

Winter 3-28-2014

The Role of Network Position for Peer Influences on Adolescents' Academic Engagement

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10.15760/etd.1635

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The Role of Network Position for Peer Influences on Adolescents' Academic
Engagement

by

Price McCloud Johnson

A thesis submitted in partial fulfillment of the
Requirements for the degree of

Master of Science
in
Psychology

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Portland State University
2014

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Abstract

Academic engagement has been found to significantly predict students' future achievement. Among adolescents, the peer context becomes an increasingly important point of socialization and influence on beliefs and behavior, including academic engagement. Previous research suggests that those peers with whom an adolescent spends much of their time significantly predict change in engagement over time (Kindermann, 2007). Bronfenbrenner's ecological systems theory (Bronfenbrenner & Morris, 1998) postulates that exosystem effects (those influencing factors that are not directly connected to individuals) play an important role in development, and social network theorists have suggested that the position one occupies within the greater network is a key factor that determines one's power of influence (Borgatti, 2005). An individual's own position in a network emerges from his or her own connections, as well as from the structures formed by the connections of his or her affiliates (the exosystem). Utilizing an existing dataset, social networks analysis techniques were used to examine how three different forms of centrality (degree, closeness and eigenvector), which are markers for micro- and exo-system effects, relate to classroom engagement and its change over time. Results showed that although centrality in a network is positively related to academic characteristics at one point in time, students who have large numbers of immediate connections (degree centrality) tend to *decrease* in engagement over time. In contrast, eigenvector centrality showed a positive interaction with peer group influence on change in engagement over time. For those students who had highly interconnected peers the positive effect of peer group engagement was *increased*.

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Chapter 1: Problem Statement

The typical image of an adolescent growing up in America today paints a picture of a young person who cannot stop talking about how school is a boring waste of time that gets in the way of the more important things in life. Hollywood is well known for exaggerating such portrayals, but in this case, the research in psychology and education supports this view of the adolescent perspective. Student motivation, interest, value and enjoyment of school have been shown to decrease linearly from elementary school through high school, with the steepest declines during the transition to middle school (Wigfield, Byrnes & Eccles, 2006; Fredericks & Eccles, 2002). These losses in motivation (perhaps coupled with other factors) can lead to negative outcomes such as low achievement and dropout (Fredericks, Blumenfeld & Paris, 2004).

One key feature of adolescence that coincides with this decline in motivation is an increased social awareness and focus on peer relationships (Collins & Madson, 2006). Some researchers have argued that peer interaction during this developmental stage may (at least in part) account for student's decreasing interest in school and increasing risk behaviors (Allen, Porter & McFarland, 2006). However, other research points out that the effects that peers exert on school motivation may depend on whether the peers with whom a student affiliates are themselves focused on academics. In fact, research has shown that students whose social network at school tends to consist of more engaged peers can show increases or at least stability in their classroom engagement over time (Kindermann, 2007; Berndt, Laychak & Park, 1990).

This positive peer effect is of great interest to educators, and in the past few decades more research has been conducted examining peers' influences on student academic engagement and performance (Berndt & Keefe, 1995; Brown, 1993; Verroneau & Dishion, 2010). The mechanisms by which this change occurs, however, are still elusive. Social networks analysis (SNA) is a particularly promising approach that explores the nature of the social context examining the meaningful connections that individuals share with one another. Not only does SNA provide a view of the social system through mapping the connections of an entire network, but it also provides a window into the mechanisms of social interaction by allowing examination of local connections of target individuals. By using SNA techniques and examining multiple aspects of a student's social network, we may be able to gain a better understanding of the mechanisms by which this change in engagement occurs. Specifically, it may make a difference how students' social networks are structured and what kind of position an individual and his or her peer group has in the social fabric of the school setting. By having a greater understanding of peer network characteristics and their effects on engagement, we can ultimately develop more successful intervention practices for improving achievement during adolescence and pre-adolescence.

One key aspect of the network that may shed more light on the mechanisms of influence is *centrality*. Centrality refers to those individuals within a network who are more highly connected and have greater control of information flow through the network (Borgatti, 2005). Little research has been done on this construct from a developmental perspective, yet research on adult learners has shown that central individuals may be

more influential on their peers in general (Russo & Koesten, 2005). SNA research tends to focus on local networks, the micro-system (Bronfenbrenner & Morris, 1998), as the means of significant interaction and influence; however theory supports the claim that exosystem effects, the interactions that exist outside of the immediate network but indirectly influence it, should also influence development. Simply put, friends of friends should influence the target individual indirectly. Centrality can provide a measure for an individual's location within the greater network and thus opens up an examination of exosystem effects. This study aims to investigate the role that centrality plays in academic engagement during pre-adolescence.

Chapter 2: Literature Review

Achievement

The goal of education is to prepare students for mature life. The acquisition of knowledge, critical thinking skills and interest in pursuing rational means of solving problems is what allows citizens to function within society. Unfortunately not every student is achieving these goals. Only 75.5% of students are graduating from high school on time, according to the National Center for Education Statistics (Aud, Hussar, Kena, Bianco, Frohlich, Kemp & Tahan, 2011). 24% of 8th graders are performing below basic understanding on reading comprehension tests, while 27% of 8th grade students are performing below basic levels on mathematics tests. Roughly a quarter of students in the 8th grade are not performing at the level deemed necessary for their grade. It is obvious that more needs to be done to improve this situation. One potentially fruitful avenue that has been pursued over the last decade to improve scholastic achievement and retention is the study of academic engagement.

Academic Engagement

Educator's and researcher's enthusiasm for the construct of engagement is based on studies showing that academic engagement is linked to increases in achievement outcomes and that it is a malleable factor. Higher academic engagement on the whole has been shown to predict standardized achievement test scores (Jimerson, Campos & Greif, 2003). For example, in the Beginning School Study (Fredericks et al, 2004; Alexander, Entwisle, & Dauber, 1993; Alexander, Entwisle, & Horsey, 1997), it was found that teacher ratings of behavioral engagement in the first grade were predictive of

achievement over the next four years, as well as high school dropout rate later. This is not surprising; a student who is motivated to perform well and who enjoys school is more likely to comprehend the material and achieve at higher levels.

Most other robust predictors of achievement are demographic (race, gender, socioeconomic status, etc.), and therefore difficult to use as targets of intervention. In the case of engagement, targeted interventions (Hawken & Horner, 2003), have been shown to influence engagement, and thus improve achievement outcomes. Intervening earlier in student's academic careers when their motivation and engagement are low can also set them on a more successful trajectory rather than waiting until achievement issues arise (Werner, 1992). When it is increasingly necessary to have an education in order to be a responsible citizen, this is a very important issue to consider. If at risk students can be identified earlier on, or if the school setting can be optimized for engagement growth across all students, then achievement should likely follow.

Conceptualization of Academic Engagement and Disaffection

There is no single definition of the construct of engagement (Fredericks, Blumenfeld & Paris, 2004), but there are two commonly explored venues of engagement for adolescents: school engagement and classroom engagement.

Components of engagement. *School engagement* is a measure of engagement at the school level, which can include involvement in clubs, extracurricular activities, sports, etc. (Fredericks et al., 2004). Although school engagement can be useful in determining how interested a student is in the overall school environment, when specifically interested in the outcomes of achievement and learning class material, it is

more appropriate to focus on classroom engagement as a measure. *Classroom engagement* has been described as a student's energized, enthusiastic, emotionally positive, cognitively focused interactions with academic activities (Wellborn, 1991). Classroom engagement refers generally to how involved the student is in academic activities, how much effort he or she put forth and his or her overall interest in the subjects of study.

Despite the lack of consensus about definitions, researchers agree that engagement is comprised of multiple dimensions, including behavioral and emotional engagement, (Cognitive engagement is sometimes cited as another component, but has been shown to have a significant overlap with the construct of behavioral engagement; Fredericks et al., 2004). *Behavioral engagement* refers to a student's effort, persistence and participation as it pertains to learning and academic tasks (Fredericks et al., 2004; Skinner & Belmont, 1993). It includes those observable actions that a student performs both in and out of class that relate to student motivation. This is the kind of engagement that a teacher would speak about if asked about a student's interest in school. For example, a student who raises his or her hand to answer questions in class or shows open enthusiasm towards a subject through participation and turns in assignments on time would be high on behavioral engagement. In contrast, a student who falls asleep in class, who never raises his or her hand and who fails to turn in assignments would be classified as being disaffected. One benefit to behavioral engagement is that it is observational in nature, allowing for teacher reports to supplement student reports, and thus provide greater reliability.

Emotional engagement refers to a student's affective reactions in or directed towards the classroom learning activities, which includes interest, boredom, happiness, sadness and anxiety (Fredericks et al., 2004; Connell & Wellborn, 1991; Skinner & Belmont, 1993). A student who genuinely likes school, his or her teachers, the environment, and his or her peers would be high on emotional engagement. A student high on emotional disaffection would display boredom, distraction and would express feelings of irritation towards school.

Structural analyses of measures of classroom engagement have shown that behavioral and emotional engagement and disaffection are distinguishable (Skinner, Kindermann & Furrer, 2009). At the same time, however, they are sufficiently intercorrelated enough to allow academic engagement to be measured as an aggregate variable. Research has shown that when comparing measures of behavioral and emotional engagement, they are significantly intercorrelated at the measurement (student reported engagement $r = .61$, $p < 0.001$; teacher reported engagement $r = .72$, $p < 0.001$) and factor ($r = .79$, $p < 0.001$) level (Skinner, Kindermann & Furrer, 2008). Students can be high on behavioral engagement and low on emotional engagement, and vice versa. For example, imagine a student who does all of his or her work and participates and performs well in class, but is only doing so because he or she has learned that school achievement is important. In this example, the student is “going through the motions” and would not be as emotionally engaged in the material. As a result, one would expect this achievement not to transfer into higher education or could be more easily lost when things became difficult. However, behavioral measures of engagement alone are more likely to show

which students are more outgoing and confident than others. These measures would miss out on the “shy” students who, though being highly engaged in the material and performing at a high level, are less active in the classroom. The student may still be highly interested and connected to the material emotionally, reporting as such, but these attitudes may be lost to the teacher through interactions with the student.

Thus, it is important to study emotional engagement alongside behavioral engagement to get a better picture of a student’s overall motivation, action and performance. Without utilizing both measures, a student’s motivation cannot be totally understood. Because measurement work demonstrates that intercorrelations among components are high, but not so high that the constructs are indistinguishable, the research does not support choosing one measure over the other as being representative of overall engagement. One can interpret engagement as a holistic variable as the measures are highly related, but it is important to still measure both forms of engagement as there are aspects that are unaccounted for by either measure alone.

Because of engagement’s power to predict achievement and its potential malleability, researchers have become very interested in the factors that can influence it. A host of personal and social factors have been studied, including learned helplessness, perceived control, achievement goal orientations, flow and self-system theory to name a few. These motivational theories are different in their interpretations of what types of behaviors or processes are crucial in determining important outcomes, such as engagement. It has been argued, however, that these theories of motivation share in common the same or similar target actions (such as interest, enthusiasm, enjoyment and

energy), and that the study of engagement captures the essential outcome of these differing theories of motivation (Skinner, et. al, 2009). The current study focuses on *self-determination theory* as a framework for adolescent academic motivation.

Self-Determination Theory

Self-determination theory (Deci & Ryan, 1985) seeks to explain how the school environment can support or undermine the development of engagement. Self-determination theory (SDT) is a theory of human motivation based on the notion that humans come with innate psychological needs that must be met in order to nurture curiosity and interest in the context within which they are embedded. Just like the body needs food in order to survive and grow, the mind needs this psychological nourishment in order to thrive. In the context of schools, these basic needs would have to be met in order to provide the proper foundation for students to allow them to comprehend and connect with the teacher and curriculum. If these needs are not fulfilled, then motivation cannot properly develop and eventually results in a lack of interest and ultimately in disaffection. These basic motivational needs, as presented by Deci and Ryan (1985, 2000), are *autonomy*, *relatedness* and *competence*.

Autonomy refers to the need to make decisions and guide one's own activity towards the goals that a student genuinely wishes to achieve in ways that are consistent with the student's authentic self (Deci & Ryan, 2000). Often, parents and teachers will resort to coercive methods of influence in which they use arguments such as "because I told you so". In these situations, they are not nourishing *autonomy*, because they are not allowing the child to make his or her own decisions. Unlike many situations in school

where students are told specifically what to do for assignments and studying, an autonomy supportive environment would provide pathways and avenues that allow students to make their own decisions and follow their own interests. In giving students multiple options and ways of achieving, instructors invite students to be creative and utilize strategies that inspire insight into themselves. In this way, students become invested in both the decisions that they make and the outcomes that they have committed to.

Relatedness is the need people have to feel they belong and are cared for by the individuals with whom they interact (Baumeister & Leary, 1995). By feeling that they belong and are welcome in the environment within which they are present, individuals experience a level of comfort and security which allows them to explore the environment without fear of reprisal. Students who are in a classroom setting where they are often bullied or feel that they are picked on by their teachers or their peers may not feel like they belong, and will therefore be unable to connect to the classroom and the material of interest. To properly support developing students, it is important to create an environment that feels warm and open to the students with little fear of judgment or ridicule.

Competence is an individual's perception of his or her ability to produce desired results from the actions that they take (White, 1959). An individual who feels competent in his or her abilities will be more likely to actively seek out those activities he or she is confident he or she can complete, and potentially more challenging tasks. Someone who feels incompetent is unlikely to seek out challenging actions or even those they are capable of completing, and therefore are less likely to grow in his or her abilities.

Environments that foster competence provide material that is reasonable but challenging, allowing the participants to learn from their actions that they can evoke the results that they desire.

Perhaps the most crucial piece to understand about self-determination theory is what it says about human relationships and interactions, and the effect they have on motivation. At the core, SDT argues that relationships and interactions with others in the school context are the most important building blocks that shape a student's engagement. As a result, the study of these other individuals is a critical aspect to an understanding of student's academic engagement.

The Importance of Peers to Student's Academic Success

The study of the academic development of adolescents focuses on a range of close relationships. Although the majority of the research on social influences on adolescent academic success focuses on teachers (Evertson & Weinstein, 2006) and parents (Skinner, Johnson & Snyder, 2005), much research has shown that the nature of parent-child relationships changes during adolescence, with a shift toward greater independence (Collins & Laursen, 2006) and increasing interactions with social partners of the same age. As adolescents develop a greater level of social awareness and comparison (Berndt, 1979), the importance of their peers increases. Research on adolescent development supports the claim that peers become the target of more focused attention during adolescence than in childhood. Research has shown that adolescents spend more time with peers than at previous developmental stages (Csikszentmihalyi & Larson, 1984),

influence each other's behaviors more (Berndt, 1979), and are highly interested in the opinions of others of their age group (Lerner & Steinberg, 2009).

Coinciding with this shift in focus from parents to peers, the nature of those relationships also change. In childhood, friendships are often based on enjoyment of common activities and mutual loyalty and caring. In adolescence, the focus shifts towards the importance of intimacy and self-disclosure (Collins & Madson, 2006; Rubin et al, 2006). Hamm (2000) asserted that observable similarity often plays a role in friendship selection (e.g., ethnic background, socioeconomic status). However, adolescents increasingly gravitate towards those peers who have similar psychological qualities (e.g., attitudes, beliefs, interests).

Not only does this shift in adolescent relationships change the social landscape, but it also has effects on students' academic achievement. Although parents and teachers are indeed important to the development of academic success, recent research suggests that peer interactions also play a significant role in the development of academic achievement (Ames, 1992). Friendship research has shown that friendship status has been positively related to academic motivation and performance (Altermatt & Pomerantz, 2003; Berndt, Hawkins, & Jiao, 1999; Wentzel, McNamara-Barry, & Caldwell, 2004), while being negatively related to behavioral problems in school (Ennett & Bauman, 1994; Poulin, Dishion, & Haas, 1999). Studies of sociometry as well as acceptance scores have shown links to academic motivation and performance (Bukowski & Cillessen, 1998; Chen, Chang, & He, 2003; Guay, Boivin, & Hodges, 1999). Social crowds, friendship groups and peer groups have all been shown to be linked to academic motivation and

performance as well (Brown, 1999; Farmer & Rodkin, 1996; Kiesner, Poulin, & Nicotra, 2003; Kurdek & Sinclair, 2000; Wentzel & Caldwell, 1997).

There are many reasons why peers should be considered as important influences on adolescent development. Unlike teachers or parents who are authority figures, adolescents are relatively equal in their social standing. This allows students to question the claims of others more readily and engage in intelligent discourse, rather than blindly trusting the authority of their parents and teachers. Additionally, adolescents get to choose their friends, those peers that they spend the most time with. Their selection is limited to those other adolescents to whom they live in close proximity and are in the same school district, clubs, neighborhoods, etc. However, among those potential friends, adolescents can choose which relationships to maintain, strengthen or lose. Unlike parents or teachers, they are able to select their friends based on similarities or desirable traits (Hartup, 1983). This phenomenon has been termed “selection” or “assortativeness” (Kandel, 1978; Kindermann, 2007).

Proximal processes as mechanisms of peer influence. A key mechanism through which peer influence likely occurs is face-to-face interactions. As described in Urie Bronfenbrenner’s (Bronfenbrenner & Morris, 1998) bio-ecological model, influence likely occurs through “proximal processes” which are “progressively more complex reciprocal interactions between an active, evolving biopsychological human organism and the persons, objects, and symbols in its immediate external environment” (p. 996).

Throughout a student's day he or she will interact with the environment and others through a number of proximal processes: he or she will be lectured to and participate (or not) in class, he or she will talk to friends, ride the bus, come home from school and interact with his or her parents, siblings and pets, go on the internet and so on. In all of these examples, the student is taking part in reciprocal interactions where he or she is both influencing and being influenced by those persons, objects, or symbols. In this way, we see that influence is not something that occurs wholesale as a package, delivered to the student's brain. Instead it is a gradual process whereby a student's everyday interactions have an additive effect ultimately making minute changes to his or her behavior and beliefs through face-to-face interactions that are continued over time. Engagement is a key variable to study because it involves face to face interactions between students and their frequent interaction partners. In the case of engagement, the interaction partner is the academic material of school. The student learns through interaction with the subject matter and assignments.

However, other proximal processes influence how successful this is. Because school is one of the contexts in which students spend so much time together, it seems likely that peers should have a significant effect on students' educational outcomes. Interactions with parents, teachers and other students all inform the student's behaviors as well as what he or she will elicit from the environment. It is in this way we can not only see how engagement is influenced by social others, but also why peer interactions should be so important. Students who are disaffected in school but have friends who are engaged will be exposed to their behaviors, which are informed by their internalized beliefs about

school, repeatedly and over long periods of time. If they continue these relationships, proximal processes should shape their opinions of school to be similar to those of their friends. As a result, the student will have more worthwhile interactions with the school material.

Research on the Effects of Peers

Much of the past research on adolescents has focused on the effects of their interactions with other students, or influence, in the studies of crowds, friendships and peers. These three areas of research will be briefly reviewed and critiqued with respect to the mechanisms of influence they suggest. This section ends with the suggestion that the study of peer networks may provide a good avenue for the study of a system of proximal processes during adolescence, and thus an important focus of research on how peers shape students' school engagement and success.

Crowds

According to Brown (1993) a social crowd is a group of people who share a reputational label that represents the stereotypes of the behavior and personality of the members of the crowd and is given by adolescents to their peers. Crowd stereotypes tend to differ by the individual who is ascribing them, but the labels and grouping of individuals tend to be consistent (Urberg, Değirmencioğlu, Tolson & Halliday-Scher 2000). Crowd research is important to consider as crowds differ from both friendship and peer groups, yet the influence mechanisms may carry over into these other areas of interest. Whereas friendships and groups are made up of individuals who interact with one another, a crowd is a label ascribed to individuals who are similar in some way, be it

in dress, music preference, interests, etc. Friends are not necessarily members of the same crowd and will therefore be differentially influenced by the effects of crowds to which they belong (Kindermann & Gest, 2009).

