squared	0.658		

Note: Standard errors were adjusted for the 25 clusters. The outcome variable was students' oral comprehension in Spring 2019. All units are standardized units except demographic variables (not reported).

### **Reading Comprehension, English Learners**

Thus far, this dissertation has explored growth in oral language comprehension due to the demonstrated theoretical and empirical connection between elementary students' relationships/friendships and oral language. However, it is also plausible that reading comprehension is associated with students' social network centrality. Model 2 tests this

theory, and it explores whether friendship centrality is associated with English Learners' reading comprehension growth.

As demonstrated by Model 2, students' friendship centrality does not predict reading comprehension growth over time (see Table 5). A 1-SD increase in friendship closeness is associated with a .03-SD decrease in reading comprehension, controlling for other variables ( $t(25) = -1.57, p = .128$ ). This result is not statistically significant. As expected, students' prior reading comprehension significantly predicts their Spring 2019 reading comprehension ( $t(25) = 15.43, p < .0001$ ), after controlling for the other variables. UThis model provides evidence that, whereas friendship centrality is associated with oral language comprehension, it is not significantly related to students' reading comprehension growth. This finding is explored in the discussion section.

Table 5

*Regression model predicting standardized reading comprehension growth using friendship centrality for English Learners*

<i>Variable</i>	<i>Estimate (s.e.)</i>	<i>t-value</i>	<i>p-value</i>
Friendship Centrality (Closeness)	−0.03 (0.02)	−1.57	.128
Prior reading comprehension (Fall 2018)	0.36 (0.02)	15.43	< .0001
Constant	−0.23 (0.09)	−2.49	.020
<i>N</i>	168		
<i>F</i> (6, 25)	194.11		< .0001
<i>R</i> -squared	0.677		

Note: Standard errors were adjusted for the 26 clusters. The outcome variable was students' reading comprehension in Spring 2019. All units are standardized units except demographic variables (not reported).



### **Oral Language Comprehension, English Learners vs. English Monolinguals**

While the first two models explore the relation between reading achievement and closeness (friendship centrality) for English Learners, the second set of models investigates whether there is a differential relation between reading achievement and friendship centrality for English Learners versus English Monolinguals. The findings from these models can be used to query whether friendship centrality, and the broader construct of friendship, is connected to ELs' reading achievement and potentially can be utilized by teachers to improve ELs' reading outcomes.

Model 3 investigates the differential relation for ELs and EMs between oral language comprehension and friendship centrality. The interaction term between English language status and centrality is not statistically significant ( $t(24) = 0.51, p = .613$ ), indicating that there is no significant difference in the relation between centrality and oral language growth for ELs and EMs. In other words, the estimated relation between centrality and oral language growth is the same for ELs and EMs, and neither group of students benefits more or less from being more connected to their peers.

Similar to the previous models, the covariates were also important predictors for oral language comprehension in the full sample. Specifically, students' prior oral language comprehension was statistically associated with their Spring 2019 scores ( $t(24) = 26.24, p < .0001$ ); girls' oral language comprehension was marginally associated with their Spring 2019 scores ( $t(24) = -1.77, p = .090$ ).

Table 6

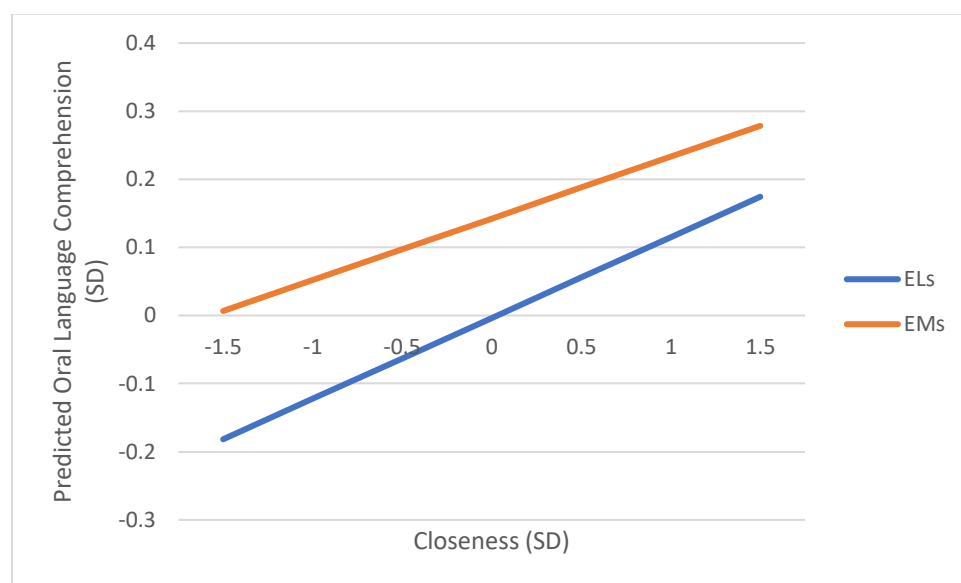
*Regression model predicting standardized oral language comprehension growth using friendship centrality and English language status, full sample*

<i>Variable</i>	<i>Estimate (s.e.)</i>	<i>t-value</i>	<i>p-value</i>
Friendship Centrality (Closeness)	0.09 (0.06)	1.50	.146
English language status	−0.15 (0.08)	−1.89	.071
Friendship Centrality * English language status	0.03 (0.07)	0.51	.613
Prior oral comprehension (Fall 2018)	0.84 (0.04)	23.30	< .0001
Constant	0.17 (0.11)	1.51	.143
<i>N</i>	221		
<i>F</i> (8, 24)	151.22		< .0001
<i>R</i> -squared	0.694		

Note: Standard errors were adjusted for the 25 clusters. The outcome variable was students' oral language comprehension in Spring 2019. All units are standardized units except demographic variables (not reported).

Figure 2

*Predicted oral language comprehension using friendship centrality, by English language status*



Note: The predicted outcome values were created using the fitted regression model from Table 6. Initial reading comprehension and gender are held constant in this graph. The predicted outcomes are for boys whose oral language comprehension was at the group mean for Fall 2018.

### Reading Comprehension, English Learners vs. English Monolinguals

While there was no differential relation between friendship closeness and oral language comprehension for ELs and EMs, Model 4 explored the differential relation using reading comprehension scores. In the ELs-only sample, reading comprehension was not statistically associated with friendship closeness, yet this model explores if the association is found in the full sample.

As displayed in Table 7, friendship closeness is statistically associated with reading comprehension in the full sample. After controlling for the other variables, a 1-SD increase in friendship closeness is associated with a 0.07-SD increase in reading comprehension ( $t(25) = 2.30, p = .030$ ). Students who are more connected within their homeroom friendship networks are more likely to improve reading comprehension scores, even after controlling for their score in the prior semester. A student who was at the 50<sup>th</sup> percentile in reading

comprehension in Fall 2018 but who was one standard deviation above the mean in terms of friendship centrality were predicted to be in the 53<sup>rd</sup> percentile for reading comprehension in the Spring 2019 semester.

