Title

Friendship and support networks among students with disabilities in middle school

Authors

Mamas, Christoforos
Bjorklund, Peter
Daly, Alan J
et al.

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Abstract

This study explored the social processes associated with tie formation in friendship and support networks of Grade 8 students with disabilities. We employed exponential random graph models (ERGMs) and separable temporal exponential random graph models (STERGMs) to explore tie formation in these networks over time. The statistical analysis of network data through ERGMs/STERGMs presents a novel approach in understanding social participation and the use of such approach is exemplified. Results suggest that students with disabilities were more likely to form support ties with each other and less likely to send and receive help ties with others. They were also less likely to receive friendship ties than their peers. Implications for practice in relation to social participation are being discussed.

Keywords: special education, social participation, social network analysis, exponential random graph models

Friendship and Support Networks Among Students with Disabilities in Middle School

Inclusion of students with disabilities in general education settings has gained momentum worldwide since the Salamanca Statement (UNESCO, 1994), which was an international call for ‘education for all’. In the United States, the reauthorized Individuals with Disabilities Education Act (IDEA, 2004) and the Every Student Succeeds Act (ESSA, 2015) have further ensured that the number of students with disabilities in general education settings has consistently increased. A primary justification for inclusion is that students with disabilities benefit from social participation—including social interactions, friendships and friendship networks, social support behaviors, play, and group activities (Koster et al., 2009)—and that this interaction is beneficial to all students (Peltier, 1997).

Despite the benefits of inclusion, students designated as having a disability often have lower social participation status (Koster et al., 2009; 2010), which can result in social isolation and marginalization (Bossaert et al., 2013; Mamas, 2013; Mamas et al., 2019; Pijl et al., 2008). In comparison to their peers, these students have fewer friends and fewer peer interactions, and they are less accepted (Koster et al., 2009; 2010; Mamas et al., 2019; Rotheram-Fuller et al., 2010). Frostad and Pijl (2007) found students with disabilities have difficulty building relationships with peers, suggesting they have fewer friends and participate less often in subgroups. Likewise, Estell et al. (2009) found they retain fewer friendships over time and are more likely

to have friends with learning disabilities, though they are as likely to have reciprocated best friends and to have as many best friends as students without disabilities.

De Boer et al. (2012) found that “girls with disabilities are less accepted by their same-sex peers when they show social issues in class” (p. 839). Similarly, students with autism spectrum disorder (ASD) are more often on the periphery of their social networks, report poorer quality friendships, and have fewer reciprocal friendships (Kasari et al., 2011). In some instances, bullying, alienation, and exclusion are reported in the context of social participation between students with disabilities and their peers (Qi & Ha, 2012; Van Mieghem et al., 2018). Research at the secondary level has shown that students with disabilities may be less accepted by peers, have fewer reciprocal friendships, and be less engaged in peer interactions than those without identified disabilities (Humphrey & Symes, 2011; Petry, 2018; Wainscot et al., 2008). Locke et al. (2010) found that high school students with ASD experienced more loneliness than their classmates and had poorer friendship quality and lower social network status.

To date, most studies on the social participation of U.S. students with disabilities in general education settings have occurred at the elementary level (e.g., Estell et al., 2009; Frostad & Pijl, 2007; Kasari et al., 2011; Koster et al., 2010; Mamas et al., 2019; Rotheram-Fuller et al., 2010). Moreover, the support networks of students with disabilities are substantially under-researched, and exponential random graph models (ERGMs) and separable

temporal ERGMs (STERGMs) for social networks have been underused. Thus, in the current study, we examined two central aspects of social participation: friendship networks (Kennedy, Cushing & Itkonen., 1997) and social support behaviors (Kennedy, Shukla & Fryxell., 1997). Specifically, we looked at tie formation mechanisms in the friendship and support networks of 32 middle-school students with individualized education plans (IEPs). In doing so, we aimed to shed light on the social participation of students with disabilities in secondary general education settings.

Theoretical and Methodological Framework

Theory of Social Networks

Social networks generally consist of people (*actors*) connected by relationships to one another (*ties*) and resources and information flow through those ties (Borgatti & Lopez-Kidwell, 2011). The theory of social networks explores the social and structural processes related to tie formation in social networks. Previous literature has shown that network ties tend to form based on perceptions of social similarity (*homophily*), like identifying as the same gender or race or teaching the same grade level (McPherson et al., 2001; Spillane et al., 2012). Physical proximity (*propinquity*), like teaching in neighboring classrooms, can influence tie formation (Small & Adler, 2019; Spillane et al., 2017). Certain beliefs or characteristics—for example, trust in a colleague—may also increase or decrease the likelihood of an actor sending or receiving a tie (Shazi et al., 2015). Other research has shown that formal leadership positions or expertise can increase the likelihood of tie

formation (Spillane et al., 2012).