As a crowd represents a categorization of individuals, those who are considered part of a crowd may not actually interact with each other. However, since we know that individuals tend to group themselves based on similar interests and that peer groups are changing constantly, the crowd may represent potential avenues for new friendships, those individuals who are the most likely potential friends. Likewise, as a crowd tends to be an artifact of stereotypes that are unique to the individual, members may seek to be more like other members of the crowd who they do not fully know, as they may have a more positive view of them as representing their preferences and style. To support this, some research has shown that crowds may influence adolescent development even though direct interaction may not occur (Brown & Dietz, 2009).

Increasingly, social identity becomes an important part of an adolescent's life. The crowds to which they are members (or at least perceived to be) then become more meaningful to them as they develop. The ideals held up by those adolescent's with whom they are friends are transferred to them. For example, the "brains" may value school and learning and thus go to the library a lot, boosting their achievement and engagement. Likewise, the "druggies" may value drug abuse and skipping school in order to do so, and thus their achievement may plummet. These effects can also be long lasting, with some studies showing that "brains" tend to go on to college and perform well, while "jocks" often are successful but have alcohol abuse issues, but not as bad as the "druggies"

(Barber, Eccles, & Stone, 2001). Although some of these personality traits and attitudes may have existed before, Giordano (2003) argues that the crowd helps to shape future development through shared experiences.

Critique of crowd research. To date, the crowd research has not shown any direct effects on changes in academics. Instead, crowd effects seem to be most oriented towards group membership activities. This is not surprising when looked at through the lens of proximal processes: No face-to-face interactions are occurring. To understand effects on academics and engagement it would seem wise to explore those other individuals with whom a student interacts directly and frequently, namely, their friends and peer group members.

Friendship

Hartup and Stevens (1997) define friendship as “the strong, positive affective bonds that exist between two persons and that are intended to facilitate the accomplishment of socioemotional goals” (p. 218). The interactions that friends share are the basis for important changes throughout the lifespan. Arguably, other than parents, friends are considered to be the most important significant others in an individual’s life in terms of influence (Rubin, Bukowski, & Parker, 2006). One key feature of friendship is the reciprocal nature of positive emotional experience that the individuals share with one another.

Friendship research has shown that beginning in childhood and moving through adolescence, close friendships become an increasingly important avenue of social support (Furman & Buhrmester, 1992). Vaughn (Vaughn, Azria, Krzysik, Caya, Bost, Newell, &

Kazura, 2000) found that having close friends increased a child's odds of being happy and socially competent, especially for those children whose relationships are with others who are themselves well-adjusted and supportive. Close friendships also reduce the odds of loneliness and depression in children (Nangle, Erdley, Newman, Mason & Carpenter, 2003). Research has shown that close friends help to buffer against the negative effects of significant life events such as divorce or the first day of school (Ladd, 1999; Rubin et al, 2006).

The way in which friendship has been studied typically is through the use of questionnaires which measure the reciprocity of perceived relationships that individuals share for one another (Bukowski, Metzow, & Meyer, 2009), and how the constructs of interest (e.g., achievement, motivation, pro-social behavior) are influenced by these relationships. General findings have shown that friendship leads to positive outcomes through emotional wellbeing, resulting in increased academic achievement and pro-social behavior (Berndt & Keefe, 1995; Wentzel & Caldwell, 1997). Much of the research has supported the notion that it is the nature of those friendships that determines the directionality of influence. Students who are low-achieving will negatively influence the achievement of their friends, while high achieving students will positively influence their friends (Veronneau & Dishion, 2010).

One of the key studies that demonstrate the effect of friendship interactions on academic motivation was carried out by Berndt, Laychak and Park in 1990. The study looked at 118 eighth graders across two junior high schools. Small groups of students were asked to report their friends, starting a list with their very best friend and working

down, of which the top five friends were considered for this study. Then, they were asked to rate their opinions of all of their same sex peers from the school on a likert-type scale, with high ratings being high-liking. This information was used in conjunction with the friendship nominations to determine friendship for use in the study.

Using this information, the researchers divided students into pairs of friends. The students were then asked about several dilemmas that were created to represent choices that would reflect either high or low academic motivation. For example, one dilemma described an upcoming rock concert that the students were excited about, but that took place the night before a big exam that they were unprepared for. The students would then rate on a scale of 0 to 10, where 0 would represent one choice, 5 would represent not-sure and 10 would be the other choice. More extreme choices represented more confidence in that decision and thus a higher or lower academic motivation, depending on the particular choice. Students could not see each other's responses, and thus provided a baseline of academic motivation for the students. This was also used to calculate a mean difference score for each pair (representing roughly how different the two in a pair responded for each dilemma). Afterwards, some of the pairs were placed into experimental conditions where they were asked to report on similar dilemmas and come to a joint conclusion about the outcome. Finally, the pairs were given a posttest similar to the first set of questionnaires. The students placed in the control groups did not discuss dilemmas with their peers.

This information was used to determine how much influence the friendship interactions had on the individual level ratings for the posttest. The findings showed that

pairs of friends that discussed the dilemmas shifted in their decision ratings after the discussion portion, suggesting that conversation between friends can influence attitudes, specifically those towards academics. Generally this shift was towards a more moderate belief or one that better reflected the combined average of each other's scores. Those students in the control condition did not change significantly between testing periods. These findings indicate that conversations among friends can modify a student's beliefs about academics, further suggesting the need to analyze friendship influences on academic motivation.

Critique of friendship research. It is clear that friendship plays a key role in shaping the beliefs, attitudes and behaviors of adolescents. However, the study of friendship may leave out other important peers who influence students but who are not their close friends. The peer group is comprised of those individuals with whom a student spends a lot of time and contains these additional interaction partners. Kindermann and Skinner (2010) observed in a study of 366 6th graders, that only 52% of reciprocal friends were members of a student's peer network, and only 27% of observed peers were reciprocal friends. Although a student's friends are important, by only studying friendships, researchers can miss out on those students whom the individual sits next to at lunch, are classmates with or perhaps with whom they spend time after school on the soccer team. Peer research aims to provide a broader understanding of social interactions by including these other frequent interaction partners in addition to friends.

Peer Interaction Networks

In his pioneering book *Who Shall Survive?* (1934; 1953) Jacob Moreno utilized what he then coined “sociometry” to explain a series of runaways at an all-girls boarding school. By gathering network data on the girls, Moreno developed some of the first social network maps, and was able to track the transfer of the idea to run away through the networks of girls and their friendships. Those girls who were connected with the girls who ran away were the girls who were most likely to runaway next, and as a result spread that idea to the other girls to whom they were connected. Here we see some of the earliest examples of peer influence and idea transfer through social networks in the literature.

Social Network Analysis (SNA) uses data to study the interconnectedness of nodes. A node is an individual within a network, whether it is a person, an idea, a location, etc. Nodes are connected to each other via edges, some common link that the nodes share. In the context of psychology, and specifically the study of adolescents, this link is often friendship. Utilizing information about social ties, one can construct a network and utilize that information to draw conclusions about friendship and its effects. The tradition of SNA has led to the area of peer interaction networks.

In this paper, the term *peer interaction network* is used as a label for the set of all of those peers with whom a person spends a lot of time. Although friends are members of a peer interaction network, so are other classmates a student sits next to, members of the student’s sports teams or clubs. Whereas friendships are not defined by the amount of time that individuals spend together, interaction networks are characterized by frequent *exposure*. Because of this constant face to face contact between members of interaction

networks, it can be assumed that those frequent interaction partners are influential. Indeed, research has shown that peer group affiliations predict changes in engagement over time (Kindermann, 2007). Additionally, most theories of friendship development assume that frequent interactions can lead children to become friends; thus peer interaction networks are also assumed to include candidates with whom children will form friendships in the future. This may make those individuals' influence even stronger. Whereas peers have frequent interaction, friends have both frequent interaction and they generally have a more emotional or intimate relationship.

Peer profiles and influence on engagement. Multiple studies have examined how peer interaction networks (peers, in this context, also including friends) can influence behavior. Cairns, Cairns and Neckermann (1989) focused on early school dropout. In this study, the researchers followed a cohort of 475 adolescents from the seventh grade each year through the eleventh grade. During this time they collected self-report (through interviews) and teacher-report data on the student's behavior, as well as peer network data and school records for dropout information. For those students who dropped out, follow up interviews were conducted in their homes rather than in school. What the researchers found was that students who had profiles of risk towards dropout were likely to be in peer groups with other students who had similar risk profiles. Likewise, the friends of students who dropped out were more likely to drop out further down the line. Students who were friends with students who dropped out in the seventh grade were more likely to dropout themselves before the follow-up in the eleventh grade (Boys: ICC $r' = .27$, $F(53/133) = 1.93$, $p < 0.01$; Girls: ICC $r' = .16$, $F(68/166) = 1.46$, $p < 0.05$). This

suggests that not only do students develop friendships with similar students, but also that their behavior patterns are similar.

The nature of peer influence, however, is a complex one. In a study of 929 children, Altermatt and Pomerantz (2005) found that high achieving and low achieving students often group together, with a predominance of one over the other. The interesting finding that the researchers reported was that although low achieving students who were friends with high achieving students tended to improve on their achievement over time, their self-evaluative reports tended to be lower than those of similarly performing peers with low-achieving friends. The assortative nature of peer groups would suggest that students would typically break these ties and join groups with similarly performing students. This was not the case, however, and the study showed that 63% of these low-achievers with high-achieving friends maintained their friendships over long periods of time, and thus benefited from the increased achievement over time. This study not only supports the claim of the effect of peers on achievement, but that it is a complex effect that is not only oriented towards achievement but also other factors in an adolescent's life.

Using social networks analysis techniques, Berndt, Hawkins & Jiao (1999) showed that the academic motivation of a student's friends predicted his or her own motivation after short discussions on the topic. Similarly, Kindermann (1993; 1996) showed that the engagement level of an adolescent's peer group predicted his or her change in engagement over time. In a longitudinal study of 6th grade students, Kindermann (2007) showed the effects of peer engagement on individual engagement

over time. The study used socio-cognitive mapping to gather peer network data, as well as student engagement in the form of teacher-report and self-report surveys. Peer profiles of engagement were created by taking the average of the engagement of a student's peers. Peer engagement in the fall significantly predicted ($\beta = .128, p < .05$) individual engagement in the spring, even after controlling for previous engagement, peer selection and parent and teacher involvement. Over long term exposure to their peers, adolescents were more likely to develop an engagement profile similar to each other. This evidence helps support the claim that friends and peers are influential on engagement.

Critique of current peer network research. When looking at peer influence, we are immediately interested in those individuals with whom a student interacts with face to face and on a regular basis. These, according to ecological systems theory (Bronfenbrenner & Morris, 1998), are the microsystem of peer interactions. Since these are the others whose ideas and attitudes will be directly experienced by the student, we would expect them to be the most influential. However, indirect effects of “friends of friends” are also potentially important, as these are the avenues of new ideas for peer relationships. The fact that most adolescents will be members of multiple groups allows for the transfer of ideas between groups, and thus it may be important to study the structure of the network as a whole alongside these individual level effects. This is where centrality and network characteristics may become important factors of influence, examining beyond the microsystem and looking at meso and exo-system effects.

Centrality

Centrality refers to a number of different measures that represent one's physical location within a network. It is defined differently based on the method which is used to calculate the centrality score. The basic thread these measures share is that they use an actor's location within the network, as compared to the others in the network, in order to calculate a score that represents this location. In the context of social networks analysis, centrality refers to the location of nodes or actors, which in the context of peer groups would refer to individuals. Centrality is calculated in a number of ways, but all of these measures take into account the paths by which nodes are connected.

Centrality in social networks was first introduced by Bavelas in 1948, for use in analyzing communication in small groups. He hypothesized that structural centrality within the network would influence communication and power (Freeman, 1979). Russo and Koesten (2005) showed that more central students to the email communication network in an online class showed significantly higher prestige (the degree to which others seek out a particular actor in a social network; $r = .80, p < 0.01$) and overall grade in the class ($r = .51, p < 0.05$). However, these types of networks are created through organizational necessity, and there has been little research on centrality in naturally occurring peer networks.

Centrality should be of interest to psychologists because it is an observable feature of the peer network that may underlie social characteristics of the individuals involved. The structure of networks, including centrality, has been shown to be influential in small groups (Russo, 2005). Through control of the flow of information, as

well as exposure to multiple attitudes and ideas, more central individuals may be the key to how influence occurs in the peer network.

Centrality and Information Transfer

Borgatti (2005) argues that the different forms of centrality are based on different assumptions about the nature of the network and thus may have different implications for analyses. As such, he argues that in the study of information or attitude transfer (the essence of which is social influence for members of a network) there are only three appropriate methods by which to calculate centrality: degree, closeness and eigenvector centrality.

Degree centrality (Freeman, 1979; Borgatti, 2005) refers to the number of direct connections that an individual node has. For example, a node that is connected to ten others would have a degree centrality of ten (if using a simple method of degree centrality). In the context of psychological inquiry, we could be viewing the immediate probability that an individual is exposed to attitudes and information (Borgatti, 2005). With ten connections, one would have ten opportunities of information transfer. Put more simply, having ten friends exposes an individual to that many more opinions and personalities that could influence his or her development.

Closeness centrality (Freeman, 1979; Borgatti, 2005) refers to those members of a network who are the least distant from all other members of a network. That is to say, the most central member of a network, when using closeness centrality as a measure, is the actor who has the fewest number of paths between him or her and every other individual in the network. Someone who is only removed from the other members of the network by

two or three people would have a higher closeness centrality than someone who was removed from other members of the network by five or six members. If one believes in the importance of friends of friends, or that ideas transfer across groups, then those individuals who are high on closeness centrality would be most important for the flow of information across groups. In essence, those who are high on closeness centrality are the gate keepers of knowledge across groups, as any transfer of knowledge across the larger network is likely to travel via these nodes.

Eigenvector centrality (Bonacich, 1972; Borgatti, 2005) is defined in statistical terms as the principal eigenvector of the adjacency matrix defining the network. “Unlike degree, which weights every contact equally, the eigenvector weights contacts according to their centralities. Eigenvector centrality can also be seen as a weighted sum of not only direct connections but indirect connections of every length” (Bonacich, 2007). Thus it takes into account the entire pattern in the network. In general terms, eigenvector centrality is a measure which takes into account not only the size of one’s group, but also accounts for how interconnected that group is with the complete network. Unlike closeness which is a more global measure and degree which is a more local measure, eigenvector uses both global and local information in its calculations. Eigenvector centrality has the benefit of taking into account the relative centrality of an individual node’s connections, and weighting its score accordingly. As such, being connected to other highly connected individuals will in turn lead to a higher eigenvector centrality score. So if an individual is connected to other individuals who are relatively highly central, then he or she will also be considered central, regardless of his or her own

number of direct connections. This means that someone who is low on degree or closeness centrality can still be high on eigenvector centrality if he or she happens to be connected to a few highly central (be they degree or closeness central) individuals. In essence, eigenvector centrality posits that it is not merely the number of connections that one has that matters, but also how interconnected they are with the network at large.

Figure 1 shows different centrality calculations for each node in an example network. Although this network was artificially created, we can see that node E is highest on eigenvector centrality (76.0), F is highest on closeness centrality (52.6) and G is highest on degree centrality (50.0). F being highest on closeness centrality is intuitively obvious, as it is most centrally oriented in relation to the rest of the network, that is, it is not very far removed from any other nodes in the network. G has the highest degree centrality, as it has the greatest number of direct connections. E is highest on eigenvector centrality, as it is connected to not only a large number of connections, but to highly central connections at that. The connection between B and E seems to give both nodes higher eigenvector centrality scores, as their diverse connections offer them a greater share of the flow of information through the network. This figure illustrates how different these three scores can be and thus the necessity for each one as measuring a different aspect of the network.

Review of Social Networks Research Methods

Although from a theoretical standpoint social networks have been studied for quite some time, the complex statistical techniques and tools needed to carry out appropriate analyses on the subject have only been around for a few decades. Social

network analysis is not without its problems. One issue with SNA is identification of networks and what they represent in the real world. Asking the correct questions is important to creating representative networks of the constructs of interest. Unlike much demographic data, network data are not concrete and easily identified. If one is searching for data on friendship, asking only about family members or classmates may leave out some other important actors. Socio-cognitive mapping provides one alternative method to data gathering than the traditional SNA method, and programs like UCINET make proper analysis of the networks easier to conduct.

Identification of Networks

Gathering data on peer networks has an inherent complication, in that the term peer or friendship often means different things to different people. Traditionally SNA data are collected via self-report and then reporter agreement is used to determine meaningful connections in the network (Freeman, White & Romney, 1992). Unlike trying to gather SNA data on organizational structure or family data, there are no clear delineations between connections and non-connections. One adolescent's idea of friendship may be different than another's. In this situation, there may be disagreement between the reporters. One way around this issue is to change the question itself. Rather than asking about friendship, researchers can ask about with whom the participants spend time. In this way you get at the heart of the issue and make it less up to interpretation. Whether or not someone is the friend of a participant, exposure to them on a regular basis could be enough to influence their attitudes.

As a more specific example, imagine a junior high school class was asked to report on who they spend time with. The results were as follows: Alex lists Brian, David and Michael; David lists only Brian and Michael; Brian lists Alex, David and Michael; Michael was absent from class on the day of data collection. In looking at this data as it stands, we see that David does not list Alex as spending time with him, even though Alex listed David as spending time with him. How is this reconciled? In mainstream social network analysis, only reciprocal ties are used to create maps (Ladd, 1983; Bukowski & Newcomb, 1984). So in this case, the map would consist of: David and Brian being friends, and Alex and Brian being friends (see Figure 2).

Here we see a problem with this methodology. First, in Michael being absent from testing, he has been removed from the network entirely. Since he cannot report on his peers he cannot have any reciprocal ties, leaving him as either isolated or removed from the network. We can assume from the others responses that Michael is an ever present peer: he was listed by all of the participants as spending time with them, but utilizing this methodology we cannot list Michael as such. In this way, Michael is lost to the network and his influence is removed, potentially skewing our view of the social map. Secondly, we also see what looks to be a group of friends here, and yet since David did not mention Alex as a friend, the network will appear as though Brian lies between David and Alex, but the two never interact. A potential solution to this issue is Socio-cognitive mapping.

Socio-Cognitive Mapping (SCM)

Socio-cognitive mapping (SCM) is a technique developed by Robert Cairns (Cairns, Perrin & Cairns, 1985) to address the issue of potentially lost data in social network analysis. SCM follows observational strategies and the students, who are expert observers of everyday interactions in school, should be the best informants. Proponents of the SCM technique argue that consensus allows for more accurate peer network representations than the traditional friendship models (Cairns, Leung, Buchanan & Cairns, 1995).

Instead of the traditional method of asking for self-report data, SCM utilizes observer-report data. Changing the nature of the question from “Who do you hang out with?” to “Who do you see hanging out together?” yields a greater amount of data. By treating the participants as experts in observing the networks within which they exist they are allowed to report on not only their own groups, but others as well. Often they will provide information on the groups that they themselves belong to, and this information can be confirmed with the data provided by the other participants. With SCM it has been suggested that with only half of the population responding, a reliable network can be generated (Cairns & Cairns, 1994; Kindermann, 2007) whereas the traditional method requires much more in order to provide a reliable network (as illustrated in the above example of the absent student). Especially in the school setting, where enrollment may change between time points and where students are often absent for data gathering, this greater flexibility is important.

If we looked at the same scenario as before utilizing the SCM technique of examining the data as observational reports, Michael would now appear in the network. Michael has been observed as being together with Alex, Brian, and David by all participating observers; there is high agreement. In SCM, connections between people are not determined by their own choices but by agreement among the many observers that these students are seen spending time together. Network information is then obtained about people who themselves have not participated in the survey. If human subject conditions do not allow for the inclusion of such individuals, the connection can still be used as a dummy coded variable so as to provide for the more accurate network thus preserving the structure. Likewise, the network that we see surrounding Brian may show a connection between Alex and David because of their often being listed as hanging out together. In this way we get a much more consistent looking network.