Furthermore, there is a differential relation between friendship centrality and reading comprehension for ELs and EMs. The interaction term between the two variables was statistically significant ( $t(25) = -2.62, p = .015$ ). While the predicted slope between friendship closeness and reading comprehension for English Monolinguals was positive, the predicted slope between the variables for ELs was not statistically different from zero in this model. Of note, the difference in the slopes between ELs and EMs was statistically significant (see Figure 3). Whereas English Monolingual students with increased centrality in their classroom networks were more likely to experience reading comprehension growth, even after controlling for their prior reading comprehension scores, ELs experienced no significant relation in the two variables. The significant relation between friendship closeness and reading comprehension for EMs but not for ELs is explored in the discussion section.

Table 7

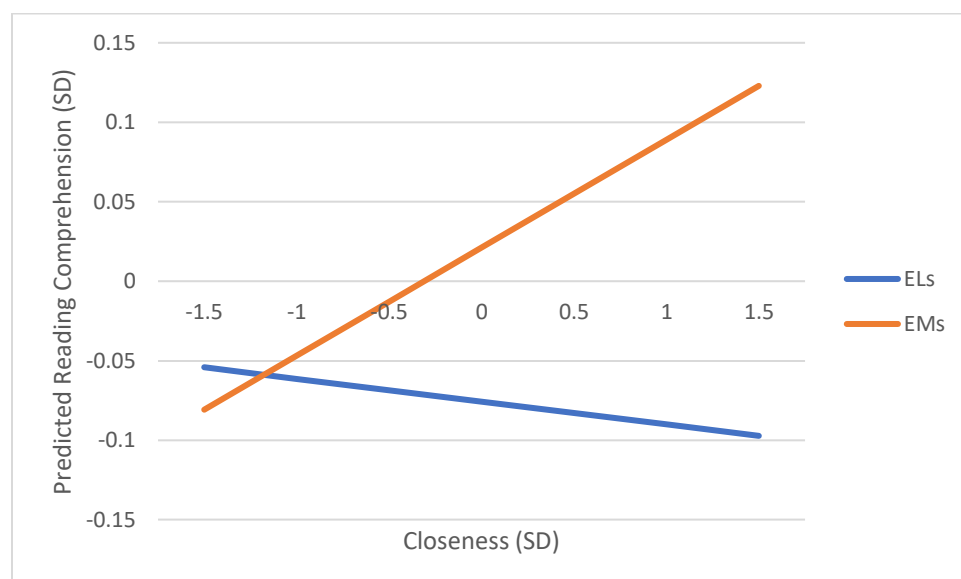
*Regression model predicting standardized reading comprehension growth using friendship centrality and English language status, full sample*

<i>Variable</i>	<i>Estimate (s.e.)</i>	<i>t-value</i>	<i>p-value</i>
Friendship Centrality (Closeness)	0.08 (0.04)	2.05	.051
English language status	−0.10 (0.05)	−2.06	.050
Friendship Centrality * English language status	−0.09 (0.03)	−2.52	.018
Prior oral comprehension (Fall 2018)	0.31 (0.04)	8.18	< .0001
Constant	0.02 (0.09)	0.18	.859
<i>N</i>	229		
<i>F</i> (8, 25)	38.94		< .0001
<i>R</i> -squared	0.633		

Note: Standard errors were adjusted for the 26 clusters. The outcome variable was students' oral language comprehension in Spring 2019. All units are standardized units except demographic variables (not reported).

Figure 3

*Predicted reading comprehension using friendship centrality, by English language status*



Note: The predicted outcome values were created using the fitted regression model from Table 7. Initial reading comprehension and gender are held constant in this graph. These predicted values were calculated for boys whose initial reading comprehension scores were at the mean.

### Limitations

This study provides evidence of the differential association between friendship centrality and reading achievement for ELs versus EMs, but there are some important limitations to the findings. The students who made up the analytic sample are not representative of the “average” US public school population for elementary students; ELs made up a larger proportion of the sample than in the overall population. While this purposive sample allowed for greater power to detect trends in the EL population, the results may not generalize to other school contexts. Friendship centrality may have dissimilar predictive power for schools in which ELs make up a slimmer proportion of the population, due to ELs feeling more excluded from the general population. Because ELs composed nearly 50% of the sample, and due to the tendency of students to interact with and befriend similar students (i.e., homophily), the estimated effect of network centrality

may be unique to school settings in which there are large proportions of students identifying as ELs. These students may or may not be conversing in English; future research may explore the ways that communication patterns (i.e., language spoken) among friends moderate the relation between friendship centrality and oral language growth. More research in other contexts and with data collected on communication patterns is necessary to explore these questions.

The measures incorporated in this study may limit conclusions that one can make about friendship and academic achievement. The study did not include a randomized control trial, so causal claims are not warranted when discussing the findings. While friendship closeness may predict achievement growth for students, lurking variables may exist which explain the model results. It is possible that these lurking variables relate to social relationships, or that they are related to other causes. For example, students with more friends may also have more access to their friends' social capital, which grants them opportunities to exceed academically; or it is possible that students who claim to have more friends are also more confident in themselves, and this increased confidence may be correlated with increased effort and self-efficacy. Future research should explore the mechanisms underlying this study.

Some variables that are often collected in research studies that examine immigrants or children of immigrants were not included in this study. For example, data were not collected about students' immigrant generation, their parents' social networks, or their family's cultural heritage, and these factors may lend explanatory power as to why particular ELs succeed while others do not, and why being connected to friends only matters for some students. These additional measures were not available, but they may have strengthened the models by ensuring all variables that are related to both immigrant status and language comprehension were incorporated. Additional research is necessary to determine how these variables affect estimated friendship centrality effects.

Last, classroom social networks are not fully representative of students' social networks. Even though elementary students spend a majority of their time with their classroom peers, students have relationships with siblings, family members, and other children outside of their classroom. These relationships also factor into student outcomes, and a comprehensive case study might explore those connections and their relation to achievement over time. However, for elementary education, in which students are clustered together in their homeroom classroom for most (if not all) of their time at school, these classroom networks are a worthwhile unit of analysis to explore.

### **Discussion and Conclusion**

Students' classroom social networks can serve as important predictors for student growth, yet there are important differences in their predictive ability between English Learners and English Monolinguals. Children who are more connected to their classroom peers are more likely to display growth in their English oral comprehension scores. These results were confirmed for both ELs and EMs, demonstrating that children who had more friendship connections with the students in their classroom—regardless of whether they themselves were an English Learner—were more likely to develop their oral language comprehension. It seems clear that elementary children having friendships within classroom networks is associated with developing English oral language skills.

This model provides preliminary evidence that friendships and the underlying friendship networks are important for elementary students' academic success. The relation among friendship centrality and oral language development, both among ELs and EMs, is unsurprising given that children's relationships are developed by oral conversations and interactions among dyads and within the social groups. On average, those children with more opportunities to engage in these interactions experience greater oral language growth than students who are less connected to their classroom peers.



While oral language comprehension predicts long-term reading comprehension (Babayigit et al., 2020; Silverman et al., 2020), the hypothesized relation between reading comprehension and friendship was not demonstrated universally in this study; reading comprehension growth was only related to friendship centrality for English Monolinguals, and not for English Learners. Specifically, English Monolinguals who are more central within their friendship network were more likely to experience growth in reading comprehension, but there was no relation between friendship centrality and reading comprehension growth for ELs. Even though being more connected was associated with oral language growth for ELs, the relation did not generalize to reading comprehension skills.