We explored the relationship between homophily and being a student with an IEP and tie formation within a help-seeking (support) network and a friendship network at the beginning and end of the school year. We hypothesized that (a) students with disabilities would be more likely to turn to each other for help and friendship than students without designated disabilities (Hypothesis 1); and (b) students with disabilities would be less likely to send and receive ties than students without designated disabilities (Hypothesis 2). In addition, we discuss how ERGMs and STERGMs may provide new insights and methodologically contribute towards deeper exploration of the social participation of students identified as having a disability.

From a methodological standpoint, the social participation of students with disabilities has been approached from a variety of perspectives, including well-established quantitative and qualitative approaches as well as sociometric techniques. The latter includes, but is not limited to, the theory of social networks and social network analysis which have been employed in the context of this study. A particularly unique contribution of this paper is the use of ERGMs and STERGMs which are relatively new techniques to predict tie formation and, to the best of our knowledge, have not yet been used to examine the social participation of students with disabilities.

A recent review of sociometric techniques has revealed their popularity in ascertaining the social impacts and participation of students with

disabilities or special educational needs in general education settings (Avramidis et al., 2017). This review identified three different sociometric approaches, including peer nominations, peer ratings, and social cognitive mapping to obtain information about the nature of students' social networks. Avramidis et al. (2017) concluded that there is a need for more innovative sociometric techniques and research designs to better understand the nature of students with disabilities peer relationships and social networks. Our study responds to that call by applying an innovative social network perspective through the use of ERGMs and STERGMs. Other studies in the field of social participation have employed a social network perspective, however primarily at the descriptive level. For example, Boutot and Bryant (2005) examined social network affiliation, Kasari et al. (2011) explored the relationship between social networks and friendship at school, whereas Locke et al. (2010) looked into friendship quality and the social networks of adolescents and Mamas et al. (2019) employed social network measures to examine the social participation of students with disabilities in general education settings. In sum, there is a methodological gap in addressing social participation through more advanced statistical social network analysis, therefore our study seeks to contribute towards filling this gap.

Data and Methods

Design, Sample, and Data Collection

As this was a longitudinal unusual case study (Yin, 2018), we collected data from a single Grade 8 classroom in a Title 1 middle school in Southern

California. The classroom was chosen primarily due to its large percentage of students with disabilities. Ten of the 32 students (31.2%) had an IEP designation (Table 1)—three times the California public school system average of 10.5% (NCES, 2019) and much higher than the school's average (18.3%). Additionally, the classroom was chosen due to its highly diverse student population and high response rate to the network survey. Overall, the school serves students in Grades 6–8 and was in the bottom 50% of all schools in California for overall test scores in English Language Arts/Literacy and Mathematics (CAASPP, 2018). The school had 71% minority enrollment (mainly Hispanic); 52% of students were receiving free or reduced-priced lunch (FRPL), and 13.7% of students had an English-language learner (ELL) designation.

[Table 1]

We distributed a social network survey to all 32 students in the classroom at two timepoints—[January 2017] (T1) and [May 2017] (T2). The overall response rate was 87.5%. Ethical approval for the project was granted by the Institutional Review Board (IRB) of the university. Informed consent forms were sent to all parents. In line with IRB requirements, each participating student also had to sign the adolescent consent form. It was made clear to parents and students that participation was completely voluntary and non-participation would in no way have any negative consequences. To examine the classroom-bounded networks, we provided students with a roster and asked them to select their "very good friends"

(friendship network) and the classmates they ask for help on schoolwork if the teacher is not available (help-seeking network). The social network survey had two relational questions. The first one asked participants ‘who are your very good friends in your classroom?’ and the second question asked ‘who do you ask for help on school work if the teacher is not available?’. Both questions followed with the prompt ‘please select as many classmates from the list below’. The paper and pencil survey was administered by one of the researchers in the team who was available to answer any clarifying questions from the participants.