It is not as simple as just taking every observed connection as true. Some candidates are mentioned more than others, so these differences in observation frequencies make it necessary to apply rules to the specific ties that should be accepted. Several methods of determining significant connections from SCM data have been developed over the years. These methods share in common the use of co-occurrence matrices into which the network data is entered (see Table 1). Where the methods differ is in how they determine significant connections. The Cairns method (Cairns & Cairns, 1994; Cairns, Garipey & Kindermann, 1990) is the most commonly used of the SCM methods. This method utilizes a significant ($p < 0.05$) set correlation of .40 as the cutoff for connections. If the patterns of connections as reported by the participants are

significantly correlated at or above .40, then a connection is established. Shared significant ties with others are utilized to determine whether a larger peer group exists beyond the dyad.

The most common alternative method (Kindermann, 1993; 1996) utilizes binomial z-tests in the place of set correlations. Binomial z-tests are used to compare the cells of the co-occurrence matrix to respectively expected values; in detail, such tests are used to determine whether a connection is reported more often than should be accounted for by chance. The Fisher's exact test is used in conjunction with the binomial z-tests to account for problems associated with low expected cell frequencies for some of the connections. A significance of .01 in large samples is typically adopted on both tests in order to determine if a connection is used (Kindermann, 2007).

The conditional probabilities method of SCM is individual oriented as opposed to group oriented, which does provide several benefits. For one, it allows for individuals to be part of multiple groups. This is more representative of how we experience the world around us, as we are all parts of multiple groups: our family, our good friends, a sports team, our coworkers, etc. By not limiting individuals to being members of single groups we allow them to represent influence from multiple sources. Secondly, by allowing the information to be individually focused, we allow for the study of interindividual context differences, as members of the same group will have different extended group memberships and thus differing sources of influence.

There are some drawbacks to utilizing this method, however. Being that this method is based on observations, the only connections that can be found significant are those that are observable. That is to say, any relationships that exist outside of the context of the study (for instance, the school) may not show up in the data. Anything that is not public knowledge will be lost. Therefore, students who have secret relationships, which could be very significant to them, will not show up as significant in the data. It is therefore important to view these networks as being observed networks, and not necessarily the entire network as it exists. This, however, does not eliminate its utility as a method and it is questionable as to whether or not the traditional method would yield such connections either. This is a minimal issue in the context of research focused on frequent interaction as a means for influence. Regardless of whom someone's "true friends" are, those individuals that he or she are regularly observed around will interact with him or her quite a bit and therefore should yield some influence on the individual.

Another drawback to the SCM method is that, like most observational methods, it yields non-directional data. Unlike friendship networks which ask for students to report on their friends (as they perceive them), the SCM data only yields data to the extent of what is observed. As a result, we do not get the added benefit of those ties that are not shared. That is to say, if a student reports on someone being his or her friend and this is not reciprocated, the traditional method would normally call this unreciprocated and relational ties would not be derived. There are some methods, however (Borgatti, 2002) that instead use this data directionally, showing that while some relationships are reciprocated, others are one sided. This may yield interesting network dynamics and

statistics, and one could argue that unreciprocated friendships may be influential towards the target individual. The SCM data yields observed networks though, which should provide sufficient information about proximal others, and thus the processes that will influence the individual's attitudes. In this way, the lack of directional data may be seen as less of a drawback.

UCINET

The University of California at Irvine Network analysis program (UCINET) was developed by Steve Borgatti (2002) to aid in the derivation of social network statistics and subsequent analyses. UCINET can use both directional and non-directional data. The statistics package included with UCINET allows for the calculation of centrality measures, subgroup identification, role analysis, elementary graph theory, and permutation-based statistical analysis as well as matrix analysis routines including matrix algebra and multivariate statistics. UCINET also has the capability to draw network maps through the use of the program Netdraw.

The benefit of utilizing UCINET is that it contains a number of highly complex statistical tools that are normally very difficult and time consuming to perform. Specific to this study, the package contains a tool that can calculate Closeness, Degree and Bonacich's Eigenvector Centrality (Borgatti, 2002) for social networks.

Degree centrality is the simplest form of centrality, being based on the immediate network of each node. Degree centrality is simply calculated by taking the sum of the number of connections that a node has. In directional data this can be useful in knowing how many nodes lead into and out of a single node, but it is less useful when trying to

understand the network at the global level. In the adolescent context, this would be equivalent to focusing on an individual's immediate friends and not taking into account the influences of his or her friend's friends.

Closeness centrality, as stated earlier, refers to how far away an actor is from all other actors in a network. In UCINET this is calculated by taking the reciprocal of the *farness*, which is calculated as the sum of the distances from the ego node to all other nodes. This is referred to as the *nearness*. This can then be standardized against the minimum possible nearness for a network of its size, giving us a good measure for how connected a node is to the rest of the whole network. This is a highly globally focused measure of centrality that does not tell us a lot about how central the individual is to his or her own sub-groups. This would be the most appropriate measure for trying to find the handful of students who are the most salient in the school, or the most isolated ones.

Eigenvector Centrality

Bonacich (1972) proposed that to be more central, one not only has to be close to all other members of a network, but also has to be connected to other well connected nodes. In this way, one can be highly central even if they do not have a lot of immediate connections as long as they are connected to highly connected friends. By bridging multiple central groups, these individuals hold a lot of *power*, or influence on the other nodes. Through the use of factor analysis UCINET is able to calculate the most appropriate centrality scores for each node.

Bonacich's method of eigenvector centrality lies somewhere between degree centrality and closeness centrality; on the one hand, it is a measure of how many connections one has in the immediate. By calculating an individual's score based on the centrality of those they are connected to, it is primarily based off of an individual node's immediate network. On the other hand, because all of the scores are calculated as how central they are to the network as a whole it takes into account the global centrality that a node possesses. This method of centrality helps to not only find those individuals who are central to the network as a whole but also how central they are to their local network, which seems more appropriate for the study of a naturally occurring social network.

Measuring Social Influence

Solomon Asch (1951) conducted a series of influential experiments in which individuals were randomly assigned to groups in order to test the effects of the influence of confederate's statements on the target's perceptions of line-length. The confederates in the experiments were, to the target individuals, simply other participants in the study. The participants were shown a drawing of a line and then asked to pick from a series of three different lines which corresponded to the original line's length. In the control group all members responded truthfully, and few errors in responses were recorded. In the experimental group, confederates (who outnumbered the participants) were asked to respond erroneously and in unison. As a result, far more errors in response were recorded in the participants as a result of the group consensus.

When studying influence, we are searching for the degree to which an individual changes based on exposure to others in some fashion whether it be conscious or

unconscious, intended or accidental. When doing so in the social context, and especially in the peer context, there are a few issues that present themselves. The Asch studies showed that social influence is a factor of importance in human perception, but applying this experimental model to the real world is far more complicated than simply following this model.

People do not assort randomly: they select the people they surround themselves with, or the situations in which they encounter others. The Asch experiments were based upon an abstract and practically unimportant evaluation of a series of images. When interested in more deeply held beliefs and patterns of behavior that take time to develop, longitudinal analysis is needed to draw conclusions about naturalistic social influence. In the academic environment, engagement is one such factor. As a result, a portion of social influence research has taken to naturalistic observations and longitudinal studies. Unlike studying the influence of parents or teachers, in most research on peer influence the effect of selection is difficult to disentangle from influence. One needs to be able to control for selection effects for student's outcomes of peer affiliates. Since peer groups have the ability to change over time, what is seen as change in peer characteristics due to influence, could actually be change due to selection effects.

Additionally, when people are randomly assigned to one another in a group, they are a priori not similar to one another. Social influence among group members is then demonstrated by emergence of similarities within groups. In the real world, people tend to affiliate with people with whom they share similarities to begin with; similarity is usually assumed to be the reason why specific people affiliate and not others (Berndt, et

al, 1990; Kandel, 1978). In natural situations, influence can be studied as the extent to which an individual becomes more similar to those who are influencing them. For example, in the context of a study of alcohol and tobacco abuse (Urberg, Değirmenciođlu, & Pilgrim, 1997), it was found that individuals become more similar to one another in alcohol consumption over time, which was interpreted as influence.

Chapter 3: Purpose of Study and Research Questions

The goal of the current study was to examine the role of social networks in adolescents' classroom engagement by integrating two perspectives on peer influence: (1) peer profiles, which look at the characteristics of students' frequent peer interaction partners; and (2) centrality, which considers the relative position of a student in the larger peer network. To frame these potentially competing claims and complementary mechanisms, the study uses Bronfenbrenner's bioecological model, and specifically his description of contextual systems of influence.

Bronfenbrenner's model conceptualizes developmental contexts as consisting of multiple interacting levels (Bronfenbrenner & Morris, 1998). From this perspective the study of peer networks has, until now, focused on the level of the *microsystem*. Bronfenbrenner defines the microsystem as consisting of "patterns of activities, social roles and interpersonal relationships experienced by the developing person in a given face-to-face setting with particular physical, social and symbolic features that invite, permit, or inhibit engagement in sustained, progressively more complex interaction and activity in the immediate environment" (1995, p. 1645). Peer profiles can be considered a microsystem (or a set of microsystems, also called a *mesosystem*) because they include only those peers with whom a given student has direct and frequent face-to-face contact. In fact, within this area of research, these peers are selected explicitly because they are direct interaction partners, and are posited to be influential based precisely on the power of these frequent social interactions, or proximal process (Kindermann, 2007).

The three constructs of centrality that are the focus of this study, namely, degree centrality, eigenvector centrality and closeness, also include peers at the level of the microsystem. Degree centrality indicates the number of peers with whom a student has face-to-face interactions, and so is a marker of the size of that student's microsystem(s). However, unlike research on peer profiles, the other two constructs of centrality include peers with whom a student does *not* interact directly. Bronfenbrenner would call these peers an *exosystem* (or systems), which is defined as the linkages, processes, and relationships taking place between settings, at least one of which does not normally contain the developing person, but in which events occur that influence the processes within the immediate setting that does contain the developing person. Because the systems described by eigenvector and closeness centrality include the peers of a student's peers, they meet the criteria for an exosystem – these other peer interactions do not contain the developing person (i.e., the student), but the interactions may nevertheless influence the peers who do belong to the student's micro- or meso-systems. While the students may be expected to see each other in the school setting, and may even interact from time to time, these interactions would not be expected to be impactful. It is through frequent proximal processes that change is expected to occur, and this is only expected to occur through direct peers. These peers of peers would have an indirect impact on the student's development, however, through his or her immediate peers.

In order to consider whether (and how) the constructs of centrality can add to current research on the effects of peer profiles on students' engagement, it is necessary to, first, explain in more detail the conceptual and methodological strategies that have been

employed in research on peer profiles to date, including how peers are identified and profiles are calculated, the designs that have been useful in capturing the effects of peer profiles on individual change, and why those designs are essential for differentiating the effects of assortativeness from those of socialization. Second, more information is provided on the three constructs of centrality, and specific ideas are developed about how (and why) each one may enhance work on peer profiles. This chapter ends by describing the specific research questions around which the study is organized, which focus on how centrality can add to, complement, or differentiate research on peer profiles.

Peer System Processes

The essential elements and strategies used in this research can be illustrated by analyzing a recent study by Kindermann (2007), which showed the benefit of using peer profiles to predict change in adolescent academic engagement over time. The study included 366 6th grade students in upstate New York, which contained 87% of the 6th graders in the town. Socio-cognitive mapping was used to determine network characteristics and membership, asking students to report on which students they observed “hanging out” together. Space was provided for up to 20 groups of 20 members. No students exhausted the space so there is little concern that students were limited in their responses by the questionnaire. Student engagement was measured in the form of student and teacher-reports of classroom behaviors. Peer engagement profiles consisted of the average engagement of all of a student’s affiliates.

The study showed that peer engagement profiles in the fall significantly predicted individual engagement in the spring, even after controlling for previous engagement, peer

selection and parent and teacher involvement ($\beta = .128, p < .05$). This study provides a concrete example of the effects of frequent interaction partners on change in academic engagement. Although the coefficients are small, motivational factors such as engagement are not expected to drastically change in short periods of time.

Selection vs. socialization. It is worth noting that in studies of peer group influence, disentangling selection and socialization effects is important. Kindermann (1993) proposed that there are three methods by which peer groups can change and therefore influence their members: *Selection, elimination* and *socialization*. Selection refers to the addition of new members to the group, while elimination refers to the loss of members of a group, and socialization refers to those changes that occur between members of stable groups. It can be posited that the first two methods alter the nature of the group by maintaining the group goal, eliminating members that do not fit the general idea of the group, or adding new members that fit that model. Socialization is often what friendship and peer researchers are interested in, which is what occurs between those individuals who are exposed to each other over long periods of time and can be expected to have numerous, meaningful interactions. All of these effects will shape an adolescent's beliefs and behaviors, but when interested in mechanisms of change it is important to be aware of the differences and to be prepared to disentangle them.

Traditional correlation analyses have an inherent flaw in them when trying to assess causation, as directionality of effects is difficult to discern without time as a factor in analyses. With the addition of multiple time points, data at earlier time points can be used to predict data at later time points on the grounds that time has allowed us to show

in which order the effects were observed, thus allowing us to infer directionality and ultimately causality. With peer effects one has an additional concern, in that peer groups are constantly changing, so to be able to infer socialization effects it has to first be assessed that the peers of interest have been in contact between the two time periods. This is done through the use of peer stability measures, in which those peers who are measured as peer members at multiple time points are seen to be stable in their relationships. Peers who are no longer in a peer group at a later point are considered to be eliminated, and those new peers added to the group are seen to have been selected in. Thus, utilizing these measures it can be assessed as to whether an effect on a variable of interest (such as engagement) is due to socialization (an effect of stable peers), elimination (an effect of peers leaving the group) or selection (an effect of new peers entering the group).

There are, however, potential areas of improvement or expansion on this model of study. As the concern is with the effect of the peer groups on change in engagement over time, measures of network characteristics associated with the larger peer network could provide a richer understanding of the nature and mechanisms of influence in adolescent peer networks.

Constructs and Potential Mechanisms of Centrality

The current study seeks to expand upon this previous research with the addition of centrality as a predictor of change in academic engagement. As outlined in the previous chapter, there is reason to believe that centrality could aide in expanding our understanding of the mechanisms of peer influence. Although current methods of studying peer networks are concerned with the effects of frequent interaction partners,

they neglect to include information about a student's position within the network. Returning to Bronfenbrenner's bioecological model, the current model focusing on peer profiles is only considering *microsystem* effects, those individuals, institutions and groups that interact directly with the target individual. In the context of social network analysis, these would be the direct connections of the student. Bronfenbrenner's theory would suggest, however, that *exosystem* effects, (the effects on social others that do not directly influence a student, but indirectly influence them through their own connections) are also at play, indirectly influencing engagement outcomes in the model. In the peer context, this would be the "friends of friends:" connections that exist outside of the target individual, but that are influencing those peers who influence the individual. Centrality, which measures one's relative connectedness to varying degrees depending on the measure used, could provide an avenue for examining these *exosystem* effects.

The different measures of centrality as outlined in the previous chapter could provide differing levels of understanding with regards to exosystem effects. Degree centrality can be considered a *microsystem* measure of centrality, being focused on the immediate interaction partners of an individual. Closeness centrality can be considered the most different, being primarily concerned with the network as a whole, providing possibly the best metric for exposure to *exosystem* influences from the entire peer network. Eigenvector centrality would lie somewhere between the two measures, as it is concerned with the immediate connections of one's immediate connections, so it could give the best view into the once removed *exosystem* effects, or the effects of "friends of friends".

The above explanation is sound in theory, however so little examination has been conducted on measures of centrality within naturalistic peer groups that it is important to consider all possibilities and insure that testing takes into account other potential explanations of effects. One could expect that any centrality effect, especially regarding degree centrality, could just be a marker for some level of social aptitude. It has been well documented that having friends is beneficial (Altermatt & Pomerantz, 2003; Berndt, Hawkins, & Jiao, 1999; Ennett & Bauman, 1994; Poulin, Dishion, & Haas, 1999) and centrality may be just a marker for popularity or some other metric of attractiveness to others. It may also be expected that this social aptitude can lead to beneficial effects in general, independent of any peer influences, leading to a direct relationship between centrality and engagement.

With the above concerns in mind, the current study will use the multiple measures of centrality (degree, closeness and eigenvector) in a series of increasingly complex analyses designed to examine the role of centrality in the study of the effects of peer profiles on change in engagement over time, and whether centrality is a marker for other effects that play a role in the development of children's academic engagement in early adolescence.

Research Question 1: Is centrality related to student engagement? Does it predict change in engagement over time?

The first research question attempts to address whether or not any of the measures of centrality have a direct relationship with engagement, and whether each predicts changes in engagement over time. If being highly central is a beneficial position to hold

within the network, it can be hypothesized that this could spill over into other aspects of a student's academic career. For example, being highly sociable could mean the student is more capable or willing to ask questions in class, affording them a better understanding of the material presented to them. If centrality works on such a principle, we would expect to see a concurrent correlation, and it would be expected that such a correlation would be positive. Moreover, if centrality does provide access to more resources, or perhaps a buffering effect against negative life events, then it would be expected that highly central individuals will on average show greater increases in engagement over time.

This would have different implications depending on which specific measure of centrality showed such a relationship or if it were across all measures of centrality. For example, if degree centrality were to be highly predictive of changes in engagement over time, it could be posited that a larger number of immediate peers is beneficial to an individual's scholastic growth, potentially from a greater confidence or security with their social position within the school. An individual high on eigenvector centrality could be expected to be benefiting from being connected to highly-connected others, providing them with access to a diverse set of resources when in need. Similarly, a student high on closeness centrality could be expected to be benefiting from the effects of positive influence throughout the whole network, as they are not far removed from any source of change and thus the effect could be expected to "trickle down" to the individual. Obviously this question is a complex one and leads one to question how the student

views his or her relationships, and if his or her feelings towards the group influences these centrality effects.

Research Question 2: Is centrality related to relatedness? Does relatedness mediate the relationship between centrality and engagement?

The second question examines one possible explanation for why centrality could predict engagement – rather than being a marker of micro- or exo-system influences, perhaps centrality is important to engagement because it is a marker of relatedness or belongingness, which is a characteristic of the child.

The “belongingness hypothesis” suggests that humans have an innate need to form lasting, significant relationships with others (Baumeister & Leary, 1995). As part of the self-system model, relatedness refers to an individual’s feelings of belonging and connection to something, often parents, friends or teachers. In the context of peer research, relatedness is often referring to how connected and secure one feels with the peer group(s) within which one is embedded. Previous research has shown that feelings of relatedness to one’s peers are positively related to academic performance and engagement (Furrer & Skinner, 2003). The relationship between relatedness and centrality is one of particular interest to this study, as one may expect highly central individuals to feel more related to the peer group. The reasoning behind this explanation stems from the idea that being central to a group, specifically degree central, may be highly salient to an individual. As such, highly central students may view themselves as having a lot of friends. This may be comforting to the individual, providing him or her

with greater feelings of belonging because he or she feels that he or she has a large network of supportive other individuals.

This concept will be explored by examining the relationship between relatedness and centrality. If a relationship is found, then the nature of centrality can be shown to be intertwined with an individual's feelings of relatedness (although the direction of the relationship will not be possible to discern). Because of this issue, a second analysis will examine relatedness as a mediator for centrality predicting engagement change over time. This analysis is supported by the theory outlined above in which the salience of position within the network to the individual leads to increased feelings of relatedness. It could be that centrality's ability to predict change in engagement over time, as outlined in the first research question, is merely mediated by the effects of relatedness. Perhaps whatever effects are discovered for centrality are in actuality just an artifact of the effects of feeling a sense of relatedness to the group.

It could also be posited that the different forms of centrality allow for a student to be aware of his or her position within the network, to view it as something beneficial or positive (i.e., a student has many friends) and thus the student will feel more related to the group, which previous research suggests would lead to improved engagement. This latter example would be a mediated relationship in which centrality leads to relatedness which leads to change in engagement. Utilizing this rationale, it would be assumed that degree centrality may have a bigger impact on relatedness, as degree centrality (i.e., the number of a student's peer partners) would be expected to be the most salient to the student. Eigenvector and closeness centrality may be less salient, as the effects of these

two forms of centrality are expected to be more related to the exosystem, which by definition exists outside of the student's immediate relationships.

Research Question 3: Does centrality predict change in engagement over and above the effect of peer profiles?