More research is needed to understand the mechanisms underlying the differential predictive power of friendship closeness by English language status, but current research does provide a few suggestions as to why greater connectivity is not associated with reading comprehension growth for ELs. More time may be necessary for oral comprehension gains to translate to reading comprehension gain for ELs; it is possible that the relationship for ELs would be uncovered over time, if the study continued to follow students' centrality within their classroom friendship network and their reading comprehension. This differential may also be symptomatic of teachers (on average) not being prepared to meet the unique language needs of ELs, at least not in general education classes. Students have access to English as a Second Language (ESL) supplemental teachers, but ELs may benefit from teachers with dedicated training in the ways to support ELs as well as native-language support in the content areas (Rumberger & Gándara, 2000). These teachers may more effectively leverage peer connections to ensure meaningful reading growth for all students, and not just those whose native language is English. Developing the content expertise of general education teachers to support ELs is the key to inclusive and effective education for all students, regardless of language status.

Additionally, it's unclear whether strong friendship network connections are contributing to the same positive classroom climate effects that EMs experience. For

example, while having friends is associated with increased self-efficacy and motivation, a moderation model can determine whether ELs similarly experience those increases when well-connected to friends in general education classrooms. The language barrier may negate some of the positive effects that a supportive classroom environment can have on student achievement, such as self-efficacy or feelings of belonging (LeClair et al., 2009).

Interventions exploring social connectivity and its impact on academic achievement (e.g., Cranley Gallagher, 2013; Krone & Yu, 2019) should investigate differential impacts based on teacher qualities (e.g., experience, training, support, and effectiveness) and student language status, in order to determine whether these interventions can help teachers leverage social connectedness to improve student outcomes, particularly for ELs.

These findings have implications for the ways that elementary teachers teach students. English language pedagogy emphasizes giving students opportunities to interact with classmates (Helfrich & Bosh, 2001), and teachers should continue using student-to-student interactions as an opportunity for students to meaningfully develop their oral language skills. Social interactions are intricately connected with other components of language development, including reading comprehension (Babayigit et al., 2020; Silverman et al., 2020). Further, elementary teachers may consider developing students' friendships as an opportunity to develop students' language skills (Helfrich & Bosh, 2011), as well as social-emotional outcomes that are associated with long-term benefits such as academic achievement (Jackson et al., 2021; MacDonnell et al., 2021) and increased perceptions of school climate among Latinx students (Jones et al., 2020), among others.

Classroom social networks matter, and they can be useful tools to predict student achievement. Specifically, elementary students' friendship centrality within their classroom social networks can predict semester-over-semester growth in reading and oral comprehension. However, the association between network centrality and achievement growth is different for English Learners and English Monolinguals. On average, students who are more connected to their peers are more likely to develop their oral comprehension skills,

which aligns with theoretical underpinnings exploring oral language growth due to the importance of verbal communication for young children's relationship development. However, the same is not true for reading comprehension. For EMs, being connected to peers is associated with gains in reading comprehension, but ELs do not experience the same predictive power. Further research is necessary to understand how to build strong classroom networks that can support ELs' growth—both developmental and academic—in the same way as their English Monolingual peers.

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## Appendices

### Appendix 1

*Regression model predicting standardized oral comprehension growth using friendship centrality for English Learners*

<i>Variable</i>	<i>Estimate (s.e.)</i>	<i>t-value</i>	<i>p-value</i>
Friendship Centrality (Closeness)	0.12 (0.04)	2.85	.009
Prior oral comprehension (Fall 2018)	0.85 (.04)	20.60	< .0001
Female	−0.10 (0.10)	−1.03	.313
Free or reduced-price lunch	0.02 (0.18)	0.11	.912
Grade 3	0.09 (0.13)	0.68	.503
Grade 4	0.10 (0.12)	0.85	.401
Constant	−0.10 (0.22)	−0.45	0.655
<i>N</i>	160		
<i>F</i> (6, 24)	112.06		< .0001
<i>R</i> -squared	0.658		

Note: Standard errors were adjusted for the 25 clusters. The outcome variable was students' oral comprehension in Spring 2019. The comparison group for the dummy-coded grade variable is students in Grade 5. All units are standardized units except demographic variables.

## Appendix 2

*Regression model predicting standardized reading comprehension growth using friendship centrality for English Learners*

<i>Variable</i>	<i>Estimate (s.e.)</i>	<i>t-value</i>	<i>p-value</i>
Friendship Centrality (Closeness)	−0.03 (0.02)	−1.57	.128
Prior reading comprehension (Fall 2018)	0.36 (0.02)	15.43	< .0001
Female	−0.07 (0.04)	−2.05	.052
Free or reduced-price lunch	0.19 (0.08)	2.32	0.029
Grade 3	0.04 (0.06)	0.70	.488
Grade 4	0.01 (0.04)	0.34	.737
Constant	−0.23 (0.09)	−2.49	.020
<i>N</i>	168		
<i>F</i> (6, 25)	194.11		< .0001
<i>R</i> -squared	0.677		

Note: Standard errors were adjusted for the 26 clusters. The outcome variable was students' reading comprehension in Spring 2019. The comparison group for the dummy-coded grade variable is students in Grade 5. All units are standardized units except demographic variables.

## Appendix 3

*Regression model predicting standardized oral language comprehension growth using friendship centrality and English language status, full sample*

<i>Variable</i>	<i>Estimate (s.e.)</i>	<i>t-value</i>	<i>p-value</i>
Friendship Centrality (Closeness)	0.09 (0.06)	1.50	.146
English language status	−0.15 (0.08)	−1.89	.071
Friendship Centrality * English language status	0.03 (0.07)	0.51	.613
Prior oral comprehension (Fall 2018)	0.84 (0.04)	23.30	< .0001
Female	−0.13 (0.08)	−1.61	.120
Free or reduced- price lunch	−0.12 (0.08)	−1.48	.152
Grade 3	0.10 (0.11)	0.90	.378
Grade 4	0.16 (0.11)	1.46	.156
Constant	0.17 (0.11)	1.51	.143
<i>N</i>	221		
<i>F</i> (8, 24)	151.22		< .0001
<i>R</i> -squared	0.694		

Note: Standard errors were adjusted for the 25 clusters. The outcome variable was students' oral language comprehension in Spring 2019. The comparison group for the dummy-coded grade variable is students in Grade 5. All units are standardized units except demographic variables.