Much like relatedness, the study of peer engagement through peer profile research has concerned itself with the microsystem effects of peers on the individual.

Theoretically, this is supported by the use of proximal processes as the means by which meaningful change occurs throughout development, and the research so far has supported these claims. Bronfenbrenner's model would suggest that exosystem effects are also at play in these influences, and yet are currently unaccounted for in peer profile research. Centrality may be able to expand this research; however it is possible that any centrality effects may in fact be artifacts of this previously researched peer effect. Theoretically, it is through these peers that the influence of centrality is occurring. It could be possible that once controlling for peer profiles the effect of centrality is lost, as the individual and immediate group level influences could account for the effects observed in previous analyses of centrality. If centrality is instead capturing micro- or exo-system effects, something removed from the immediate peers, the effect should persist.

To determine whether centrality enhances the study of the effects of peer profiles, it is important to examine whether any of the indicators of centrality predict changes in engagement over and above peer engagement. Past research has shown that peer engagement profiles predict change in engagement over time (Kindermann, 2007). As such, it is important to be sure to disentangle the effects of centrality from that of peer

engagement profiles. One could argue that in fact the effect of centrality on engagement is merely a marker for the peer profile effect. A greater number of peers could lead to greater influence, and similarly a higher centrality for the target individual, because one would have to have many connections in order to have many peers.

It is expected that eigenvector and closeness centrality will continue to be significant after the addition of peer engagement, as they are theoretically very different from the peer profile measures. They are the measures of exosystem effects, to varying degrees, and thus should not be heavily influenced by local effects. The pathways through which these exosystem effects reach the target individual is through his or her peers, so it is possible that the peer profile effects eliminate the exosystem effects once added to the model, as it may eclipse the exosystem effects. However, the theoretical framework of this study would suggest that exosystem effects would play a role in development above and beyond that of microsystem effects, simply because of their differing and non-salient nature, and that it captures an aspect of the student and his or her context within the school, rather than the student's immediate group (peer profiles).

It may be that the effects of degree centrality are somewhat altered by the addition of peer engagement profiles to the model, though it should not be expected to be lost entirely. Whereas degree centrality is a measure of the number of immediate peers an individual has, peer engagement is an average of the engagement of those peers. One student could have twenty peers, and another could have two, and yet their peer engagement profiles could be highly similar. In this example, one would expect the

mechanisms by which those averages affect the target individual to be different due to the differing nature of his or her peer environment.

Research Question 4: Does centrality moderate the effect of peer engagement profiles on change in engagement over time?

The final research question of the current study seeks to address the theory that centrality interacts with peer engagement profiles. In question 2, it was hypothesized that peer relatedness and centrality are related, such that those individuals who are highly central may have higher feelings of relatedness with their friends. This could be expanded to include the idea that being highly central may lead to more or less influence from peers. Those individuals, who are highly central, in having a large number of connections or in being highly central to the greater network, may be differentially influenced by their peers.

For example, an individual high on *degree* centrality may be expected to be more influenced by their peers. With a greater number of connections, or points of pressure, the target individual may be more likely to be influenced by their peers. Thus it would be expected that highly central individuals would show a greater peer engagement profile effect.

Alternatively, the reverse could be true, in which a student with a greater number of connections could be buffered from the effects of influence, changing very little over time. This would be because the greater number of connections the individual possesses would potentially “wash out” the effects of any one or two interactions, and thus the net effect would be to expect that individual to stay relatively stable, or as similar to the

average group member, as possible, while the less central members would be more effected by significant interactions, as they would have a smaller number of interaction partners.

Closeness centrality being a significant moderator of the peer effect on engagement could be interpreted as reflecting the effects of a diverse experience. Being high on closeness centrality says nothing about the number of immediate connections an individual has, but it does tell us where the individual is positioned in relation to the entire network. It may be expected that a student high on closeness centrality would show greater change in engagement, as he or she is the least removed from all of the other individuals within the network. It could be expected that the net effect of the entire network on the immediate connections of the individual would be significant, as there is a short distance between those individuals and the rest of the network. These immediate connections could then be very different in their exposures to ideas (from being so nearly connected to all of the available ideas within the network), leading to extreme belief and behavior differences between them. Thus the interactions between the individuals could be expected to be more intense due to increased diversity of experiences, and thus be more significant interactions. We would thus expect there to be more rapid or extreme change for those individuals who are high on closeness centrality.

With *eigenvector* centrality the effect would be somewhat more complex, but of a similar nature. Because the individual high on eigenvector centrality would be, by definition, connected to other highly connected individuals, it could potentially lead to a similar case as the one outlined in the previous paragraph. Because there are a large

number of peers just removed from the individual, the number of potential partners is high (and possibly salient to the student) along with the potential for diversity of those connections. It could be expected that the direct connections of the central individual are highly influential and significant. This would most likely lead to greater changes in engagement over time. Regardless of the observed effect, it is clear that this is a complex and interesting set of questions to address in order to expand peer network research.

Chapter 4: Methods

Sample

The data for this study came from an existing longitudinal dataset gathered by Skinner and Kindermann (Kindermann, 2007; Skinner, Kindermann & Furrer, 2008). The study was conducted in rural upstate New York. Data were gathered during the first year of middle school, in a town with a population of around 15,000, with about 90% being of Caucasian descent. Roughly 87% of the adults in the town had a high school education or above. The school was the only public school for 16 miles. The study was given approval by the University of Rochester and the local school board, and has continued approval from the Portland State University Human Subjects Review boards. Additionally, the Principal and teachers at the school also gave their support and approval of the project.

93% of the town's 6th graders (340 participants out of 366 total) participated, of which 48% were female. Proper consent procedures were followed, and parental consent was obtained for all 340 students who participated in the study. Although information on ethnicity of the students was not obtained, the information on the town as a whole suggests that the students at the school were predominantly of Caucasian descent.

At the school there were a total of 13 homeroom classes, with every student in the school being assigned to one. The homeroom teachers were selected to participate because they were familiar with their students and saw the students in class every day. All 13 teachers participated in the study.

Design and Measures

The study utilized student self-report, teacher-report and peer-report measures to collect data on the constructs of interest.

Student Engagement and Disaffection. Teacher report of student's academic engagement was assessed using a 14-item, likert type scale developed to tap teacher's perceptions of student engagement (Wellborn, 1991). The scale consists of two dimensions: behavioral and emotional engagement. Previous studies show the two to be moderately intercorrelated ($r = .31, n = 144$; Wellborn, 1991; $r = .72, n = 1,018$; Skinner, et al., 2008) and that they form an internally consistent indicator of engagement ($\alpha = .95, n = 144$; Wellborn, 1991; $\alpha = .90, n = 1,018$; Skinner et. al, 2008). Teacher ratings of engagement were also found to be moderately correlated with grades and achievement scores, ($r = .40$ in mathematics achievement, $r = .58$ in reading; Skinner& Belmont, 1993; Skinner et al., 1990) as well as being highly stable over an 8-month period ($r = .73, p < .001, n = 144$; Wellborn, 1991; $r = .78, p < .001, n = 1,018$; Skinner et al., 2008).

Engagement data were collected at two time points: once at the beginning of the school year in the fall and again in the spring. Of the 340 participants with permission to participate at time one, teacher-engagement reports were collected on 318 of them. At this time, seven of the 340 students had switched homerooms, another eight had just recently enrolled in the school and were therefore unfamiliar to the teachers, and the remaining seven had yet to arrive at the school.

In the spring, 18 of the fall participants had left, but those students that had been missed in the fall were now included, leaving a total of 322 participants at time 2. This

left a total of 300 students who had data at both time points (88% of those with permission; 82% of the population).

Peer Relatedness. Participating students themselves completed a 20-item self-report questionnaire created to measure their perceived relatedness with significant individuals, including parents, teachers and peers (Skinner, 2009). The questions were all formed from the same root, “When I’m with my (friends, classmates, father, mother or teacher)” and followed up with some emotional cue such as “I feel special” or “I feel ignored.” Student ratings were on a 1 to 5 scale (with appropriate reverse coding where necessary). For the purposes of this study, *peer relatedness* was utilized as an aggregate of the friendship and classmate variables of relatedness (8 items).

Demographics. Several demographic variables were collected as a part of this study including gender, grade and prior achievement. Gender has been shown in the past to influence achievement in schools, such that girls tend to be more motivated towards school and outperform boys consistently (Eccles, Wigfield, & Schiefele, 1998), suggesting it is important to control for gender effects in studies of engagement. Similarly, those who have performed well in the past can be expected to continue to do so and to be motivated in the future, so prior achievement is an important variable to consider. Grade level is also important, but as all of the participants in this dataset are 6th graders it is an unnecessary variable to include in analyses.

Peer Network. Student’s peer networks were measured using socio-cognitive mapping (Cairns et al, 1985). The participants were given questionnaires in which they

were asked to list groups of students that they saw frequently “hanging out” together. The students were asked to list as many groups as they could think of, to include dyads (groups of only 2), to include the same students in multiple groups if it was applicable, and to include themselves. The questionnaires had space for 20 groups, with lines for 20 members in each group, but no student ever used the entire space. Students were also asked to give each group a name when possible that would describe the group

In the fall, at the beginning of the school year, 280 students participated in the peer group nomination surveys, with roughly 56% of those participants being female. 53 children did not provide any information on peer networks, with either illegible or unanswered surveys, as well as the seven students who had yet to arrive at school. These 60 students were spread fairly evenly across homerooms and gender. In the spring, 219 students responded to the peer surveys to provide data on stability of the network.

The 280 participants nominated 3,047 group member nominations, for a total of 694 groups with a minimum of 2 and a maximum of 15 members each. The average participant nominated 2.7 groups with about 5 members each. In the spring, the 219 participants provided 3,590 nominations for 664 groups, with an average of 3 groups of 5.4 members provided by each student.

These nominations were arranged in a co-occurrence matrix (see Table 1) denoting the number of times two individuals were nominated as being in the same group. Utilizing binomial z-tests, the significance of the connections was determined beyond what would be expected by chance. Significant connections that were based on

single connections were omitted as they were most likely self-reports from single individuals and thus not reliable. After these criteria were met, the resulting map consisted of all significant co-nominations as reported by the students. As a test of reporters' accuracy, kappa indices were used to test for errors of commission (average kappa of .88, Kindermann, 2007). Errors of omission were excluded from reliability tests due to it being an unreasonable expectation to assume that all students would have the same information about the entire network (e.g. girls may know less about the boy's networks).

Network Measures. *Network size* was determined by the total number of direct connections an individual had, and will be used as the measure for *Degree Centrality* as they are fundamentally identical. *Group stability* was indicated by the number of a student's connections with group members that remained over time. *Group engagement characteristics*, or *peer engagement profiles*, were determined by averaging the teacher-rated measures of engagement across every member of a student's group (not including the target student). For example, if student A is listed as being in groups with B, C, D and E, then the average engagement score of B, C, D and E would be A's *peer engagement profile* score. This allows for the analysis of interindividual differences which is valuable as contexts vary from student to student and yet are independent of the individual. It is important to note that these peers are not necessarily connected to one another, and this measure is merely used as a marker for the average level of engagement that the target individual is exposed to by their immediate peers.

Centrality. The Time 1 (Fall) SCM data were used to calculate traditional network characteristics. Only those connections which were found to be significant utilizing the SCM analyses were considered for the network measures. *Network size* was used as the measure for *Degree Centrality*, the number of immediate connections that an individual has.

Closeness Centrality was measured utilizing UCINET's basic Closeness Centrality measure focused on minimum geodesic path distance from the ego to all other nodes in the network. The reciprocal of this minimum distance is then taken so as to allow higher scores to represent greater Centrality. Closeness Centrality is then standardized relative to the minimum possible closeness for a graph of the same size and connection.

Eigenvector Centrality was calculated using UCINET. The Eigenvector Centrality calculation utilizes the method developed by Bonacich (1972; 2007) in which Centrality is calculated using the equation $c_i = \alpha \sum A_{ij} c_j$ where "c_i" represents the target node and "A" represents the adjacency matrix. Utilizing factor analysis, the Eigenvector method creates a table of eigenvalues that best represent the true network and the corresponding Closeness Centrality scores for each individual. The Centrality scores calculated are thus based on the Centrality of those nodes to which the target nodes are connected. Thus the greatest eigenvalue (at least 2.0 or better) represents the model of Centrality that best represents the network and is thus used.

This method provides scores that represent a student's Centrality as it relates to both the immediate network of the individual as well as the global network, in this case the school. This is most appropriate when compared to Closeness and Degree Centrality, as these methods do not make any assumptions about the importance of specific connections. In Closeness Centrality, the focus is on those individuals that are most central to the global network and are thus the least removed from the other members of the group. Degree Centrality is concerned with those connections that an individual directly experiences, regardless of the network profiles of the individuals to which one is connected. The Eigenvector method weights each of the direct connections an individual has based on their Closeness to the entire network. In that way, each connection an individual has is no longer seen as equally contributing to their centrality, as a peer who is higher on Closeness Centrality will be given a greater weight in the Eigenvector calculation. As such, it gives us both pieces of information in one score, and the assumption is that this will better represent a naturally occurring characteristic of the individual. However, as Centrality has been little studied in this context, all three methods of calculation were explored in some part so as to help justify the use of the Eigenvector method.

Chapter 5: Results

Previous Research

Kindermann (2007) investigated the extent to which peer engagement predicted individual engagement over time. By observing peer groups using SCM, average peer engagement scores were calculated and used to predict changes in individual engagement from Time 1 to Time 2. The analyses were conducted using structural equation modeling (SEM; AMOS 5; Arbuckle, 2003) and controlled for the following variables: peer group size, gender, parent involvement, teacher involvement, academic achievement, percentage of same sex group members, person-to-group differences in engagement, and group membership stability.

Results from a fully-latent structural equation model suggested that peer engagement profiles in the Fall significantly predicted changes in individual engagement from Fall to Spring ($\beta = .128, p < .05$), and peer engagement profiles accounted for 2% of the variance in engagement in the spring when controlling for the variables listed above. This may seem small, but the nature of changes in engagement over time are thought to be a slow, ongoing process. This study considered only two time points that were six months apart, but one would expect this effect to cumulate and thus become greater over time.

This suggests that adolescents who associate with highly engaged peers will increase in their engagement over time (or merely decrease less over time than those with disaffected peers). Likewise, those adolescents who associate with students who are low on engagement will tend to decrease in their engagement scores over time. The current

research project seeks to expand upon the findings of Kindermann (2007; see Figure 3) by introducing the variables of Centrality as predictors of change in engagement over time.

Preliminary Statistics

Prior to analyzing the research questions, preliminary analyses were conducted in order to test for violations of basic assumptions. Analyses showed no major violations of assumptions of *normality, multicollinearity, heteroscedasticity, etc.* For all analyses of research questions, missing data were estimated using full-information maximum likelihood (FIML).

Descriptive Analyses

Mean levels were calculated for all variables of interest (Table 2). Kindermann (2007) reported about this data set which indicated that mean levels of children's engagement were high in both Fall and Spring ($M_s = 3.09$ and 3.08 respectively); the results were verified by re-analyses. Additionally, findings showed an average change in engagement over time of $.01$ ($SD = .40$) suggesting engagement is relatively stable over time. The new analyses showed that overall peer relatedness in the fall was also high, with a mean of 3.33 , suggesting that on average students felt highly related to each other.

On average, girls increased in engagement by 0.04 over time, while boys on average decreased in engagement over time by 0.04 . However, these trends did not constitute a significant difference in change in engagement over time (Kindermann, 2007). Taken together, these findings indicate the need to control for gender in subsequent analyses regarding Centrality.

The average of Degree Centrality (average group size) was 5 members. Closeness Centrality showed an average score of 1.16 ($SD = .301$) and Eigenvector Centrality showed an average score of 1.77, as well as a significant skewness ($SD = 7.8$, skewness = 4.612, $S.E = 0.128$, kurtosis = 21.140, $S.E = .254$). Because of the abstract nature of these two variables, interpretation of these means outside of the context of other analyses is difficult. Because of the significance of the skewness of Eigenvector Centrality, further analyses utilizing the variable took into account the potential effects of skew and accounted for these effects as they became apparent.

Correlation analyses were conducted among all variables of interest to determine important relationships between variables before conducting further analyses. Congruent with previous analyses (Kindermann, 2007), fall and spring engagement scores were found to be highly correlated ($r = .731$, $p < 0.001$), suggesting high stability in engagement across the school year. Similarly, peer engagement in the fall was significantly correlated with individual engagement in the fall ($r = .402$, $p < 0.001$), suggesting that the makeup of students' peer group engagement profiles are somewhat similar to their own engagement profile.

Degree Centrality was found to be significantly correlated with Eigenvector Centrality ($r = .368$, $p < 0.001$), suggesting that those individuals who have highly connected friends are also highly connected themselves. The relationship between Closeness Centrality and Degree Centrality was also found to be significant ($r = .361$, $p < 0.001$), suggesting that those individuals who are more central to the network as a whole

are also highly connected themselves. Eigenvector Centrality and Closeness Centrality were not found to be significantly correlated.

Boys were found to be more central to the peer network as a whole (Closeness Centrality $r = -.114, p < 0.05; t(326) = 2.070, p < 0.05$). Table 3 contains mean differences between boys and girls.

Gender. Correlations relating to gender showed several significant results, so further analyses using t-tests were carried out to determine the significance of differences between group means. Table 4 contains *t*-statistics and *p*-values pertaining to this analysis. Girls were found, on average, to be more highly engaged in both the fall ($r = .183, p < 0.01; t(364) = -4.289, p < 0.001$) and the spring ($r = .219, p < 0.01; t(364) = -3.553, p < 0.001$), and to associate with more highly engaged peers ($r = .213, p < 0.01; t(364) = -4.164, p < 0.001$). Additionally, girls were found to have larger groups on average (Degree Centrality $r = .274, p < 0.01; t(364) = -4.702, p < 0.001$) and to have more highly connected peers (Eigenvector Centrality $r = .256, p < 0.01; t(364) = -5.059, p < 0.001$).

Methods to Explore Research Questions

For all correlational analyses, the program AMOS 17 (Kline, 2011) was used to estimate structural equation models. These models were based on the Kindermann (2007) model in which individual and peer engagement in the Fall are used to predict changes in individual engagement between Fall and Spring, while controlling for gender and group stability. The benefit of using these models over standard regression or path analyses is that they allow for the use of engagement as a latent factor derived from the components

of behavioral and emotional engagement. Additionally, missing data were imputed in these models using FIML (full-information maximum likelihood). The original model is included in Figure 3.

When appropriate, multigroup models were examined to further explore the models of interest. When doing so, comparison of between-group differences were conducted utilizing critical ratio tests to identify significant differences in coefficients between groups, as outlined by Byrne (2010). These tests were carried out utilizing a program created by Gaskin (2012) that calculates z-scores based on critical ratio tests of the multigroup model and unstandardized estimates.

Research Questions and Analyses

The reporting of the results will follow the structure of the research questions as set forth in Chapter 3. When necessary, additional follow-up analyses will be included to clarify or expand upon the results.

Research Question 1: Is Centrality related to student engagement? Does it predict change in engagement over time? Bivariate correlations showed a significant relationship between Degree Centrality and overall engagement ($r = .194, p < 0.001$), suggesting that having a larger number of peers is associated with being more highly engaged in school. Closeness Centrality was also found to be significantly correlated with overall engagement in the fall ($r = .119, p < 0.05$), suggesting that those students who are more central to the entire network are also more highly engaged, while those on the periphery of the network are more disaffected. Additionally, a significant correlation was also found between Eigenvector Centrality and overall engagement ($r = .114, p < 0.05$),

suggesting that those students who have more highly connected peers are on average more highly engaged, whereas those who are in less connected groups are not as highly engaged. These findings are consistent with the hypothesis made earlier that being highly central, regardless of which centrality measure is being used, is a beneficial factor in terms of student engagement.

However, these correlations do not constitute sufficient evidence to draw causal inferences. It could be postulated that being highly engaged makes someone a more attractive social partner and thus could put them in a more central position within the network. Further analysis is needed to determine whether or not Centrality in any of its forms actually predicts changes in engagement over time.