## Appendix 4

*Regression model predicting standardized reading comprehension growth using friendship centrality and English language status, full sample*

<i>Variable</i>	<i>Estimate (s.e.)</i>	<i>t-value</i>	<i>p-value</i>
Friendship Centrality (Closeness)	0.08 (0.04)	2.05	.051
English language status	−0.10 (0.05)	−2.06	.050
Friendship Centrality * English language status	−0.09 (0.03)	−2.52	.018
Prior oral comprehension (Fall 2018)	0.31 (0.04)	8.18	< .0001
Female	−0.03 (0.03)	−1.04	.307
Free or reduced- price lunch	0.02 (0.07)	0.34	.740
Grade 3	−0.03 (0.08)	−0.40	.689
Grade 4	−0.02 (0.06)	−0.30	.763
Constant	0.02 (0.09)	0.18	.859
<i>N</i>	229		
<i>F</i> (8, 25)	38.94		< .0001
<i>R</i> -squared	0.633		

Note: Standard errors were adjusted for the 26 clusters. The outcome variable was students' oral language comprehension in Spring 2019. The comparison group for the dummy-coded grade variable is students in Grade 5. All units are standardized units except demographic variables.

### **Do Executive Functioning Skills Predict Reading Comprehension Growth?**

#### **Paper 3**



Developmentally, children have cognitive processes that may facilitate their academic success. Executive functioning skills are one set of cognitive processes that have been a primary focus in the developmental psychology literature base because researchers have linked these skills to various academic outcomes, including one's reading comprehension (Cartwright et al., 2017; Cartwright et al., 2020; Locascio et al., 2010). Understanding which skills are associated with and predict executive functioning development can support researchers as they devise interventions to bolster students' goal-planning abilities, and, more importantly, the outcomes that are associated with increased executive functioning, such as increased numeracy and mathematics performance (e.g., Agostino, Johnson, & Pascual-Leone, 2010; Raghobar, Barnes, & Hecht, 2010), increased literacy (Monette, Bigras, & Guay, 2011), and social and emotional well-being (Best, Miller, & Jones, 2009).

However, the causal claims in the research base are limited for a variety of reasons, including small sample sizes, short-term studies, and the possibility of bidirectionality between executive functioning and reading comprehension. Specifically, questions about whether executive functioning leads to reading comprehension growth, or vice versa, or even if the skills develop together, makes intervention creation challenging unless researchers know which skills should be targeted first to best improve student outcomes. Additionally, prior studies generally focus on one component of executive functioning (e.g., cognitive flexibility, working memory, or inhibition) rather than combining all components into a composite measure. This study contributes to the research base by using longitudinal data from children in five elementary schools, by incorporating all components of executive functioning, and by using methodology that more rigorously supports causal claims than correlational analyses or pre-post differences.

Recent work has examined the bidirectionality of reading comprehension and executive functioning, but largely using theory and correlational analyses (see Peng & Kievit, 2020 for a review). This line of work suggests that students' executive functioning

and cognitive processes develop alongside their reading and mathematics skills, and that both likely influence the other through a theory known as mutualism (van der Maas et al., 2006). However, the samples used to study this relation are generally typically developing children (Peng & Kievet, 2020), and the theoretical and correlational analyses do not definitively answer whether the constructs are causally linked or merely mutually developing. Studies using children experiencing developmental delays have not demonstrated this bidirectional relationship (Ferrer et al., 2010), instead supporting the traditional view that executive functioning leads to improvements in reading and mathematics. Furthermore, studies have rarely explored the relation using other groups who are often underserved by the education system, such as English Learners (Taboada Barber et al., 2020).

This study explores the relation between reading comprehension and executive functioning using student data collected within the classroom over the course of an academic year. I provide evidence that executive functioning contributes to elementary students' reading development. I use ordinary least squares (OLS) multiple linear regression with a rich set of covariates, aiming to limit concerns of omitted variable bias and provide stronger evidence of the connection between the constructs than with correlation. This model contributes evidence that executive functioning skills in part lead students to develop their reading comprehension skills. This paper concludes with pedagogical implications from this set of findings, as well as limitations from the study's methods.

## **Literature Review**

### **Theoretical Underpinnings**

Reading comprehension [RC] is a complex skill that is critical for many life outcomes, such as knowledge acquisition, educational attainment, and employment (Ricketts, Sperring, & Nation, 2014; Smart et al., 2017). However, many children struggle to meet grade-level expectations on RC tests (NAEP, 2017). While word decoding skills significantly

predict reading comprehension (García & Cain, 2014), some children display deficits in reading comprehension even though they exhibit age-appropriate abilities in word decoding (Oakhill & Cain, 2017). Further, students with above-average word decoding skills can demonstrate below-average reading comprehension (Applegate et al., 2009), which suggests that there is more to reading comprehension than just one's ability to 'read' (i.e., decode) the words. This deficit has led researchers to explore phenomena beyond comprehension abilities that might explain this finding.

Of note, research has demonstrated that children who display deficits in reading comprehension also have deficits in coordinating thought processes to achieve cognitive goals, also known as executive functioning [EF] skills (Miller & Wallis, 2009). Cartwright et al. (2017) define executive functioning as "cognitive processes that enable individuals to manage and direct their thinking toward particular goals" (p. 34), and the ability to manage goals is particularly important for students' reading success. Researchers have identified three components of executive functioning: inhibition, working memory, and cognitive flexibility (Diamond, 2013).

Inhibition is one's ability to suppress information that one sees or hears, and instead follow directions to report other information (Pimperton & Nation, 2010). For example, if a teacher primes a student to always report an "up" arrow as "down," the student is successful at inhibiting their typical response when they correctly call the up arrows 'down.' Inhibition is connected to reading because inhibition allows children to ignore surroundings and other stimuli, instead being able to focus on the text. These stimuli can include words or phrases in the text that are unimportant to the overall understanding of the story (Butterfuss & Kendeou, 2018). Additionally, children with stronger inhibition skills are better able to retain directions and reading strategies that teachers prime children with prior to engaging in the reading activity.

The second executive functioning component, which is highly related to inhibition, is working memory. Working memory involves one's ability to recall a limited number, or

'bits', of information (Cain, Oakhill, & Bryant, 2004). Studies suggest that students who can retain more pieces of information from working memory might be more successful at reading because they have a stronger ability to recall the words from the sentences while constructing, and remembering, a model of text meaning.

The final core component of executive functioning is cognitive flexibility, which is one's ability to switch back and forth between elements of tasks (Cartwright et al., 2017). For example, a student who can sort pictures by both color (red versus yellow) and type (fruits versus flowers) would have higher cognitive flexibility than a student who can only sort using one dimension at a time (Cartwright et al., 2017). Cognitive flexibility is important because readers need to simultaneously navigate decoding the words and sentences while understanding the context of what they are reading (Cartwright et al., 2010).

Because reading relies, in part, on skills connected with EF, such as focusing, decoding, sorting, and memory (García & Cain, 2014), it is reasonable to test how closely tied the two constructs are. Given links between reading comprehension and executive functioning, some have hypothesized that a critical way to increase the former is to build skills in the latter. Indeed, there is a robust body of literature that suggests that executive functioning skills are associated with reading comprehension (e.g., Cartwright et al., 2017; De Beni, Palladino, Pazzaglia, & Cornoldi, 1998; Oakhill, Hartt, & Samols, 2005; Yuill, Oakhill, & Parkin, 1989). For example, the literature base suggests that students with higher inhibition, working memory, or cognitive flexibility skills tend to be the same students who are strong comprehenders. Numerous studies demonstrate the connection between executive functioning skills and reading comprehension (see Butterfuss & Kendeou, 2018, for a review).