To test the second part of research question one, SEM was used to examine whether the different forms of Centrality predict *change in engagement* over time. The complete models, with standardized estimates and control variables, can be seen in Figures 4.1-4.3. Closeness Centrality was not found to significantly predict engagement in spring when controlling for previous engagement, group stability and gender, with $\beta = -.04, p = .297$ ($\chi^2(5) = 5.372$, CMIN/DF= 1.074, CFI=1.00, RMSEA=0.014). This suggests that being highly central to the network as a whole does not directly influence changes in engagement over time. Similarly, Eigenvector Centrality also did not significantly predict changes in engagement over time when controlling for group stability and gender, with $\beta = -.01, p = .791$ ($\chi^2(5) = 5.297$, CMIN/DF= 1.059, CFI=1.00, RMSEA=0.013). This finding suggests that having highly connected peers does not directly influence change in engagement over time.

Degree Centrality, however, was found to significantly predict change in engagement over time when controlling for group stability and gender, with $\beta = -.12, p < 0.001$ ($\chi^2(5) = 8.438$, CMIN/DF = 1.68, CFI = .997, RMSEA = .043), but it had a negative effect. A graph of mean differences (see Figure 5) was created in order to examine the specific form of this effect. As the graph illustrates, those students who were higher on Degree Centrality in the fall decreased in their engagement over time, whereas those lower on Degree Centrality showed increases in engagement over time.

This is an interesting finding when taken in conjunction with the earlier results that in the fall those who were higher on Degree Centrality were more highly engaged. In terms of the model, those students who were lowest on Degree Centrality were shown to increase in engagement over time. This finding suggests that the number of direct connections a child has is related to his or her change in engagement over time, such that having *fewer* direct connections (or a smaller network) is beneficial to growth in engagement.

Further follow up analyses were conducted to explore this effect in greater detail. Multi-group analyses were carried out to explore the differential effects of gender, and how those students who have high engagement in the fall differ from those students with low engagement in the fall. Multi-group SEM compared the same model across genders and found that, descriptively, the effect of Degree Centrality in predicting change in engagement over time differed as a function of gender. It is important to note, however, that these effects were not found to differ significantly between groups when utilizing critical ratio tests. Regardless, the analyses showed that girls ($\beta = -.13, p < 0.05$) were

more influenced by Degree Centrality than boys ($\beta = -.10, p < 0.05; \chi^2(6) = 7.622$, $CMIN/DF = 1.270$, $CFI = .999$, $RMSEA = .027$). These results, while not significant, may show promise with further investigation in future studies.

An additional model, which compared students in the top-half of fall engagement to those in the bottom-half, also found descriptive differences in the effects of Degree Centrality. In general, highly engaged students were shown to decrease in engagement over time by .07 ($SD = .36$) on average, while students low on engagement were shown to increase by .07 ($SD = .49$) on average (see Table 5 for means grouped by engagement status). Specifically, the low engagement group ($\beta = -.12, p = 0.065$) was not significantly influenced by Degree Centrality, while students in the highly engaged group were ($\beta = -.17, p < 0.05; \chi^2(10) = 15.537$, $CMIN/DF = 1.554$, $CFI = .992$, $RMSEA = .039$). It is important to note, however, that these effects were also not found to differ significantly between groups when utilizing critical ratio tests.

Overall these findings support the importance of Degree Centrality in predicting change in engagement over time. Additional analyses showed that this effect is greater for girls, as well as for highly engaged students. Although no significant effects for Eigenvector or Closeness Centrality were found in this set of analyses, it is important to consider the possible impact of other factors on Centrality and how they may influence this effect. Further research questions seek to explore the relationship between the different variables of Centrality and their ability to predict change in engagement over time.

Research Question 2: Is Centrality related to relatedness? Does relatedness mediate the relationship between Centrality and engagement? To analyze the second research question of whether the pathway of the effects of Centrality on change in engagement was mediated by relatedness, the Baron and Kenny (1986) method of mediation analysis was applied. This method is a commonly used, three step method of analysis to determine whether a relationship between two variables is mediated by a third variable.

Bivariate correlations were calculated for all variables of interest. Peer Relatedness was found to be significantly correlated with engagement in both the fall ($r = .244, p < 0.01$) and the spring ($r = .177, p < 0.01$), as was to be expected from previous research (Furrer & Skinner, 2003). Peer relatedness was not found to be significantly related to gender, Eigenvector or Closeness Centrality (Table 6). Peer Relatedness was, however, found to be significantly correlated with Degree Centrality ($r = .138, p < 0.01$). Further analyses were conducted to determine whether or not a mediated relationship existed as outlined in the research question.

Analysis of mediation was conducted using the Baron and Kenny (1986) method in which several regression analyses were carried out in order to determine whether or not the relationship between Degree Centrality and Spring Engagement was mediated by Peer Relatedness. The results of all analyses can be found in Table 7. While Degree Centrality was found to be a significant predictor of both Engagement ($\beta = -.081, t(364) = -2.210, p < 0.05$) and Peer Relatedness ($\beta = .138, t(364) = -2.650, p < 0.01$), when Peer Relatedness was included in the final model to be tested, it was not found to contribute significantly to prediction of Engagement ($\beta = .006, t(364) = .165, p = .869$) and showed

no significant change in R^2 (*Model 1*: $R^2 = .541$, $F(2,363) = 214.030$, $p < 0.001$; *Model 2*: $R^2 = .541$, $F(3,362) = 142.31$, $p < 0.001$; R^2 change = .000, $F(3,362) = .027$, $p = .869$).

Thus, Peer Relatedness was not found to be a mediator of the relationship between Degree Centrality and Engagement.

Finding no mediation effect of relatedness does not entirely discount it as a measure of interest, however. Follow up analyses were conducted in order to explore the previous analyses for groups of students high on peer relatedness to those low on peer relatedness. Multi-group SEM compared models from the previous research question across groups and found that the effect of Degree Centrality in predicting change in engagement over time was descriptively different, though not significantly when utilizing critical ratio tests. Specifically, highly related students showed greater prediction of spring engagement by Degree Centrality ($\beta = -.14$, $p < 0.05$) while low related students showed no such effect ($\beta = -.06$, $p = .284$; $\chi^2(10) = 6.935$, $CMIN/DF = .694$, $CFI = 1.00$, $RMSEA = .00$). Examinations of the effects of Eigenvector Centrality and Closeness Centrality produced no descriptive or significant differences.

This finding is quite interesting, as it seems to suggest that feeling related to one's peers may influence the effects of Degree Centrality, even though no statistically significant relationship was found. Specifically, a student having feelings of high relatedness to his or her peers may be necessary for group size (degree centrality) to influence his or her change in engagement over time. It could be that there is a threshold of relatedness, in which students begin to be influenced by their peers once they reach a certain level of relatedness. Further analyses should consider this grouping as important

to explore in order to better understand the nature of the relationship between centrality and change in engagement over time.

Research Question 3: Does Centrality predict change in engagement over and above the effect of peer profiles? One potential variable accounting for the effects of Centrality on change in engagement over time is the engagement level (peer group profile) of one's peer group. Previous research has shown the significance of peer engagement as a predictor of change in engagement over time (Kindermann, 2007). It is important, then, to explore the relationship between Centrality and peer engagement, since Centrality is expected to influence an individual's engagement through his or her peers. The complete models with standardized estimates can be found in Figures 6.1-6.3.

Similar to research question 1, Closeness Centrality was found to negatively predict change in engagement over time, over and above the effect of peer profiles when controlling for group stability and gender, with $\beta = -.06$, $p = .089$ ($\chi^2(11) = 13.497$, $CMIN/DF = 1.227$, $CFI = 0.99$, $RMSEA = 0.025$) with marginal significance. It is important to note that Closeness Centrality as a predictor does approach significance in this model, suggesting that future analyses should not entirely discount the variable.

Because previous analyses found a significant correlation between gender and Closeness Centrality, correlations were examined across gender. Results from these analyses showed that for girls (but not boys), Closeness Centrality was significantly related to spring engagement ($r = .201$, $p < 0.01$). However, follow up SEM analysis using the entire model (restricted to the female subset of the data) did not show

significant prediction of spring engagement by Closeness Centrality with $\beta = -.07$, $p = .221$.

Eigenvector Centrality was also not found to significantly predict change in engagement over time, over and above the effect of peer profiles when controlling for group stability and gender, with $\beta = -.02$, $p = .491$ ($\chi^2(11) = 12.542$, $CMIN/DF = 1.140$, $CFI = 0.99$, $RMSEA = 0.02$). These findings are not shocking, as it was not hypothesized that the absence of peer engagement from the first model would suppress the effects of Centrality as a predictor.

In accordance with the earlier findings, Degree Centrality was found to negatively predict change in engagement over time, over and above the effect of peer profiles when controlling for group stability and gender, with $\beta = -.14$, $p < 0.001$ ($\chi^2(11) = 18.812$, $CMIN/DF = 1.710$, $CFI = 0.996$, $RMSEA = 0.044$). This shows that the effect of Degree Centrality as a predictor of change in engagement over time was not due to the effects of peer engagement. The overall model now shows that while having a larger number of peers is, by itself, detrimental to a student's engagement over time, this continues to be the case when controlling for peer group profiles.

Follow up analyses exploring multi-group SEM models found similar effects as those for research question 1. Multi-group SEM compared the same model across genders and found that the effect of Degree Centrality in predicting change in engagement over time differed descriptively as a function of gender. Specifically, girls ($\beta = -.19$, $p < 0.01$) were more influenced by Degree Centrality than boys ($\beta = -.12$, $p =$

.095; $\chi^2(16) = 28.234$, $CMIN/DF = 1.765$, $CFI = .993$, $RMSEA = .046$). It is important to note that these effects were not found to differ significantly between groups when utilizing critical ratio tests. An additional model, which compared students in the top-half of fall engagement to those in the bottom-half was also examined, but showed no significant differences between models.

Research Question 4: Does Centrality moderate the effect of peer engagement profiles on changes in engagement over time? Because the effect of peer engagement was found to be significant and related to Centrality, it is important to explore the potential interaction between the two variables. It is easy to hypothesize that if one is connected to many highly engaged peers, they may have a positive effect on change in engagement over time. The interaction between the two may be expected to be multiplicative, in which higher Centrality boosts the effects peers can exert on change in engagement over time.

However, similar to all previous analyses, Closeness Centrality was not found to significantly predict change in engagement over time, over and above the effect of peer profiles and the interaction between Closeness Centrality and peer profiles when controlling for previous engagement, group stability and gender, with $\beta = -.06$, $p = .224$ ($\chi^2(14) = 17.371$, $CMIN/DF = 1.241$, $CFI = .998$, $RMSEA = .026$). Additionally, the interaction between peer profiles and Closeness Centrality was not found to significantly predict change in engagement over time with $\beta = .03$, $p = .451$. The findings confirm that Closeness Centrality is not related to changes in engagement over time.

Degree Centrality was found to significantly predict (negative) change in engagement over time, over and above the effect of peer profiles and the interaction between Degree Centrality and peer profiles when controlling for previous engagement, group stability and gender, with $\beta = -.14, p < 0.001$ ($\chi^2(14) = 22.089$, $\text{CMIN/DF} = 1.578$, $\text{CFI} = .996$, $\text{RMSEA} = .04$). The interaction between peer profiles and Degree Centrality was not found to significantly predict change in engagement over time with, $\beta = .02, p = .521$. These findings support the earlier analyses, while suggesting that there is no interaction between Degree Centrality and peer engagement. In other words, group size does not appear to show a significant interaction with peer engagement profiles when predicting change in engagement over time. Thus, there do not seem to be levels of peer group engagement at which having many peers would be beneficial to students.

Finally, Eigenvector Centrality was also found to significantly predict change in engagement over time, over and above the effect of peer profiles and the interaction between Eigenvector Centrality and peer profiles when controlling for previous engagement, group stability and gender, with $\beta = -.24, p < 0.05$ ($\chi^2(14) = 15.891$, $\text{CMIN/DF} = 1.135$, $\text{CFI} = .999$, $\text{RMSEA} = .019$). Additionally, the interaction between peer profiles and Eigenvector Centrality was also found to significantly predict positive change in engagement over time, with $\beta = .23, p < 0.05$. However, due to the significance of the skew of the variable of Eigenvector Centrality found in earlier analyses, it was important to control for potential outliers in the data. To accommodate for this, further analyses were conducted in which the participants were grouped in terms of their

Eigenvector Centrality. The complete models with standardized estimates can be found in Figures 7.1-7.3.

Those students in the top quarter of Eigenvector Centrality ($N = 72$) were compared to the rest of the group ($N = 293$). The reason for this disparity in group sizes was due to the heavy, positive skew of the data in which most participants had an Eigenvector Centrality value of 0. Because of this skew, all inferences made about the effectiveness of Eigenvector as a predictor of Centrality will be purely exploratory and significance will be taken as merely evidence to pursue the study of Eigenvector Centrality in the future, not as evidence of a significant effect in the current study.

Multiple groups SEM found that the model separating the data into high-Eigenvector vs. low-Eigenvector groups fit the data well ($\chi^2(16) = 36.554, p < 0.01$, CMIN/DF = 2.284, CFI = .989, RMSEA = .059; Full models can be found in Figures 8.1-8.2). Peer engagement better predicted change in engagement over time for those students with high Eigenvector Centrality ($\beta = 0.278, p = 0.065$) than for those with low Eigenvector Centrality ($\beta = 0.103, p < 0.05$). Although the effect for the high Eigenvector group was not statistically significant at the $p < 0.05$ level, it was marginally significant at the $p < 0.10$ level. Additionally, the smaller sample size of that group ($N = 72$) would suggest the need for much greater effect sizes to detect change. A larger sample in the high Eigenvector group could be expected to produce more significant results. Figure 9 demonstrates the eigenvector interaction by comparing group means in engagement change over time for eigenvector centrality and peer engagement. This graph illustrates how the peer group profile effect is much stronger for those students who are high on

eigenvector centrality, showing mean increases over time, while those students who were low on Eigenvector Centrality showed a plateau or even mean decreases in engagement over time.

Assessment of between-group differences of the multi-group model found there to be no significant difference between the two groups in how peer engagement predicted spring engagement ($z = -1.383$). These findings are discouraging, however as stated earlier, the low sample size in the high-Eigenvector Centrality group may be influencing these tests. With a larger sample size, significance might be expected to emerge.

The findings from these analyses suggest that for those students who have high Eigenvector Centrality, the effect of peer engagement on changes in engagement over time is much larger. For those students who have highly disaffected peers, however, being high on Eigenvector centrality is negatively related their change in engagement over time. For the majority of those students who are not highly central, there is no such effect. This supports earlier hypotheses that having more highly connected peers will lead to a greater amount of influence from those peers. These findings must also be considered with a certain level of scrutiny, as skew is high, sample size is low, and significance is marginal at best. The overall conclusion from the Eigenvector Centrality analyses is that further studies are needed to draw conclusions about the variable.

Follow up analyses compared the same models across genders and found that the effect of Centrality (both Degree and Eigenvector) in predicting change in engagement over time was not significantly different across groups (nor intuitively different based on

the differences in estimates). Additional models which compared students in the top-half of fall engagement to those in the bottom-half were also conducted, but also showed no significant or interesting effects and suffered from the same issues of non-significant z-score differences between models.

Chapter 6: Discussion

Social networks analysis has contributed much to understanding peer influences on academic engagement and achievement during adolescence (e.g., Kindermann, 2007; Berndt, Laychak & Park 1990). The goal of the current research project was to add to these findings by examining the effect of a student's position within the social network at school as a predictor of change in his or her classroom engagement over time. In the literature, there is evidence that people (mainly adults) who are better connected and more central in a network and connected to powerful others, are better adjusted (Alina & Loredana, 2011), more successful (Cross & Cummings, 2004; Maria, 2010) and more productive (Yan & Ding, 2009). The current study found that within a cohort of 6th graders, a student's centrality at school may not only affect his or her own academic engagement in the classroom, but also make a difference to how he or she is influenced by those peers who are members of his or her peer group.

Summary of Findings

Three forms of Network Centrality were examined: Degree, Closeness and Eigenvector Centrality. Degree Centrality denotes the number of direct connections a student has to peers (i.e., group size). Closeness Centrality taps the extent to which students are most central to the greater network as a whole. Thus, Closeness includes indirect connections (peers of affiliated peers), and people high on Closeness are those who are the least far from all other members of the greater network. Eigenvector Centrality measures the interconnectivity of networks, since it is based on the Centrality of one's immediate peers. This gives more weight to those students who are not only

highly connected themselves, but who also have peer group members who are highly connected.

The first set of analyses confirmed existing findings on adults (Bonacich, 1987; Freeman et. al., 1992) that the three forms of centrality are moderately positively correlated. Thus, they are similar but not redundant. In addition, they were also positively correlated with students' classroom engagement. This suggests that being highly central is indicative of being well-adjusted and successful in a setting, in this case being highly academically engaged. Additionally, there were gender differences: On average, girls were higher in degree and eigenvector centrality, indicating that they had larger directly connected networks and were affiliated with better connected peers – of course, mainly other girls. Boys, on the other hand, were higher in closeness centrality, indicating that they had larger, more diffuse networks when indirect connections were included. Thus, gender seemed to play a role in how students formed their social networks at school.

Some of these findings, specifically the difference between genders in degree centrality, contradict a portion of the literature. Benenson (1990) showed that boys were found to have larger social networks on average. This finding was corroborated by several other studies that support the two cultures theory of childhood social groups (Maccoby, 1998; Rose & Rudolph, 2006). However, several other studies did not replicate these findings when studying adolescents (Ennett & Bauman, 1996; Urberg, Değirmencioğlu, Tolson & Halliday-Scher, 1995; Gest, Davidson, Rulison, Moody & Welsh, 2007). Some even showed that this effect diminishes as children transition into

adolescence (Cairns et. al, 1995). Because the current study was concerned with a cohort of sixth graders, the transitional model seems the best account of the current findings.

The overall goal of the study was to determine the role of network Centrality in predicting students' change in engagement over the school year. The direction of the relationship between Centrality and classroom engagement was further explored to determine if network position can predict future engagement. The role of centrality in student engagement differed depending on the kind of centrality considered.

Degree Centrality. Degree Centrality was found to predict changes in engagement, although contrary to expectations, this relationship was found to be negative. Although Degree Centrality was correlated positively with engagement in the fall, it was found to have a negative relationship when predicting changes in engagement from fall to spring. This finding is supported by previous research on group size (Kindermann, 2007); students who have larger peer groups tend to decline more in school motivation over time. Thus, Degree Centrality is beneficial towards engagement in the short term, but it may be detrimental over time.

Additionally, a gender difference was found: Girls' change in engagement seemed to be more effected by their degree centrality than boys'. Thus, girls seem to be more effected by the number of peers they have in their peer group. Since girls are typically more engaged in the classroom than boys, similar effects should be expected for students with different levels of classroom engagement. The data showed that highly engaged students' appeared to be negatively affected by degree centrality over time, while the

students who were low on engagement were not. One possible explanation for these findings could be that (at least some) students were juggling too many relationships, and that this came at a cost for more highly engaged students, while less engaged students suffered no such effects. In the fall, high engagement (a potentially attractive characteristic for social partners) may have given access to more peers which, over time, made it hard to maintain such high levels of engagement. In having so many peers to interact with, students may allocate more time to social endeavors, allowing their studies to fall by the wayside. It should be noted that a lack of such an effect for students who are already low on engagement could be representative of a floor effect in which students are not likely to drop below a certain level of engagement.

Since Centrality is determined by peer connections it is intuitive to assume that the effect of Centrality on change in classroom engagement occurs through peer interaction. Thus, further analyses explored the nature of Centrality and how it related to peer variables. The first set of analyses explored whether *peer relatedness* mediated the effect of Centrality on engagement. It could be expected that the extent to which an individual is affected by his or her peers is related to how that student feels about his or her peers. However, no such relationship was found.