## **Challenges Testing the Relation between Executive Functioning and Reading Comprehension**

While the connection between the constructs is clear, extant research has not been conclusive on the directionality between EFs and RC. There is a body of literature in the developmental psychology field that shows evidence for a directional relation between EF and RC (Dahlin, 2011; García-Madruga et al., 2013), yet a separate body of literature within the broader cognitive psychology field demonstrates bidirectionality between EFs and RC for students in early grades (Peng & Kievit, 2019). More evidence is needed to determine whether growth in one construct leads to changes in the other construct, or whether both are developing simultaneously.

Researchers have primarily used two methods of investigating the relation between EF and RC, each with its own strengths and limitations. Longstanding lines of research have focused on conceptualizing and measuring these distinct constructs, and then examining the relation between them (i.e., Cain, Oakhill, & Bryant, 2004; Cain, 2006; Cutting & Scarborough, 2006). While the research has demonstrated the association between the constructs, most researchers have used correlation analysis that is limited in its ability to demonstrate that student growth in EF can lead to change in RC.

A second line of research has examined the extent to which classroom or laboratory-based interventions improve RC and also EF (i.e., Cartwright, 2002; Cartwright et al., 2017; Dahlin, 2011; García-Madruga et al., 2013). Intervention work, in which the treatment is randomly assigned, is useful in supporting causal conclusions about the effect of that intervention on RC and/or EF. However, to date, the interventions involve a component of reading instruction in order to support students' executive functioning, which prevent researchers from untangling which construct—reading comprehension or executive functioning—develops first, and whether the constructs lead to one another.

Omitted variable bias has been the largest threat to internal validity claims in the literature on executive functioning and reading comprehension abilities (Cartwright et al.,

2017). A typical method involves classifying participants as either high or low on RC, and then testing if the groups have significant EF differences. For example, De Beni et al. (1998) used this method to distinguish among students with high versus low working memory capabilities, and then the researchers used the classification to test for significant reading comprehension abilities between the two groups. In this study, the researchers found that students with high working memory skills performed better on reading comprehension tasks, so they were confident that there is a connection between these two skills. However, they were unable to determine which construct developed first, or if there might be another trait that causes both high executive functioning and high reading comprehension. Without using methodology that can plausibly answer this question, one cannot rule out the possibility that the relation is spurious, or that the causal link actually exists in the direction that is opposite from what the researcher might expect (Murnane & Willet, 2010). For example, strong reading comprehension skills might cause a student to have higher-than-average working memory abilities, since the student has more practice at reading stories, and this skill could influence their ability to recall information. A causal framework could tease out this distinction and serve to illuminate the direction of the relation (Murnane & Willett, 2010).

Finding a directional relation between executive functioning skills and reading comprehension, using more robust methods, would be important because there are intervention methods that might allow schools to improve a students' executive functioning abilities in order to affect their reading comprehension. However, few studies demonstrate the effectiveness of executive functioning interventions to specifically target reading comprehension, and especially within an authentic classroom setting (Cartwright et al., 2017). Those studies that do exist generally target one component of executive functioning, rather than executive functioning writ large as a construct. For example, Cartwright et al. (2017) tested this relation within a classroom setting and did find that teachers were able to improve reading comprehension scores after implementing a cognitive flexibility intervention

in the classroom, so there is evidence that executive functioning interventions targeting cognitive flexibility can lead to increases in reading comprehension. However, the aforementioned study only examined one classroom, and it used only one component of EFs. The present study examines if Cartwright et al.'s (2017) findings generalized to a larger sample while using a causal framework. Furthermore, this study uses information from all three types of executive functioning skills (i.e., cognitive flexibility, working memory, and inhibition) to determine if the skillset overall improves reading comprehension.

### **Methods**

In the current study, I explore the connection between EFs and RC using a sample of elementary-aged children. The goal of using covariate-adjusted regression is to limit biases in estimating the effect of EFs on RC, thereby producing a closer approximation of how growth in executive functioning skills can develop one's reading comprehension abilities. This study contributes to the broader literature by exploring the directionality for elementary-aged students who are developing their reading capabilities. Understanding the extent to which EFs contribute to students' reading comprehension can help teachers and policymakers understand whether interventions that target EFs can supplement reading comprehension development instruction for students.

### **Sample**

This study is part of Project LEARN (Language, Executive skills, And Readng for engagement; Taboada Barber, Cartwright, & Stapleton, 2016). The larger study sought to explore how English Learners' reading comprehension develops alongside domain-general

cognitive skills such as EFs, in English Monolingual and English Learners in the elementary grades.<sup>6</sup>

For the present study, data from the first year of Project LEARN are utilized. Table 1 displays demographic information for the analytic sample, including the grade-level proportions and English Learner proportions. The analytic sample in the present study was limited to those students whose executive functioning skills were measured in both the fall and the spring school semesters, which means students who missed one observation point were excluded from the present sample. The total sample size was 672 students (out of the original 762 students who Project LEARN collected data from across the two semesters).

Table 1  
*Demographic Information.*

	<i>Frequency</i>	<i>Percentage</i>
English Learners	392	41.67
English Monolinguals	280	58.33
Grade 1	152	22.62
Grade 2	168	25.00
Grade 3	189	28.12
Grade 4	163	24.26
School 1	254	37.8
School 2	267	39.73
School 3	151	22.47
Speaks Spanish at Home	426	63.39
Speaks English at Home	555	82.59

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<sup>6</sup> For example, there is an explicit focus on measuring traditional reading abilities, such as comprehension, decoding, inference making, vocabulary, and oral comprehension. The study also collects information on executive functioning skills, theory of mind, motivation, reading engagement, and social network data. The goal of Project LEARN is to determine if the predictors for reading development differ between English Learners and English Monolinguals so that interventionists and policymakers can determine the best way to support the two different groups. In year one of the study, the project collected data from three schools in a medium-sized urban area in the Mideastern United States. These schools were selected because they were located in high-proportion immigrant areas, meaning the schools had high percentages of English Learners in comparison to other schools in the state. All students in grades one through four who did not have special education accommodations formed the initial analytic sample (as long as consent was given), unless the student could not understand directions given to them in English.



Speaks Other Lang. at Home	43	6.40
Male	338	50.75
Female	328	49.25
Qualifies for Free/Reduced-Price Lunch	558	83.78
Average Days Absent per Semester	3.94	—
<b>TOTAL STUDENTS</b>	672	—

## Measures

Various measures were collected over the course of the two semesters. A Project LEARN assessor individually administered the battery of assessments to each child in a one-hour assessment block. Assessments took place during the school day, both in the fall and spring semesters, and the assessments generally occurred in an empty classroom, the hallway, or a book closet, depending on where the school could offer space to the assessment team. Assessors were trained on each measurement, and they had to pass two fidelity checks with one of the project leaders in order to administer tests to students.

Following the hypothesis that executive functioning leads to changes in reading comprehension, the outcome measure in this study is the student's reading comprehension score in the spring semester. Reading comprehension was measured using the Woodcock-Johnson IV passage comprehension reading subtest (Schrack, Mather, & McGrew, 2014), a standardized reading assessment that is given nationally to people of all ages. This test was selected because it has both a low floor and a high ceiling, meaning it is sensitive enough to differentiate among levels of reading at all points on the reading comprehension spectrum. Additionally, it was a vertically scaled test, so scores across grade levels align with students' developmental trajectories. Possible scores range from 0 to 54. Split-half reliability coefficients for children ages 6-10 range from 0.89 to 0.98 (McGrew et al., 2014).

The primary predictor variable was a student's executive functioning abilities, so special care was dedicated to creating a variable that represented all aspects of executive functioning. To capture inhibition, Project LEARN used the Inhibition subtest from the

NEPSY-II standardized measure. Students were asked to name the arrows/shapes as quickly as they could without making mistakes, and then they were asked to inhibit what they were seeing and report the opposite arrow/shape. The 'Naming' portion of the test establishes a baseline time and level of accuracy, and then the 'Inhibition' portion of the test allows assessors to see how the student's score changes when asking students to inhibit what they are seeing. Inhibition scores were calculated by dividing the number of correct responses by their time (in seconds), meaning students with higher scores were more accurate and proceeded more quickly than students with lower scores. At Time 1 (the fall semester), scores ranged from 0 to 1.55 ( $M = 0.78, SD = 0.24$ ), and at Time 2 (the spring semester), scores ranged from 0.10 to 1.74 ( $M = 0.90, SD = 0.26$ ). Internal consistency in the fall semester was 0.77 and 0.85 in the spring semester (Taboada Barber et al., 2020).

The second component of executive functioning is working memory. Project LEARN used the Letters Backward Subtest of the Test of Memory and Learning-2 (TOMAL-2) assessment to measure this variable. This assessment involves reading series of letters to students of increasing length, and then the student was asked to report the letters backwards. This measurement allows us to assess the number of bits a student can hold and transform (i.e., by reversing the order of the original list) in their working memory. A student's final score was the total number of letters they could remember in order after 14 different items. The Time 1 scores ranged from 0 to 53 ( $M = 10.65, SD = 4.65$ ) and the Time 2 scores ranged from 0 to 53 ( $M = 11.67, SD = 5.12$ ). Again, higher scores indicate higher levels of working memory. Internal consistency in the fall semester was 0.78 in the fall semester and 0.84 in the spring semester (Taboada Barber et al., 2020).

The last component of executive functioning is cognitive flexibility. This was measured using Cartwright et al.'s (2017; Cartwright, 2002; Colé, Duncan, & Blaye, 2014) task to assess cognitive flexibility, which asks students to sort pictures or words by two dimensions at the same time—for example, by type and by color. Like the inhibition measurement, a student's score was composed of the number of correct responses they

gave and the time it took the student to complete the task. Higher scores indicate that the student is able to sort correctly, explain how they sorted the cards, and complete the task quickly, which indicates higher cognitive flexibility abilities. At Time 1, scores ranged from 0 to 75 ( $M = 13.11, SD = 11.82$ ), and at Time 2, scores ranged from 0 to 30.86 ( $M = 9.00, SD = 6.39$ ). Internal consistency in the fall semester was 0.60 and 0.77 in the spring semester (Taboada Barber et al., 2020).

After creating scores for each of the three components of executive functioning, I standardized the scores so that a student's score indicates how many standard deviations above/below the mean the student performed, within the total sample of students. Then, I averaged each student's scores to form the composite executive functioning score per semester. I also calculated a student's change in executive functioning from the fall to spring semester. The change in z-scores ranged from  $-6.37$  to  $6.52$  ( $M = 0.09, SD = 1.52$ ).

Other variables that form part of this study include the student's school ID (a dummy variable to indicate which school they attended), their grade level, whether the student was identified by the district as an English Learner, and whether the student qualified for Free or Reduced-Price Lunch.

## **Analytic Plan**

**Covariate Adjustment.** Because prior literature largely does not make use of methodology that limits concerns around omitted variable bias, I use two techniques that provide stronger evidence of the relation between executive functioning and reading growth. I start by conducting a multiple linear regression model with a robust set of covariates (see Levine & Painter, 2008). While in general, covariate adjustment has the weakest claim to causality (Murnane & Willet, 2010), using a rich set of covariates can strengthen claims that

the participants are only being compared to other similar participants.<sup>7</sup> This model will identify whether a bidirectional relationship exists among reading comprehension and EFs, in line with findings from the research base. Controlling for baseline reading comprehension scores and key demographic variables strengthens claims that participants are only being compared to similar students.

There are strengths and limitations to using covariate controls as a primary way of estimating effect size, in comparison to matching methods such as propensity score matching. The biggest strength is that the final model can incorporate all participants, unlike matching methods in which participants are unmatched and thereby left out of the model (see Leow, Wen, & Korfmacher, 2015). Increasing the number of participants incorporated into the model increases power and therefore the ability to make claims about differences between the two groups. These regression models are also more easily understood than propensity score matching since regression models are more common in the literature (NICHD Early Child Care Research Network & Duncan, 2003). However, the key limitation is that researchers must be certain that the covariates actually remove differences between the two comparison groups, or else they cannot expect the groups to be equal in expectation (Murnane, & Willett, 2010). Without this requirement satisfied,

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<sup>7</sup> If the covariates can explain away any initial differences that exist between the two groups, then this set of variables minimizes the threat that selection bias poses, allowing for greater confidence that the groups are equal on expectation. Ideally, the covariates are the only differences between the two groups, allowing for the coefficient to represent the unbiased effect size that executive functioning skills have on reading comprehension abilities. However, it is challenging to identify and collect all such variables, particularly when confounding variables likely exist which may bias estimated effect sizes. Additionally, the final model must meet all regression model assumptions or else these models may introduce systematic bias into the estimated effect sizes (Zanutto, Lu, & Hornik, 2005). Researchers must determine theoretically driven covariates based on existing literature, and even then, the work is limited due to the possibility of lurking variables. Additional steps must be taken, such as verifying effect sizes using other methodologies, or else estimates may naively describe the relation among the constructs.

conclusions may be invalid since differences other than the independent variable may drive the estimated effect size of the models.

For these reasons, it is important to identify those variables that can strongly explain variation between participants across the spectrum of initial executive functioning skills. I include a set of reading variables to compare children whose reading skills would be expected to be similar, on average. These reading variables include initial English language vocabulary understanding and initial oral comprehension understanding. To test this set of variables, I ran a regression model to determine whether each variable significantly predicted one's executive functioning; each variable was statistically significant, and the set of variables jointly were statistically significant, which provided evidence that this set of variables is associated with differences among children with differing levels of executive functioning abilities.