This question was further explored by examining the differential effects of centrality for groups high on feelings of peer relatedness compared to those who were low on peer relatedness. Results showed that for students who reported high feelings of relatedness, the effectiveness of Degree Centrality in predicting change in classroom engagement over time was larger ($\beta = -.14, p < 0.05$) than for students who reported

feelings of low relatedness ($\beta = -.06, p = .284$). However, the groups were not found to be significantly different from one another. The overall lack of support for feelings of peer relatedness in these analyses is puzzling. Since the measure of peers in this study is focused on observed relationships rather than friendships, it could be that the frequency of interactions is the mechanism of change rather than the emotional strength of connections. Further studies should explore the relationship between relatedness and friendship groups as compared to peer groups. It could be hypothesized that in friendship situations the student's relatedness to his or her friends is actually highly important to how influenced he or she is by his or her friends. For the current study, however, peer relatedness was not found to be helpful in investigating the role of Centrality in academic engagement.

Finally, the effect of *peer group profiles* of classroom engagement and its interaction with the different forms of Centrality was explored to tease out the effects of Centrality from the direct effects of peers. Results showed that the effect of Degree Centrality on change in individual engagement over time was robust, not changing with the addition of peer group profiles and the interaction between the two variables. This finding suggests that there is something about group size that is directly related to individuals' classroom engagement, regardless of the psychological characteristics of the group (peer group profiles). It could be that being highly engaged in school allows for the acquisition of more peer members due to it being a desirable social characteristic. However, over time, this increase in number of peers leads to an increased amount of time spent focused on social relationships, and as there are only a finite number of hours

in the day, a decreased amount of time spent on school work. The juggling of multiple relationships could lead to an overall lack of attention paid towards school, or perhaps increases in disaffected behaviors (i.e., talking to peers in class, less attention to assignments due to social obligations, etc.). Regardless of whether or not those peers are highly engaged in school if, over time, they develop a greater proportion of time oriented towards social endeavors they may neglect their school work.

Closeness Centrality. Analyses examining the effect of Closeness Centrality on changes in classroom engagement over time showed no significant results. However, the model for research question 3 (which included closeness centrality and peer engagement as predictors of spring engagement) did approach significance ($\beta = -.06$, $p = 0.082$). This marginal significance could suggest a small effect of Closeness Centrality on change in engagement. The direction of this effect was negative suggesting that being more central to the entire peer network as a whole is detrimental to engagement change over time. Similar to the interpretation of the Degree effect this could be due to an overall focus of these individuals on social interactions with their peers, with school taking a back seat to their social lives. Whereas the degree effect was interpreted as being due to the number of peers that one interacts with, the Closeness effect may be due instead to the position within the greater network as placing a certain amount of pressure on the student. While he or she may only have a few connections, those connections may expose the individual to a number of diverse ideas and experiences which may make focusing on school difficult. As Closeness is not expected to be salient to the individual, the effect it has on his or her engagement is expected to be indirect. No significant interaction with peer

engagement profiles was found. This suggests that being highly central to the whole network does not alter the effect of peer group profiles on changes in individual engagement over time. This effect is similar to that of degree centrality in that network position was not found to interact with the effect of peer group profiles on change in engagement over time.

Eigenvector Centrality. Like Closeness, Eigenvector Centrality was not found to significantly predict changes in classroom engagement over time. However, when controlling for peer group profiles of engagement and the interaction between the two variables, a significant effect was found. While the main effect for Eigenvector Centrality was found to be negatively related to changes in engagement, the interaction between Eigenvector Centrality and peer group profiles was found to *positively* predict change in individual engagement over time. These findings, however, should be interpreted with caution due to significant skew of the Eigenvector Centrality variable. That being said, this finding is potentially quite exciting. It suggests that having highly interconnected networks could be beneficial for changes in engagement if those immediate connections are highly engaged. Interpreted in the inverse, being highly interconnected is detrimental for those individuals who have low peer group profiles of engagement. Another way of viewing this could be that for those students with highly engaged peer groups, being highly interconnected has a beneficial impact on changes in engagement. For those individuals who have highly disaffected peer groups, however, the impact of interconnected networks appears to be detrimental, or at least not beneficial, to changes in engagement. From the perspective of Bronfenbrenner, this suggests that *exosystem*

effects are present in changes in engagement, such that the number of peers that are indirectly connected to an individual will actually affect his or her individual engagement over time, even though there is no reason to expect that the two would directly interact. This suggests that peers are gateways to exposure and that the mechanisms of social influence extend beyond those individuals with whom a student directly interacts.

Gender Effects. Girls were found not only to have higher classroom engagement in the fall and spring, but also to have larger average increases in engagement over time. Additionally, girls were found to have larger peer groups. Due to these observed differences, many analyses explored the effect of gender on changes in engagement over time in the context of network position. Explorations of centrality yielded an interesting result in that girls' change in engagement was found to be more influenced by the number of peers they had (as opposed to boys). These findings suggest that the nature of social influence via network structure may not be limited to merely the direct effects of network position, but may also be shaped by the characteristics of the child, specifically, his or her gender.

Relatedness. Another intuitive avenue of interest to explore in the context of peer influence is relatedness. As students are being influenced by one another, it is easy to assume that this effect may differ based on how the student's feel about each other. To account for this, peer relatedness was explored as a potential mediator of the effect of centrality on change in engagement. It was hypothesized that a student's feelings of relatedness to his or her peers would increase how influential those peers were, specifically towards changes in engagement. If students had lower ratings of relatedness

towards their peers, they may be expected to be influenced less by them. Such an effect would reduce centrality's impact on engagement as peers are the means of change through centrality. However, no such relationship between relatedness and the other variables of interest was found.

However, when explored in a multi-group model (i.e., high vs. low relatedness groups) there did appear to be a moderator effect. The multi-group model showed that the effect of Degree Centrality in predicting change in engagement was greater for the highly related group, while the low relatedness group showed no significant effect of Degree Centrality. This suggests that feeling highly related to a student's peers may be necessary for the number of peers he or she has to negatively affect his or her change in engagement over time. It could be that there is a threshold of relatedness, in which students begin to be distracted by their peers. This seems intuitive, as it suggests that for there to be any effect of the number of peers an individual has, he or she must actually feel related to them.

Another possible interpretation of the lack of expected effects of relatedness could be that the relatedness variables used are inadequate to answer the question at hand. The current variable asks students to give an overall rating for their feelings of relatedness towards friends and classmates. Underlying this variable is an assumption that this average level of relatedness applies to all of a student's connections. An ideal variable would assess the differing levels of relatedness for each peer that a student had significant contact with. As the hypothesis relies on the idea that feeling related towards peers alters

their levels of influence, a measure of how the student feels towards the specific peers in his or her group might allow for a clearer test of the hypotheses of this study.

Network Centrality in the 6th Grade School System. Overall, the findings of the current study support the notion that network position may be an important characteristic to examine when concerned with peer influence, specifically as related to classroom engagement. Degree centrality showed consistent effects across models, suggesting that having more peer connections may be beneficial in the short term, but ultimately leads to detrimental effects on engagement in the long run. Eigenvector centrality showed amplifying effects on peer engagement, but further analyses concerning this kind of centrality are needed before firm conclusions can be drawn to support the findings due to a number of problems with the indicator in the current study.

The importance of these findings is that they add complexity to the growing model of understanding peer group influences in the school system. In being concerned with engagement, a direct predictor of future achievement, these findings can help to optimize the school setting so as to improve achievement for adolescents. Utilizing network characteristics, educators and interventionists can identify points of leverage with which to interact to improve the engagement (and subsequent achievement) of those students who would benefit the most.

Strengths and Limitations

There are a number of strengths to this study that give the findings merit. First, the setting within which the data were gathered was a small rural town that had only one

middle school, meaning that inclusion of all potential network members within the study was far more likely than in a more diffuse, urban setting. The study also used SCM assessments (participant observations) and not student self-reports to establish social networks. Together, this means that the social network data are comprehensive, accounting for what would be expected to be *all* of the significant connections for the 6th graders for whom data was gathered. This allows for the conclusion that there are not likely any “truncated” networks in which individuals are missing due to lack of information.

In most studies of this nature, it is hard to tease out the importance of peer relationships outside of school as compared to those within. Kiesner (2003) observed differences between in-school and after-school groups for adolescents. The study found that both group settings provided unique contributions to predicting specific problem behaviors in the students. This highlights the importance of being as inclusive as possible in conducting social network analysis research. There are a number of arbitrary boundaries put in place that determine who goes to which schools, and thus some of a student’s most significant relationships could be missing from the study. In the current dataset, however, we know that the vast majority of the children who were of the appropriate age in the area were accounted for. In addition, group names were gathered in the original study (Kindermann, 2007) and those suggested that many of the identified peer groups were groups of people who met outside of school (i.e., “soccer team”). Finally, instead of relying on self-report markers for friendship, the study utilized a form of other report through SCM. As stated earlier, this allows for a more complete data set,

because SCM utilizes participant observers and as a consequence, no one is excluded. Thus, the chance of those outside influences having a spurious effect on the data was greatly reduced.

A second strength comes from the use of significance tests to identify students' peer group members, which filter out noise that would potentially interfere with the accuracy of the networks. By relying on consensus, the network information gathered from these data is highly reliable, as simple mistakes in reporting would not be expected to occur across the whole group (average kappa of .88, Kindermann, 2007). As these children are "experts" in the social context to which they belong, it is expected that the rich data they provide are highly accurate.

Third, with regard to Centrality as an observational measure, SCM leads to higher inclusion rates of individuals who may not have provided information on their peer groups. Thus, it would be expected that all three measures of Centrality would be more accurate in this study than in nomination-based studies; the measures were based on all individuals in the town, rather than a subset of individuals from a school. The central assumption was that people's amount of connectedness with one another makes a difference for how peer influence processes occur in school. This emphasizes the importance of having complete and accurate network data. Having the entire town represented makes it highly likely that the characteristics of the network are complete, and thus the Centrality indices could be expected to be more accurate.

Fourth, the use of time as a factor lends strength to this study. Any study that seeks to draw conclusions about influence processes needs to contain a component of time (Kindermann & Gest, 2009). Without it, causation cannot be determined, and variables can only be related. By including this time element, we are able to utilize individuals as their own controls in order to tease apart what is predicted by a student's initial classroom engagement level, and what role the other variables of interest play in developing engagement. This is especially important in peer group studies, since group member selection processes are expected to be strong. In this study, peer influence processes were examined over and above (prior) peer selection processes.

As with any research project, there are a number of potential *limitations* to this study as well. First, there is never the ability to tease out all potential spurious variables involved in putative causal effects. There could be other variables that were not examined at play here, influencing the relationships the study sought to understand. However, when using individuals as their own controls in analyses of change over time, many such variables will be controlled already on an individual level, so this helps to reduce some of these potential problems.

Second, the age of the data is another factor that may influence its applicability. Since the study was first carried out in the 1990's, the nature of peer interaction among adolescents may have shifted dramatically. With the advent of computer technologies, the internet, cell phones and social networking websites, the ways in which adolescents interact now could be qualitatively different from the ways in which they interacted only

fifteen years ago. Some research suggests, however, that this is not necessarily the case (Kiuru, Aunola, Nurmi, Leskinen & Salmela-Aro, 2008).

Regardless, one could argue that websites like Facebook and the use of cell phones for constant communication at least open up the possibility of selection processes that may differ from those in which peers are sought out based on classroom contacts. Adolescents have numerous new avenues to find like-minded individuals within the greater community with whom to pursue possible friendships that may not have been previously available due to a lack of proximity. With these new technologies, peer selection may have become a much more streamlined process. Still, face-to-face interactions are expected to be the most important factor in influencing meaningful changes in beliefs and behaviors, so the findings from this study should still be applicable today.

Third, another issue with this study is the demographic homogeneity of the participants. The students in the study were predominately white and middle to lower middle-class. There are no comparison groups of other communities within the data, so the findings are also limited to representations of one specific community. Additionally, the students were all in the sixth grade, so applying this data to other age groups would be difficult to justify. Further studies would benefit greatly from a more diverse dataset across ethnicities, communities, and age groups.

Fourth, in regards to the peer context, only *peer groups* were studied, which are a salient and arguably more general measure of regular social interaction (akin to the

crowds of earlier research). There are other important aspects to peer interactions that were left out including friendship and “enemies” (those others who are actively avoided). These other variables are harder to define (e.g., what level of intimacy constitutes a friendship over an acquaintance?), harder to measure (e.g., how does one accurately and ethically determine those individuals that someone avoids or is potentially afraid of?) and yet arguably more important than peers. However, it is probable that these relationships are born out of the peer context. By observing peer interactions we allow ourselves to view potential friends, thus justifying the peer context as an important factor in individual change over time.

Fifth, a limitation of the data that has been reported on throughout this study is the significant skew of the value of Eigenvector Centrality. Because of the theoretical basis and the lack of other research on the use of Eigenvector Centrality as a variable, the findings utilizing this variable were included so as to provide a basis from which to further pursue the use of this measure. These findings, however, should not be used as a means of interpreting the effect found in this specific study, merely as a means by which to justify exploring this variable in the future, and possible directions to pursue. Split group analyses were utilized to try and account for outliers; however the reduced group size limits the capacity to detect significant effects and the interpretation of such effects. Further studies would benefit from larger sample sizes to potentially account for this issue.

Sixth, the use of teacher-reports as a measure of classroom engagement is both a strength and a limitation. Teacher reports give us consistent measures across a classroom,

as well as avoiding “self-enhancement” bias. However, what they miss are the internal states, such as emotions that are not visible to others. This measure relies on teachers being astute observers of the student’s behavior and emotional states. It is easy to suggest the potential for teachers to be unaware of some of the less obvious markers of motivation. Future studies would benefit from the addition of student measures of classroom engagement, specifically emotional engagement.

Finally, there are other potential areas of limitation that could be improved upon in the future. One may be the time frame. As was stated earlier, changes in classroom engagement are expected to occur slowly over time, and thus it would be beneficial to analyze these relationships over longer periods of time with a greater number of time points. It would also be valuable to examine how changes in the peer context over time influence, or are influenced by, these variables. However, as classrooms and teachers change from year to year, the complexity of such analyses becomes much more difficult. As peer data were only analyzed at one time point, there was no opportunity to explore such factors. Finally, the mechanisms of change were not explicitly studied, only the context. Although theoretically this model supports SDT, it would have been constructive to examine specific behaviors and interactions that lead to change in engagement over time.

Potential Implications and Further Studies

This study has shown that a student’s number of peers plays a key role in how his or her academic engagement develops. Additionally, findings from this study suggest that the nature of peer influence can be qualitatively different depending on a student’s

position within the social network. Through the use of Eigenvector Centrality, exosystem effects were found to play a role in influence processes, and as a result future studies in this field should consider the entire network when trying to draw conclusions about peer effects.

The nature of the relationships found in this study may give reason to explore the impact of peers on academic engagement more thoroughly in future research. While Degree Centrality was found to be beneficial in the short term, it showed negative effects over time, in regards to engagement. While this may be immediately interpreted as peers having a detrimental effect on overall academic engagement, we know from the literature that having close social relationships is beneficial to mental health as well as academic growth. The Eigenvector interaction indicates a further layer of complexity, whereby the position within the network may be differentially impactful depending on the level of engagement the individual is exposed to by his or her immediate peers. What the results of this study indicate is the need to further explore the impact of Centrality in all forms, which will allow for the better understanding of the processes that underlie the changes in engagement that we see in adolescents as a result of social interactions.

One of the most important aspects of network analysis is that it is based on the idea that a social network or situation is an observable phenomenon. Unlike most other variables typically used to predict achievement and engagement which are generally internal (perceptions of ability, attitudes, etc.), exist outside of the school (parent/family relationships), or cannot be altered by intervention (demographics, SES), peer networks are something that can be observed in the classroom and at school. Centrality, as well, is

something that should be readily observable. Those students who are highly central, as well as those who are isolates, will most likely be easy for educators to spot due to the frequency and breadth of interactions that are observed on a moment to moment basis.

The observable patterns of connections could be intuitively used by educators to carry out simple interventions to alter a student's exposure to other students in order to improve their engagement, such as modifying seating arrangements. Van den Berg (2012) showed that one such intervention increased feelings of liking towards other students when seated closer to one another, and it would not be a stretch to assume that this could lead to future peer relationships. In light of the results of the Eigenvector interaction, one could alter the seating arrangements to expose an individual to more highly engaged others who are also highly interconnected. The results of this study suggest that the target individual would benefit from such an intervention in his or her changes in engagement over time.

The skewness of the variable of Eigenvector Centrality has pointed out the importance of understanding how different networks are influential. Students who are isolated or within relatively self-contained networks would score lower on Eigenvector Centrality. The findings from this study suggest that the nature and impact of peer influence is different for those individuals. Further analyses should examine the different kinds of sub-networks that exist within a complete network. If there are students who do not appear to be connected to the rest of the network, or at least are not connected to any highly central individuals, then they may have a different profile of influence. The central individuals of those smaller groups may be more influential, or they may behave

differently than the greater network entirely. While current research has often looked at the impact of peers as being the same for all individuals, results from this study indicate that future research may benefit from investigating contextual differences between groups, as they may be expected to alter the nature of the impact of peers.

Another possible focus for future research in this area is how social networks change over time. Being able to identify the stability of Centrality over time and the stability of social partners could be crucial to understanding peer influence processes. Those individuals who have stable peer groups may in turn be more stable in their classroom engagement than those with volatile ones. The opposite could also be true, in that more stable groups may foster experimentation in behavior as they are more secure in their connections, where volatile groups may suggest stability in the individual's personal beliefs and behaviors, as they are still developing a commonality with the group. Additionally, these volatile groups may be selecting and eliminating members based on relative fit with the group, whereas stable groups would be expected to be undergoing processes of socialization. Stability in Centrality measures could help to provide a method of identifying those individuals who are at risk for isolation or elimination. This could allow for interventions targeted at altering these students' behaviors to help them reconnect with the larger peer group, helping these peers to avoid the negative effects of not forming close friendships.

The nature of how the different variables of Centrality are interrelated may be another area of interesting future research. The current study examined the different measures of Centrality as if they were completely different from one another.

Correlations showed, however, that there is some relation between the variables. This leads to interesting questions about how the different forms of Centrality may interact. One could imagine that highly central groups could become connected to one another, in which highly Degree central individuals are also becoming interconnected with other highly connected (Eigenvector Central) individuals. If certain students are more concerned with their social lives than school, it could be expected that their networks would also become highly interconnected. Future studies could find that peer group profiles are even more influential for those students who are high on multiple measures of centrality rather than just one.

The findings from this study have supported the need to take into account the effects not only of local social partners, but also of the network as a whole, when considering change in academic engagement. There is still much work to be done in order to expand upon these findings and gain a greater understanding of the mechanisms of social influence. Regardless, it is clear that not only do peers influence each other, but whole networks are a key context of interest in understanding change. As Bronfenbrenner theorized, the exosystem may exert influence on the microsystem; In this case, Centrality influences peer groups which in turn influence the individuals embedded within those peer groups. Future studies in this field should consider such exosystem effects when drawing conclusions about patterns of influence based on social networks.

In the field of education, finding levers upon which to act in order to improve motivation towards school is crucial. During adolescence, where we see a difficult transition, greater social orientation, and great declines in both achievement and

engagement, this is truer than ever. The current study has expanded on previous research into the effects of peer groups and social network position on changes in academic engagement over time. While practical application of the statistical methods utilized here will take further studies to expand upon these findings, from a theoretical stand point there appear to be reasons to conduct such research. Understanding the social landscape of adolescents that much more puts us one step closer to being able to truly understand what it is that motivates adolescents in the school environment. In a world where education is becoming increasingly necessary to grow into a functioning member of society, it is important that as psychologists we explore every possible avenue to improve the likelihood of a successful school experience for all students.