The regression model incorporates all specified covariates, and I use the change in executive functioning across the two semesters as the key independent variable. The regression model tested is:

$$\begin{aligned} reading\ comp\_final_i &= \beta_1 EF\_change_i + \beta_2 EF\_initial_i + \beta_3 reading\ comp\_initial_i + \beta_4 vocabulary\_initial_i \\ &+ \beta_5 oral\ comp\_initial_i + \varepsilon_{ij} \end{aligned}$$

where  $\beta_1$  through  $\beta_5$  are the estimated coefficients in the model for student  $i$  in school  $j$ . The residuals ( $\varepsilon$ ) are clustered by school to account for nesting of students within schools. This model will indicate how growth in executive functioning is associated with growth in reading comprehension. In line with other studies that include initial scores and change scores on predictor variables (see Taylor et al., 2013), this model allows for an understanding of whether students' initial executive functioning or the amount of executive functioning growth in a semester are more predictive of reading comprehension growth. The goal in this

model is to attempt to make the groups equal on expectation, meaning differences among students that are associated with both executive functioning and reading comprehension should remain in the final model. For that reason, the non-significant covariates remained in the final model.

## **Results**

In this section, I provide the results from the regression model predicting the estimated association between growth of executive functioning skills and reading comprehension development. I find that both models indicate a link between executive functioning and reading comprehension, and the match between the models strengthens claims to validity.

The independent variable in this model is whether one's change in executive functioning between the fall and spring semester can predict one's reading comprehension, after controlling for initial reading variables. Does expanding one's executive functioning skills lead a student to increase their reading comprehension? This question is explored in this model.

Table 2 contains the estimated regression model. As mentioned earlier, no non-significant variables were omitted from this model to ensure the set of covariates was expansive enough to control for any omitted variables. Of course, it is not possible to ensure that there are no lurking variables, but I used the language literature base to identify any variable that I have access to and which theory suggests might predict reading comprehension.

Table 2

*Multiple Regression Model Predicting Change in Reading Comprehension as a Function of Change in Executive Functioning Skills*

	Standardized Coefficient	Robust Standard Error	T-statistic
Change in Executive Functioning Skills	0.114	0.026	4.47***
Initial Executive Functioning Skills	0.102	0.016	6.38***
Initial Reading Comprehension	0.574	0.072	8.03***
Initial Vocabulary	0.066	0.028	2.35**
Initial Oral Comprehension	0.112	0.040	2.84***
Constant	0.020	0.020	0.97
			$F(5,664) = 354.39$ $p < .0001$ $R^2 = 0.74$

Note: The outcome variable is the student's standardized reading comprehension score in the spring semester. School identification was absorbed in this model in order to cluster the residuals.  $N = 672$

\*  $p < .1$

\*\*  $p < .05$

\*\*\*  $p < .01$

This model indicates that increases in executive functioning are associated with increases in reading comprehension. Specifically, controlling for all covariates in the model, a 1-standard deviation increase in executive functioning skills from the fall to the spring semester is associated with an increase in reading comprehension of 0.114 standard deviations ( $t = 4.47, p < .001$ ). This predicted increase is associated with a child at the 50<sup>th</sup> percentile in reading comprehension in the fall semester moving to the 56<sup>th</sup> percentile in the spring semester.

This regression model also indicates that significant predictors of one's change in reading comprehension include a student's initial reading comprehension ( $t = 8.03, p < .001$ ), a student's initial English vocabulary knowledge ( $t = 2.35, p = .02$ ), and a student's initial oral language comprehension ( $t = 2.84, p = .01$ ). Additionally, students' initial executive

functioning skills in the fall semester significantly predicted reading comprehension, even after controlling for the other variables ( $t = 3.67, p < .001$ ).

The model provides evidence that executive functioning skills do matter in predicting changes in reading comprehension. Both initial executive functioning skills and change in executive functioning are associated with predicted increases in reading comprehension. Not only are those children with higher executive functioning skills experiencing greater increases in reading, but also those children who more strongly improve their executive functioning skills from the fall to the spring semester are expected to see increases in reading comprehension. Both indicators provide evidence that executive functioning is predictive of reading growth.

### **Discussion**

The regression model supports that students' cognitive functioning capabilities are statistically significantly associated with a student's reading comprehension growth. The multiple regression model indicated that a 1-standard deviation change in executive functioning is associated with a student improving their reading skills by 0.114 standard deviations, controlling for all covariates. The model improves confidence in the finding that executive functioning skills do lead a student to improve their reading comprehension each semester. This finding has policy implications, which I discuss in this section.

Understanding the connection between EF and reading comprehension bolsters the idea that schools may need to rethink the way they conceptualize improving reading scores. "Drill and grill" test prep, especially for young kids, is clearly not the only way to increase test scores. Rather, school administrators can also focus on improving executive functioning skills, with the understanding that growth in these skills may lead students to improve their reading comprehension both immediately and over time. There are interventions for both working memory and inhibition skills, and researchers are developing interventions to help students improve their cognitive flexibility skills (Cartwright et al., 2017). I do not suggest



that district officials and school administrators should revamp reading curricula immediately, but these results lend credence to the possibility that executive functioning interventions should be further studied to determine their impact on reading comprehension. Future studies can investigate whether interventions targeting executive functioning can work in conjunction with reading instruction, thereby increasing student reading outcomes.

Furthermore, this study is part of a longitudinal study, so it will be important to see if this pattern holds as data are analyzed from the subsequent two years of the study. If students with higher executive functioning skills continue to improve their reading comprehension scores beyond the scores of their classmates with lower executive functioning skills, there would be further evidence that these skills matter for desired reading outcomes. It also may be possible that this trajectory is not linear over time; instead, the data may suggest that those students with higher executive functioning skills proceed along a parabolic or exponential trajectory, such that the students continuously exceed their peers by greater and greater amounts over time. If this pattern occurs, then there will be even stronger evidence that limited resources should be allocated to executive functioning skills for kids at younger ages, with the understanding that these interventions may lead to reading gains as the children get older.

Whereas other studies investigated connections among specific components of executive function, this study provides evidence that executive functioning overall matters for reading outcomes. Previous literature has suggested the importance of working memory and cognitive flexibility for reading outcomes (e.g., Cartwright et al., 2017; De Beni, Palladino, Pazzaglia, & Cornoldi, 1998; Oakhill, Hartt, & Samols, 2005; Yuill, Oakhill, & Parkin, 1989), but this study expands those findings to suggest that executive functioning writ large is connected with reading. Helping students to expand on their cognitive abilities may be one strategy that schools use to improve student outcomes, but future studies are necessary to support this claim.

Additionally, this study provides preliminary evidence that the relation between executive functioning and reading comprehension is unidirectional, at least for the population of interest. Using data from 2<sup>nd</sup>–5<sup>th</sup>-grade students, there is evidence that changes in executive functioning lead to increase in reading comprehension, at least in part. This finding aligns with research suggesting that executive functioning and reading comprehension are not bidirectional for particular populations of children (Ferrer et al., 2010). Future work can continue to use more rigorous causal methods, such as experiments, to determine if gains in EF lead to gains in RC.

While this study does support the explanatory power of executive functioning on reading comprehension, it is important to note that the methods are not experimental in nature, and thus there is a possibility that the claims are overstated. The literature base would benefit from a 'gold-standard' experimental method, or even a more robust quasi-experimental method, to ensure that these causal claims are justified. Since we cannot randomly assign executive functioning capabilities to students, we would need to stick to other rigorous methods to test the theory that executive functioning interventions improve reading comprehension. An intervention with multiple rounds of data collection, allowing for structural equation modeling to test the pathways among constructs, would strengthen causal claims and may improve internal validity claims from the present study.