Appendix A: Tables

Table 1

	KER	RYB	DAL	COD	SUO	ROM	STQ	CHR	KAA	KAW	ELT	JEP	LIP	Total Nominations
KER	-	28	23	12	10	3	3	0	0	0	0	0	0	36
RYB	28	-	20	11	12	3	4	0	0	0	0	0	0	32
DAL	23	20	-	10	9	4	2	0	0	0	0	0	0	28
COD	12	11	10	-	19	8	13	0	0	0	0	0	0	29
SUO	10	12	9	19	-	9	10	0	0	0	0	0	0	29
ROM	3	3	4	8	9	-	4	0	0	0	0	0	0	11
STQ	3	4	2	13	10	4	-	0	0	0	0	0	0	17
CHR	0	0	0	0	0	0	0	-	10	10	9	10	0	14
KAA	0	0	0	0	0	0	0	10	-	13	13	12	0	16
KAW	0	0	0	0	0	0	0	10	13	-	13	10	0	17
ELT	0	0	0	0	0	0	0	9	13	13	-	10	0	18
JEP	0	0	0	0	0	0	0	10	12	10	10	-	0	13
LIP	0	0	0	0	0	0	0	0	0	0	0	0	-	24
No. of Informants														260
Total Nominations														3047
No. of Groups Generated														694

Subset of a cooccurrence matrix of girls in 6th grade (Kindermann, 2007)

Table 2
Means and Descriptive Statistics

	n	Mean(sd)	Min	Max	Skewness
Std. Eng. Fall	366	3.09(.59)	1.45	4	-.156
Std. Eng. Spring	366	3.08(.66)	1.18	4	-.355
Peer Eng. Fall	366	3.11(.36)	1.69	4	-.145
Sex	366	1.47(.5)	1	2	.110
Peer Relatedness	366	3.35(.55)	1.5	4	-.79
Degree	366	5.13(3.67)	0	15	.41
Closeness	328	1.16(.301)	.2740	1.3	-2.59
Eigenvector	366	1.77(7.19)	0	44.61	4.65
Engagement Change	366	.01(.40)	-1.48	1.32	-.076

Table 3

Mean Differences Grouped by Gender

	n	Mean	SD
Std. Eng. Fall	173(193)	3.19(2.98)	.53(.59)
Std. Eng. Spring	173(193)	3.23(2.94)	.58(.63)
Peer Eng. Fall	173(193)	3.19(3.04)	.32(.37)
Peer Relatedness	173(193)	3.38(3.33)	.57(.52)
Degree Closeness	173(193)	6.05(4.30)	3.85(3.29)
Eigenvector	169(159)	1.13(1.19)	.34(.25)
Mean Eng. Change	173(193)	3.71(.024)	10.12(.11)
	173(193)	.04(-.04)	.40(.40)

Note. Means reported as Female (Male).

Table 4

Results from T-Test of Gender

	<i>df</i>	<i>t</i>	<i>p</i>
Degree	364	-4.702***	.000
Closeness	326	2.070*	.039
Eigenvector	364	-5.059***	.000
Fall Engagement	364	-4.289***	.000
Spring Engagement	364	-3.553***	.000
Peer Engagement	364	-4.164***	.000

Note. *** $p < .001$, ** $p < .01$, * $p < .05$.

Table 5

Mean Differences Grouped by Engagement

	n	Mean	SD
Std. Eng. Fall	183(183)	2.60(3.56)	.34(.30)
Std. Eng. Spring	183(183)	2.67(3.49)	.53(.42)
Peer Eng. Fall	183(183)	2.97(3.25)	.34(.32)
Peer Relatedness	183(183)	3.33(3.34)	.58(.66)
Degree Closeness	183(183)	4.29(5.96)	3.56(3.60)
Eigenvector	151(177)	1.14(1.17)	.32(.28)
Mean Eng. Change	183(183)	1.42(2.12)	6.83(.7.53)
	163(166)	.07(-.07)	.49(.36)

Note. Means reported as Low Engagement (High Engagement).

Table 6
Correlations Among Variables of Interest

	1	2	3	4	5	6	7	8	9
Std. Eng. Fall	1								
Std. Eng. Spring	.731**	1							
Peer Eng. Fall	.459**	.402**	1						
Sex	.183**	.219**	.213**	1					
Peer Relatedness	.244**	.177**	.146**	.046	1				
Group Stability	.056	.067	.023	.011	.009	1			
Degree	.236**	.096	.241**	.274**	.138**	.063	1		
Closeness	.098	.028	.203**	-.114*	.017	-.020	.361**	1	
Eigenvector	.114*	.112*	.167**	.256**	.026	.071	.368**	.064	1

Note. *** $p < .001$ ** $p < .01$ * $p < .05$.

Table 7

Results from Baron and Kenny Mediation Analyses

	B	SE(B)	β	<i>t</i>	<i>p</i>
<i>Model 1: Degree on Engagement</i>					
Std. Eng. Fall	.826	.040	.750	20.513	.000
Degree Centrality	-.014	.006	-.081	-2.210	.028
<i>Model 2: Degree on Relatedness</i>					
Degree	.019	.007	.138	2.650	.008
<i>Model 3: Degree and Relatedness on Engagement</i>					
Std. Eng. Fall	.825	.041	.749	19.950	.000
Degree	-.014	.006	-.081	-2.213	.028
Relatedness	.008	.047	.006	.165	.869

Note: Fall Engagement was included in models 1 and 3 because the variable of interest was change in engagement over time rather than prediction of Spring Engagement.

Table 8

Mean Differences Grouped by Relatedness

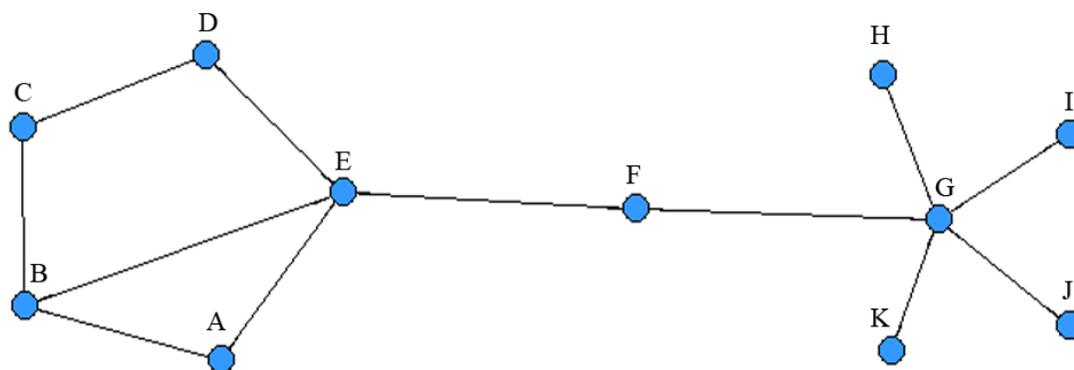
	n	Mean	SD
Std. Eng. Fall	167(199)	2.84(3.15)	.62(.61)
Std. Eng. Spring	167(199)	2.91(3.18)	.69(.68)
Peer Eng. Fall	167(199)	3.04(3.17)	.34(.35)
Peer Relatedness	167(199)	2.87(3.76)	.41(.23)
Degree Closeness	167(199)	4.35(5.20)	3.88(4.04)
Eigenvector	145(183)	1.16(1.16)	.30(.30)
Mean Eng. Change	167(199)	1.47 (2.01)	6.49(7.73)
	167(199)	.08(.04)	.47(.50)

Note. Means reported as Low Relatedness (High Relatedness).

Appendix B: Figures

Figure 1

Example Social Network and Corresponding Centrality Scores

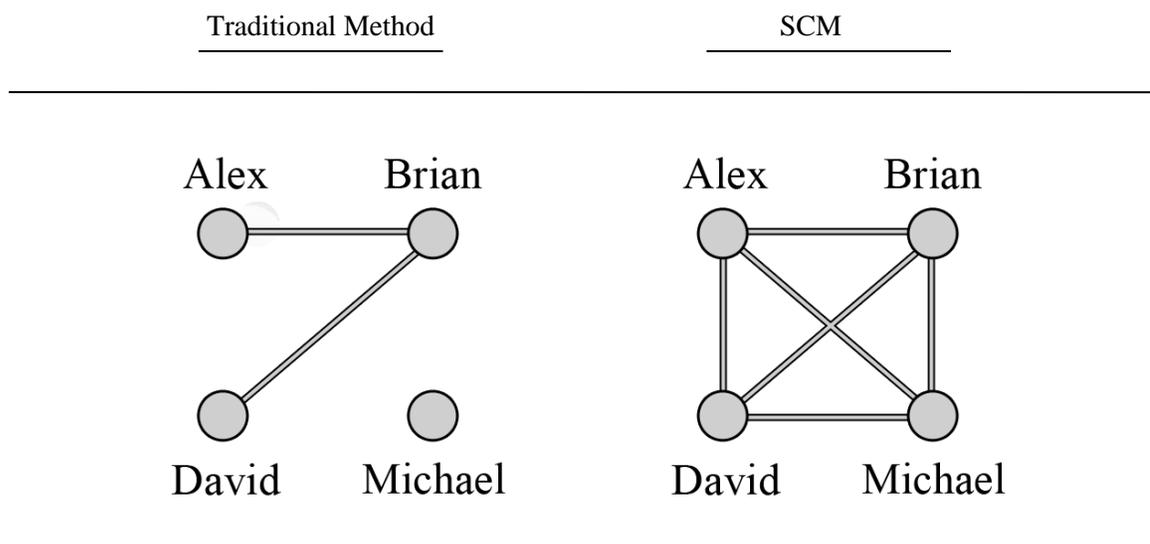


	A	B	C	D	E	F	G	H	I	J	K
Closeness	37	38.5	30.3	37	50	52.6	50	34.5	34.5	34.5	34.5
Degree	20	30	20	20	40	20	50	10	10	10	10
Eigenvector	52.4	63.5	40.3	43.7	76	42.4	36.7	13.8	13.8	13.8	13.8

Note. Centrality scores were calculated using UCINET.

Figure 2

Example of Traditional Social Networks Method vs. SCM



Note. A comparison of two social network mapping techniques. The traditional method leaves Michael as an isolate for having been absent from testing, and the relationship between Alex and David is omitted due to lack of reciprocation. Assuming these relationships do exist in the “true network”, the SCM technique would maintain these connections as it relies on consensus of the participants rather than reciprocity to determine connections.

Figure 3
Kindermann 2007 Model

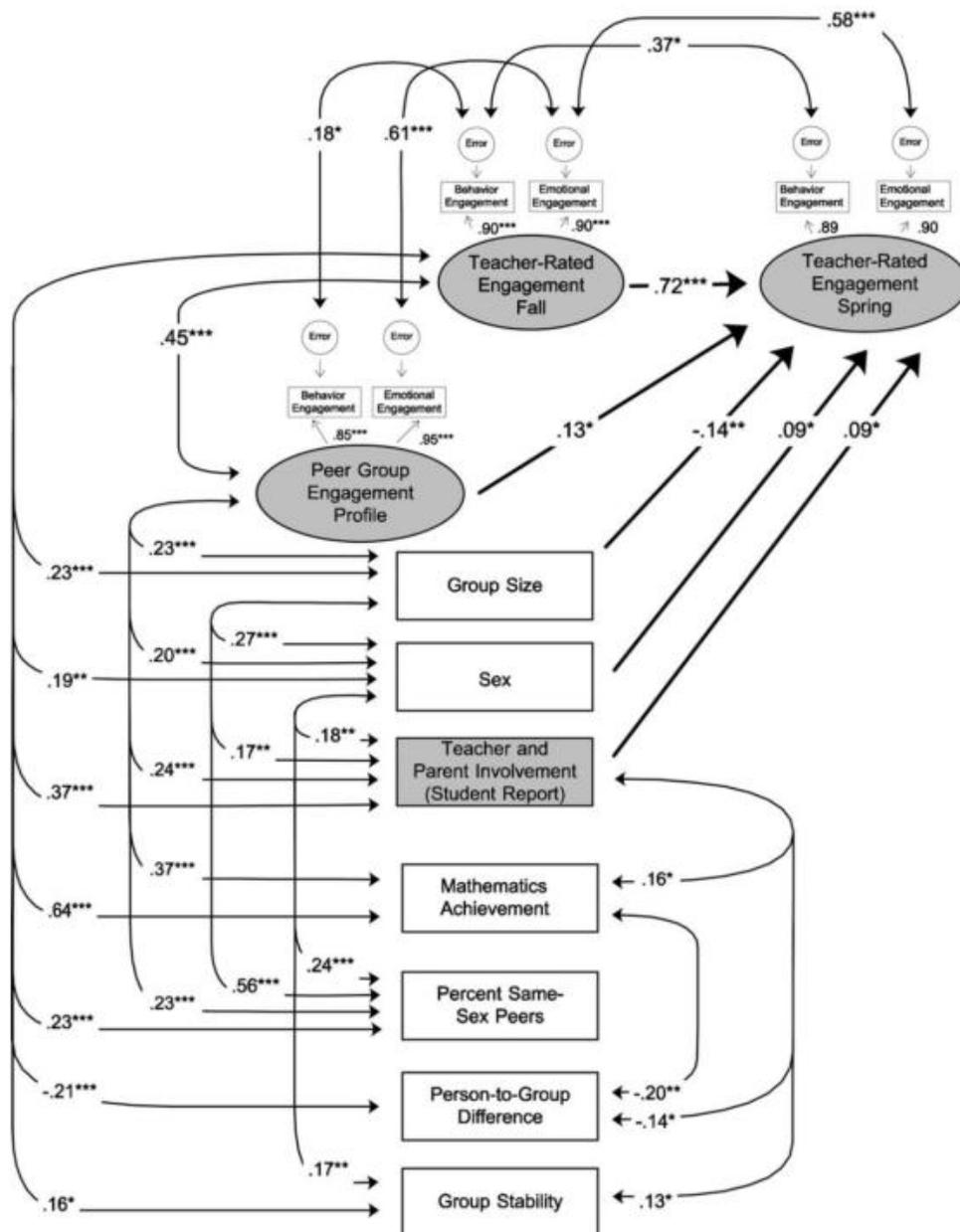
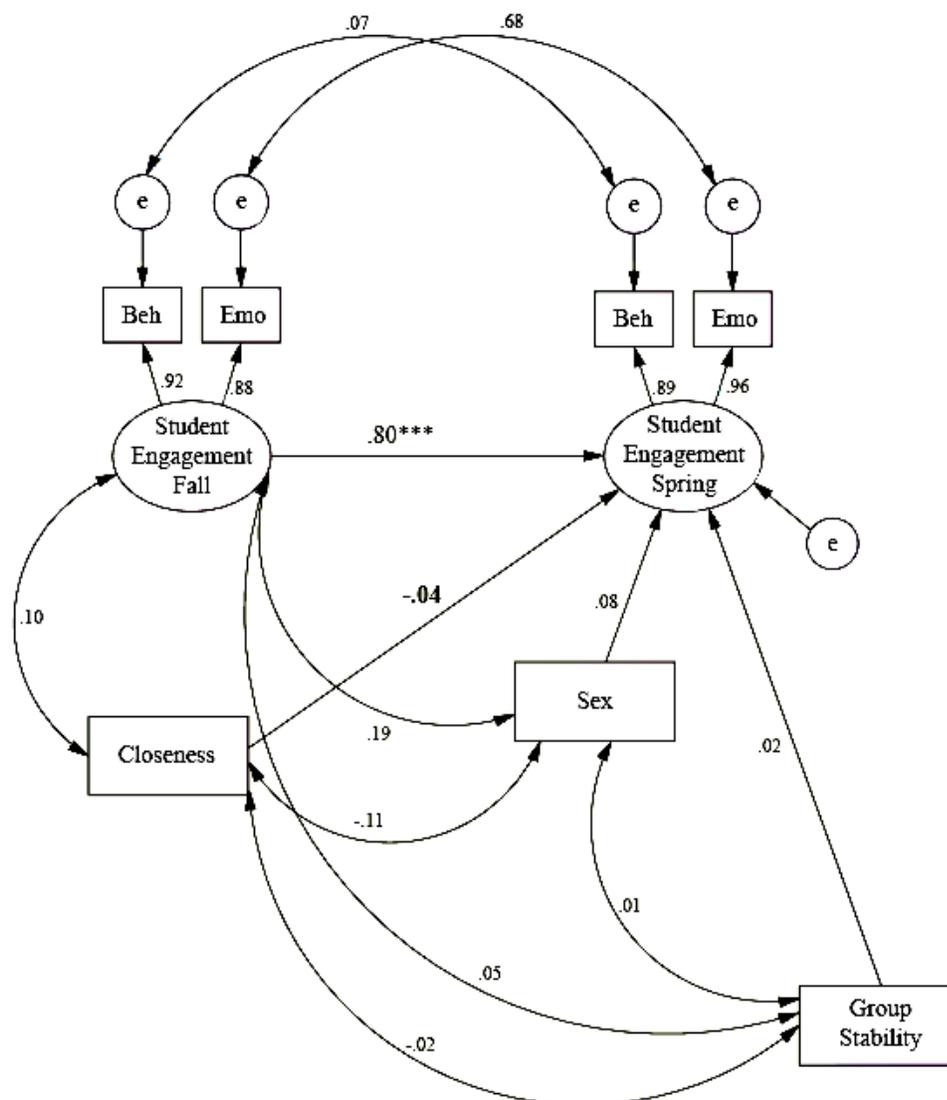


Figure 3. Structural equation model of peer group influences on students' engagement during sixth grade.
* $p < .05$. ** $p < .01$. *** $p < .001$.

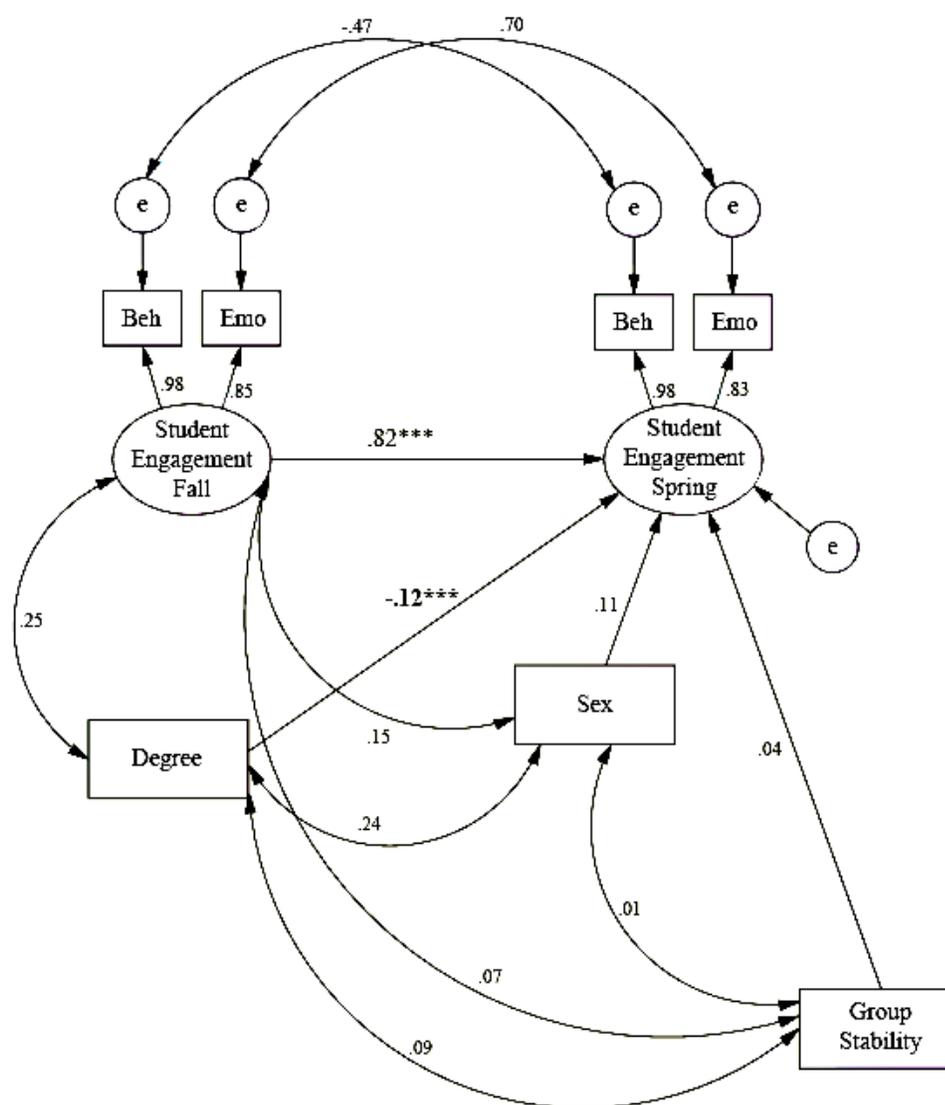
Note: Figure reproduced from Kindermann, 2007.

Figure 4.1
Closeness Centrality Predicting Change in Engagement



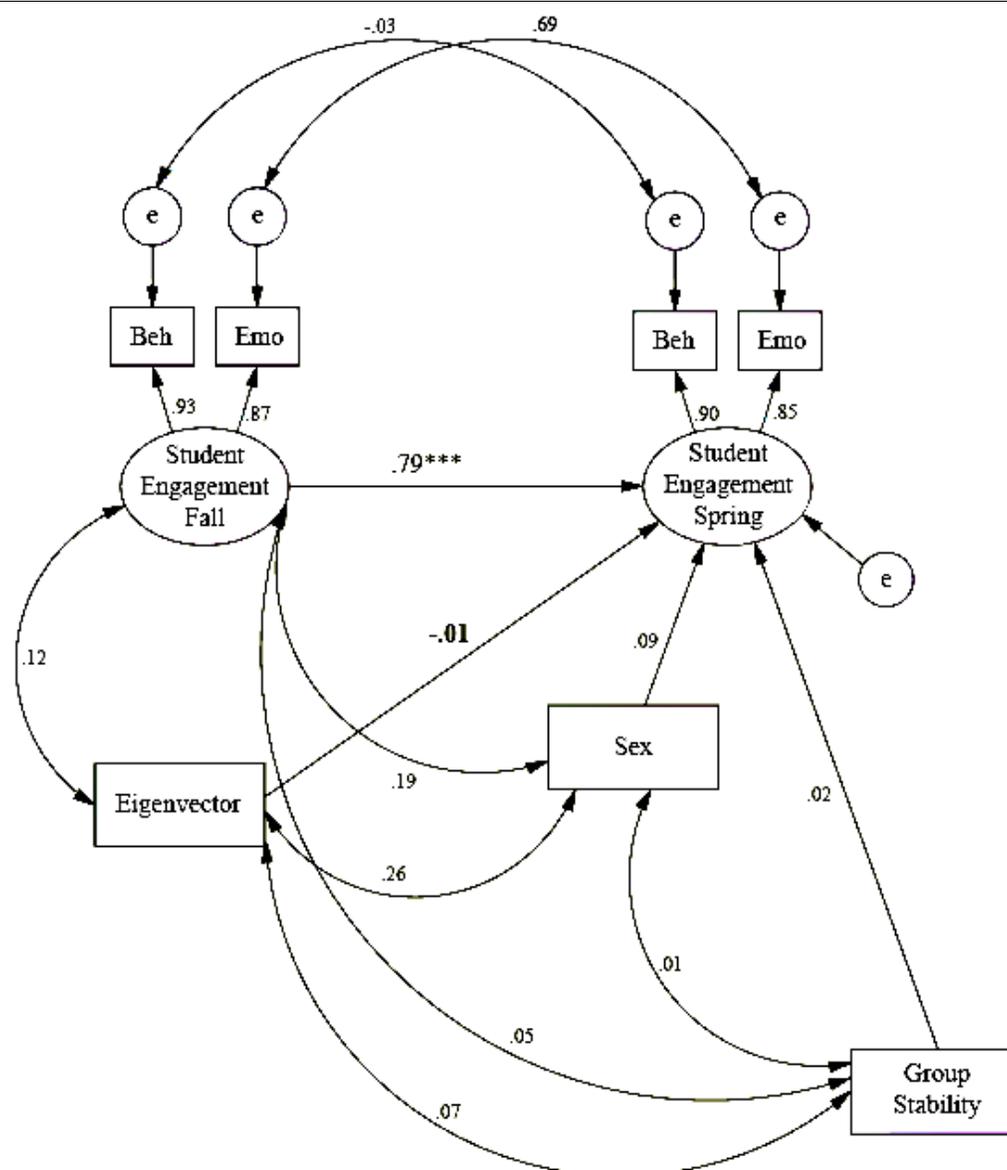
Note. All estimates provided are standardized: $\chi^2(5) = 5.372$, $p = .297$, $CMIN/DF = 1.074$, $CFI = 1.00$, $RMSEA = 0.014$; $N = 366$. $***p < .001$ $**p < .01$ $*p < .05$.

Figure 4.2
Degree Centrality Predicting Change in Engagement



Note. All estimates provided are standardized: $\chi^2(5) = 8.438$, $p < 0.001$, CMIN/DF=1.68, CFI=.997, RMSEA=.043; N=366. $^{***}p < .001$ $^{**}p < .01$ $^{*}p < .05$.

Figure 4.3
Eigenvector Centrality Predicting Change in Engagement



Note. All estimates provided are standardized: $\chi^2(5) = 5.297$, $p = .791$, CMIN/DF=1.059, CFI=1.00, RMSEA=.013; N=366. *** $p < .001$ ** $p < .01$ * $p < .05$.

Figure 5
Mean Differences in Engagement Over Time by Degree Centrality

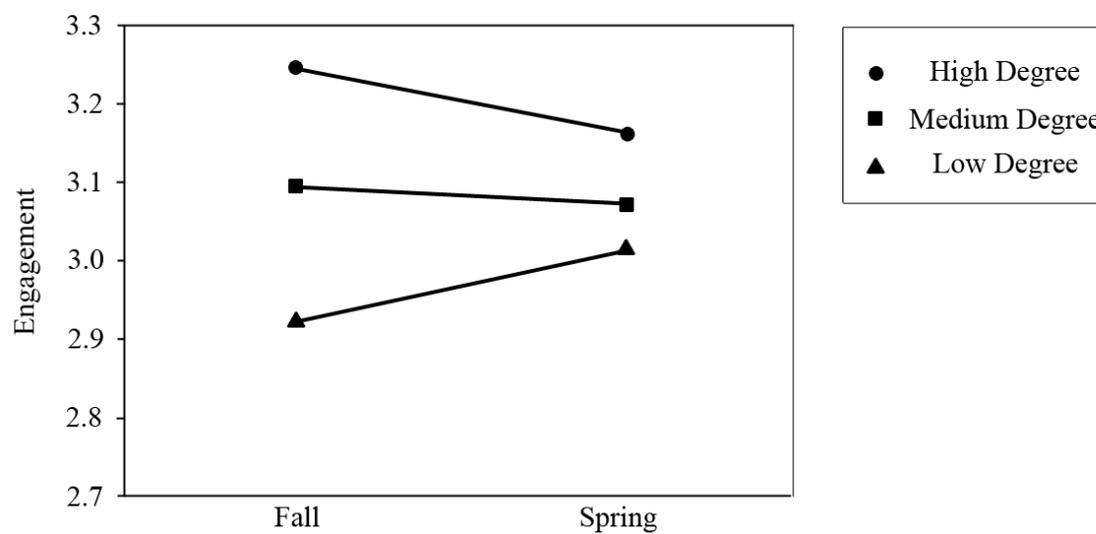
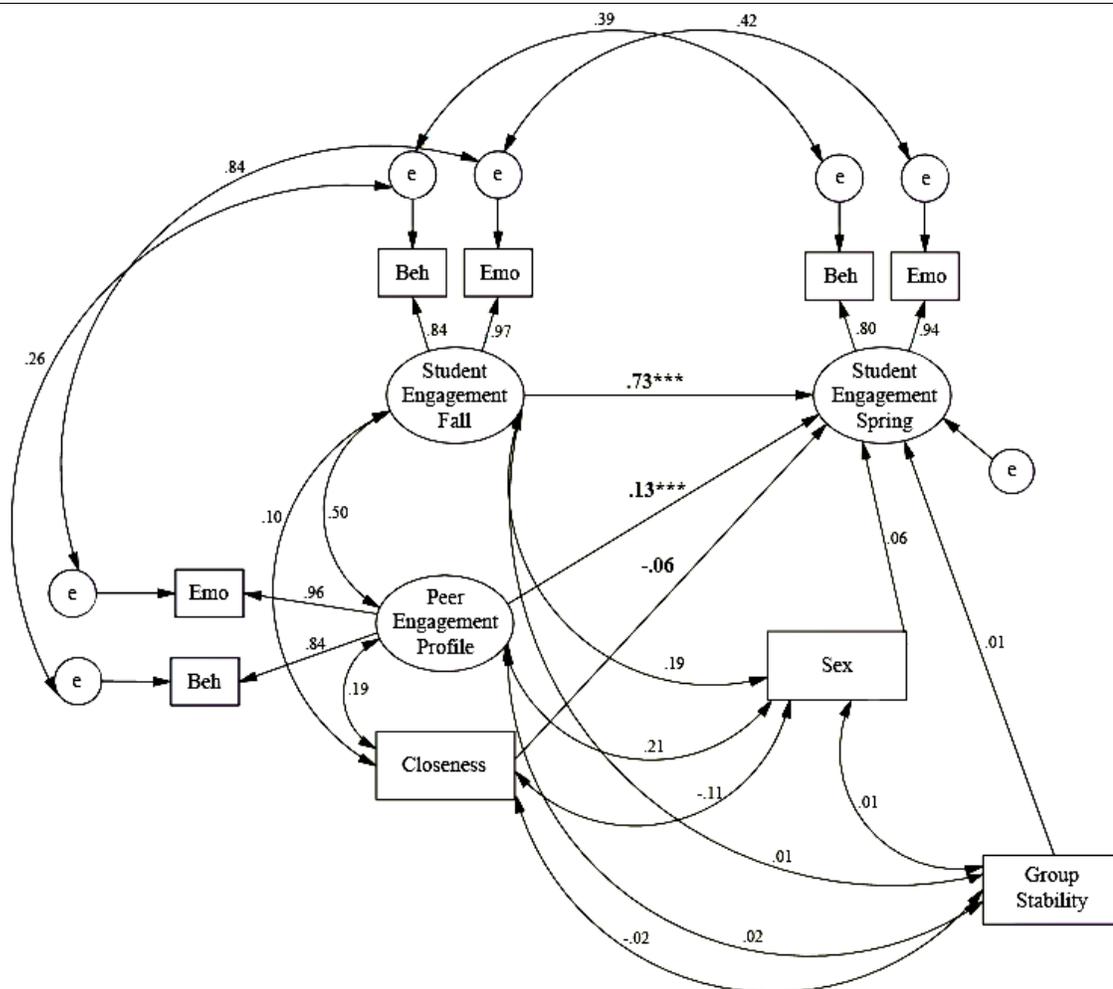


Figure 6.1

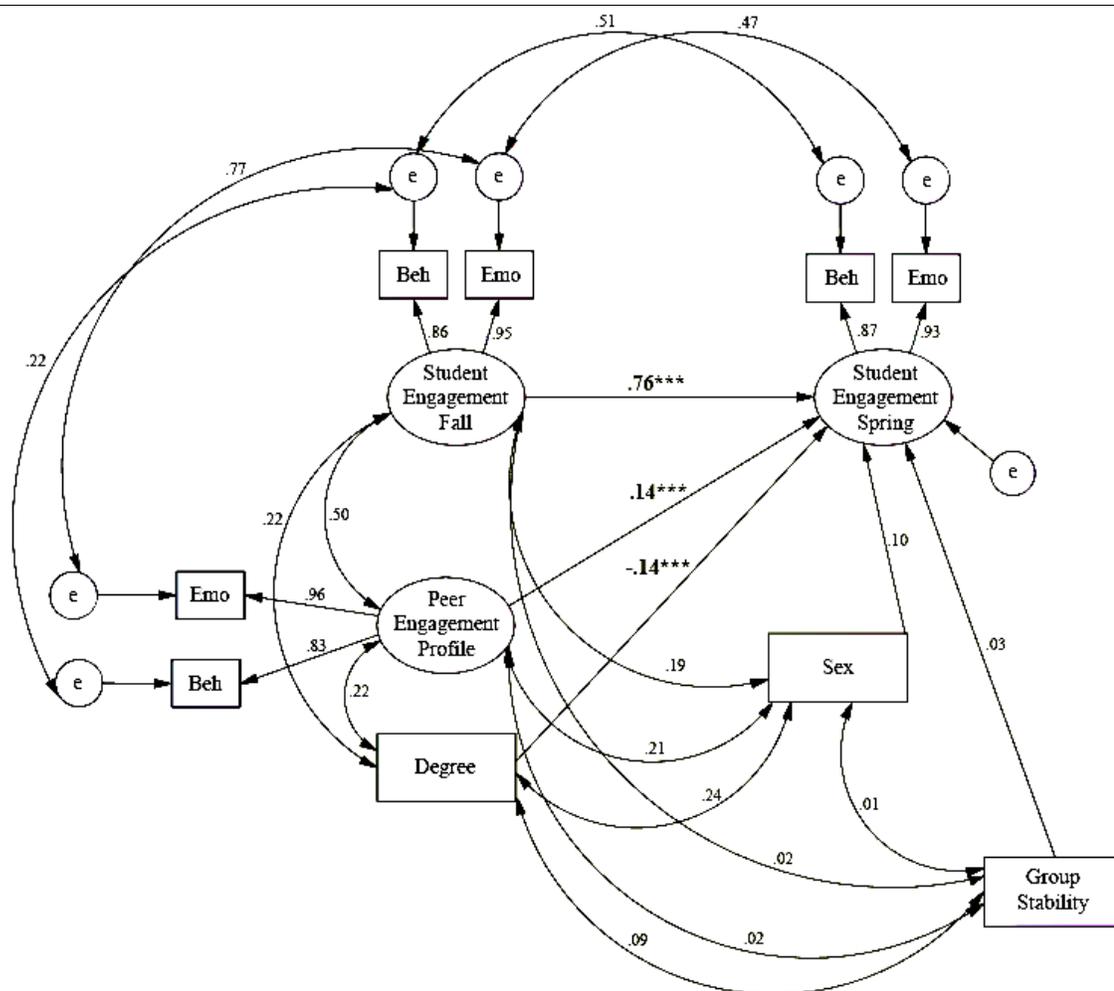
Closeness Centrality Predicting Change in Engagement with Peer Engagement



Note. All estimates provided are standardized: $\chi^2(11) = 13.497$, $p = .089$, $CMIN/DF = 1.227$, $CFI = .99$, $RMSEA = .025$; $N = 366$. *** $p < .001$ ** $p < .01$ * $p < .05$.

Figure 6.2

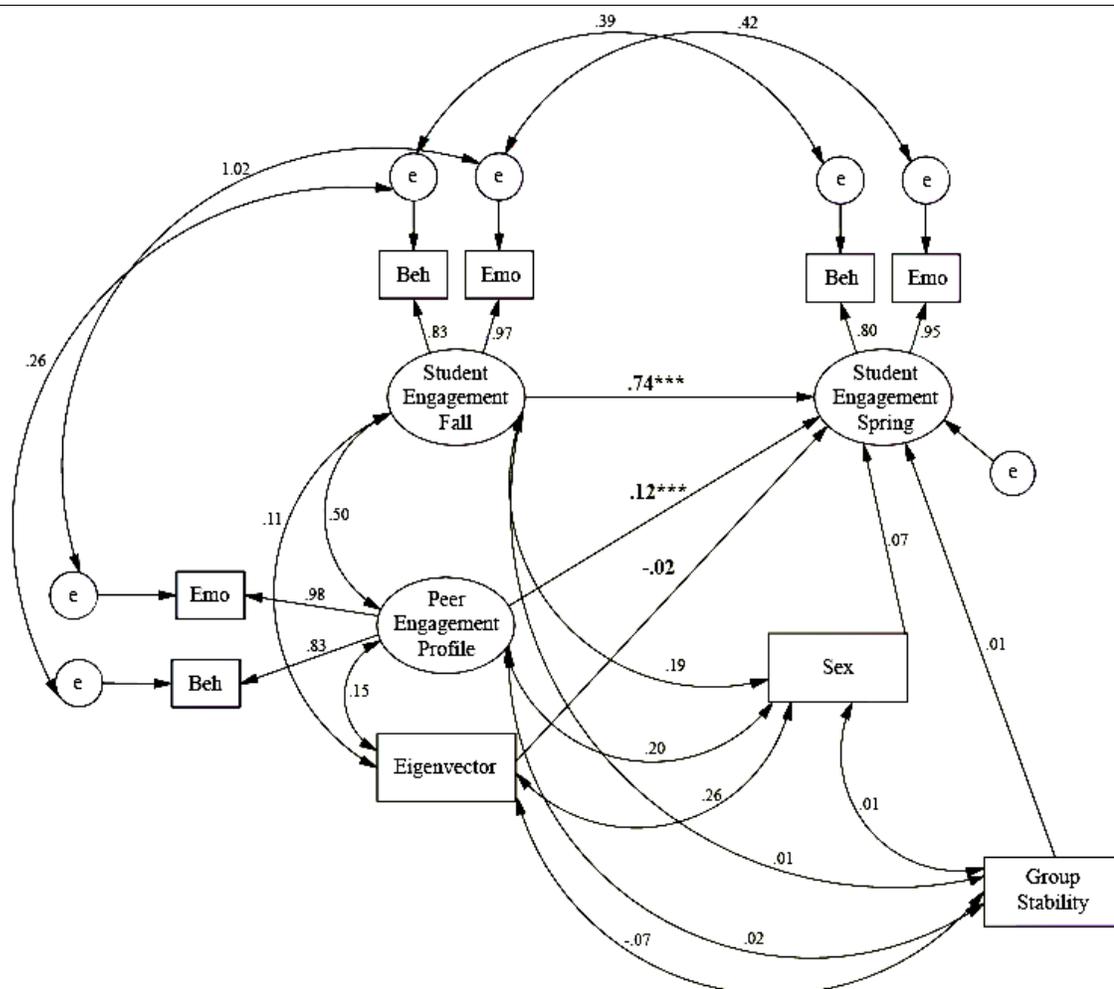
Degree Centrality Predicting Change in Engagement with Peer Engagement



Note. All estimates provided are standardized: $\chi^2(11) = 18.812, p < 0.001, CMIN/DF = 1.710, CFI = .996, RMSEA = .044; N = 366. ***p < .001 ** p < .01 * p < .05.$

Figure 6.3

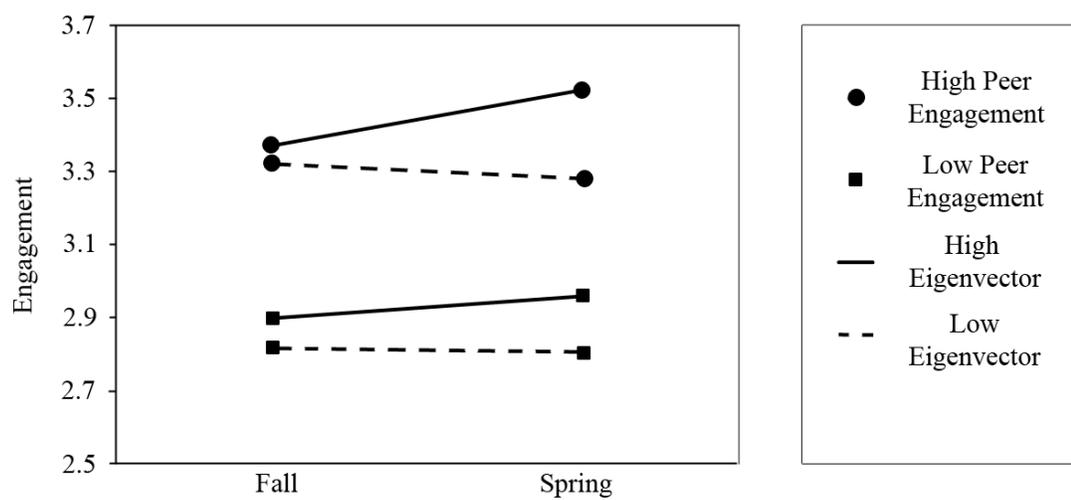
Eigenvector Centrality Predicting Change in Engagement with Peer Engagement



Note. All estimates provided are standardized: $\chi^2(11) = 12.542$, $p = .491$, $CMIN/DF = 1.140$, $CFI = .99$, $RMSEA = .02$; $N = 366$. *** $p < .001$ ** $p < .01$ * $p < .05$.

Figure 9

Mean Differences in Engagement Over Time by Peer Engagement and Eigenvector Centrality



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