There are other important limitations to this study. While there is evidence that executive functioning can lead to increases in reading comprehension, it would be negligent to claim that executive functioning *on its own* will improve children's reading skills. Executive functioning can improve children's planning skills, memory, desire and ability to reach goals, and other abilities that are correlated with academic successes, but there are other variables with which executive functioning likely works in tandem to predict reading outcomes. For example, strong reading teachers (e.g., Etim, Etim, & Blizard, 2020), as well as evidence-based literacy interventions (for a review, see Puzio, Colby, & Algeo-Nichols, 2020), can both improve reading outcomes for students, and it is possible that executive

functioning skills may moderate the relation between these school-based factors and reading outcomes. Future investigations would benefit from testing the extent to which children's executive functioning skills play a role in mitigating children's reading improvements.

Reading outcomes matter, both for test-based accountability systems and for helping students to become successful adults. The search to improve reading outcomes has led researchers and policymakers alike to find methods that can be used to strengthen practices in the classroom. One question that remained unclear from the literature was whether executive functioning led to increases in reading achievement, and I used two methods to demonstrate that there is predictive power for growth in executive functioning on reading comprehension growth. The present study can inform the debate about how best to serve students, since these executive functioning skills fulfill accountability needs of school administrators—raising test scores—and these skills also help students develop their thought processes and become critical, logical citizens. Policymakers should continue to investigate the role that executive functioning instruction can play in elementary schools so that schools can maximize the cognitive growth that students can expect as they proceed throughout their schooling.

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## Conclusion

This dissertation explores the connections between students' centrality within their classroom friendship networks and reading development, as well as the relation between executive functioning and reading outcomes. This dissertation is one of the first studies to use Social Network Analyses to explicitly connect students' friendship networks to academic achievement growth, including for both the general student body and for English Learners. To my knowledge, only two other studies have utilized network data to predict student learning (Cooc & Kim, 2017; van Rijsewijk et al., 2018). It seems likely that interest in children's social and emotional wellness, as well as their effects on students' academic achievement, will continue to grow in light of the recent momentum that social-emotional outcomes have had in schools and among policymakers. The research from this dissertation can affect policy and future research in a few ways.

First, this dissertation provides further evidence that friendships matter in the classroom. Students are significantly more likely to improve their oral language comprehension during semesters in which they are more central within their classroom friendship networks. In essence, students who are more connected with classroom peers have more opportunities to develop their language through meaningful interactions, and these students are more likely to thrive in the classroom setting when not threatened by peer rejection or isolation. Additionally, English Monolinguals are significantly more likely to improve their reading comprehension—an important skill that is foundational to English Language Arts high-stakes tests—when students are more central within their classroom friendship networks. These findings support that educators and researchers should explore whether friendships and social connectivity can support student reading development, particularly for elementary students. Interventions that foster friendships and dense classroom networks (i.e., classrooms in which students are well-connected to each other) may support positive reading outcomes for students while simultaneously supporting student social-emotional well-being.

Second, social connectivity does not uniformly predict reading outcomes for English Learners and English Monolinguals, so peer interventions aimed at increasing achievement need to be examined with an equity lens. Even though English Monolinguals were more likely to demonstrate reading comprehension growth when they were more connected within their classroom friendship networks, there was no relation among centrality and reading comprehension for English Learners. Elementary children who were simultaneously building their English language skills and learning content in their non-native language, while navigating the social landscape, experienced no detectable pattern between their centrality and their reading development. Regardless of the mechanisms at play, research exploring the potential of social interventions to improve reading outcomes must pay particular attention to whether English Learners—a substantial and growing population in US public schools—equally benefit. Future research may investigate how to support reading teachers of ELs and ensure that they have sufficient training and expertise to connect students regardless of students’ language status. As more is known about the differential impact of interventions for various student groups, educators can continue to close achievement gaps and work towards equitable outcomes for all students.

While I hypothesized that the relation between friendship centrality and reading comprehension would be stronger for English Learners than English Monolinguals, due to the importance of friendships on ELs’ learning of the English language, these findings support the opposite: classroom instruction currently does not foster ELs to capitalize on friendships in the same way that it may benefit EMs. This finding may be indicative of a few mechanisms, which would need to be explored further: a) friendships may take longer to impact ELs’ reading outcomes (in which case the relation between friendships and reading comprehension is mediated by oral comprehension growth); b) ELs’ who are primarily communicating with other ELs are not experiencing the benefits on reading comprehension that EMs would receive due to speaking in the same language in which they are reading, or c) there are other factors at play which are preventing ELs from gaining social capital due to

expanding friendship networks, such as being part of a network of other ELs and not gaining access to supports associated with reading achievement growth. Future work should compare centrality of ELs as well as controlling for the proportion of one's friends who are EMs, to determine if there is a difference in predictive power for ELs whose networks include higher proportions of EMs.

In the third paper, I found additional evidence supporting the theory that executive functioning contributes to reading comprehension development. Whereas there are hypotheses that the two constructs may develop in tandem, I used a method that aimed to limit omitted variable bias in order to more validly estimate the effect size of executive functioning on reading comprehension. Developing students' reading comprehension is one of the primary goals of elementary education, and this dissertation supports that one approach may involve supporting students' executive functioning growth. By contributing to students' inhibition, memory, and cognitive functioning, students may be more likely to develop their propensity for understanding challenging texts. School environments, including positive teacher-student and student-student relationships, as well as supportive parenting can contribute to children's executive functioning development (see Cumming et al., 2020), so more can be done to explore the ways that educators can leverage relationship-building to improve students' EF, as well as their reading comprehension. Future interventions that are developed to improve executive functioning vis a vis developing positive and supportive classroom relationships should be investigated for their predictive ability to improve students' reading comprehension.

While this dissertation is exploratory in nature, it provides evidence that friendships are an overlooked resource which may have benefits that go well beyond preparing children for happy and meaningful social lives. Many educators strive to support students' well-being, helping to develop students' relationships in order to strengthen children's developmental processes and ensure children have support from their peers. However, this dissertation contributes to education research by suggesting that friendships may also be a

building block to develop academic benefits for children, including supporting their reading development. Without evidence bolstering an intervention, I do not claim that friendships are the most important resource; decades of research support the importance of teachers, high-quality curricula, safe learning environments, and many other inputs that can improve children's learning. Even though much more work is necessary to understand how to leverage peers to develop reading outcomes, research that identifies the value in developing students' friendships is paramount given that peers are a universal resource that is already available to all districts—rich and poor—throughout the country. All recent major federal policies (e.g., No Child Left Behind, Race to the Top, Every Student Succeeds Act) have utilized reading test scores in some capacity to measure student performance; thus, demonstrating that students' friendship networks are connected to achievement is important because it justifies the role that relationship building must continue to have in the schools. Comparing pedagogy is outside of the scope of this dissertation, but it is clear that friendships—which are important for so many aspects of children's development—are also important when considering their connection to student achievement. It is my hope that this dissertation may provide another datapoint highlighting the importance of peer relationships in our education system as policymakers continue to debate what is the purpose of schools, and how might we best prepare our children for the future.

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