Data Analysis

As noted above homophily, propinquity, and character traits can influence tie formation. It is also the case that social network structures can influence tie formation. For example, receiving a tie often increases the likelihood that an actor will reciprocate that tie. If student *i* confides in student *j*, it increases the likelihood that student *j* will reciprocate and confide student *i* (Lusher & Robins, 2013). As such, social network data do not meet the independence assumption of ordinary least squares regression and logistic regression, so we cannot use these methods to explore network ties (Borgatti et al., 2013; Hanneman & Riddle, 2005). Thus, we used ERGMs to explore tie formation.

In theory, our observed network is one possible configuration of a set of possible networks (Robins et al., 2007). ERGMs allow us to test the likelihood of ties by comparing them to a distribution of random networks

with given parameters (Lusher, 2011). This lends insight into tie formation in our observed network relative to chance alone (Lusher, 2011; Robins & Lusher, 2013a). Put another way, ERGMs compare our observed network to all other possible ways it could be arranged and helps explain relationships between ties, network structures, and participant attributes (Lusher, 2011; Robins & Lusher, 2013a).

ERGMs provide insight into cross-sectional data, but we were also interested in tie formation over two timepoints. As such, we incorporated dynamic ERGMs (Snijders, 2011), also known as separable temporal ERGMs (STERGMs; Krivitsky & Goodreau, 2019; Krivitsky & Handcock, 2014). With STERGMs, we can model the relationship of structural effects and individual effects on tie formation and dissolution between two timepoints (Krivitsky & Handcock, 2014). We can also explore tie formation and tie dissolution as distinct processes and create a separate model for each (Krivitsky & Goodreau, 2019; Schaefer & Marcum, 2017). In other words, STERGMs fit two separate ERGMs, one for each process (Bodin et al., 2019). The underlying theory is that it is likely that, in some cases, the model for tie formation will be different than the model for tie dissolution—that is, people form relationships for different reasons than they dissolve them (Krivitsky & Goodreau, 2019). To run our models, we used the ERGM and STERGM commands in the ERGM package in R (Handcock et al, 2018; Hunter et al., 2008a). Because our main concern was with tie formation, our paper does not address tie dissolution. ERGMs and STERGMs provided an innovative

statistical network approach to examine tie formation processes to better understand the social participation of students with designated disabilities. We argue that this is a rigorous approach which, if used properly, can provide enhanced and detailed insights into aspects of the social participation of students with disabilities. Below we provide further details on how we executed our models.

Structural Effects

In all models we conditioned on seven structural effects that are prominent in social network theory literature (Robins & Lusher, 2013b): *arcs, reciprocity*, *simple connectivity* (two-paths), *activity spread* using geometrically-weighted outdegree (GWOD), *popularity spread* using geometrically-weighted indegree (GWID), *triangulation/transitivity* using directed geometrically weighted edgewise shared partners (DGWESP), and *multiple connectivity* using directed geometrically weighted dyad shared partners (DGWDSP; Figure 1). Snijders et al. (2006) and Snijders (2011) suggested using geometrically-weighted effects to improve convergence of ERGMs. We used weighting parameters that gave us the best goodness-of-fit for our models (Hunter et al, 2008b; see appendix for goodness-of-fit plots).

The arc term functions like an intercept in a traditional regression model (Siciliano, 2015). Reciprocity conditions on the idea that when Person *i* receives a tie from Person *j* it increases the likelihood that Person *i* will send a tie to Person *j*. Simple connectivity conditions on the theory there is a relationship between sending and receiving—that is, people who receive ties

are more likely to send them and vice versa (Robins & Lusher, 2013b).

[Figure 1]

Activity spread addresses the outdegree distribution in the network, while popularity spread controls for the indegree distribution. For example, if popularity spread is positive and significant, it suggests that the network is centered on a few people who receive an outsized share of the indegree distribution. Transitivity/closed triads account for the theory that two actors associated with an actor in common are more likely to form a tie—a friend of a friend is a friend (Davis, 1963; Lusher & Robins, 2013). Multiple connectivity conditions on dyads that close due to transitivity and those that do not. Transitivity and multiple connectivity are generally included together in models, as transitivity conditions the model on transitive triads, and multiple connectivity controls for non-connected dyads with a partner in common (Harris, 2014).

Actor-Level Effects

At the actor level, we measured homophily and heterophily effects to determine the relationship between perceived similarity and tie formation. Because ties tend to form based on gender, ethno-racial group, and SES homophily (Lomi et al., 2014; Reagans, 2011; Reagans & McEvily, 2003), we included same gender, ethno-racial group, and FRPL status. Likewise, we included same special education and ELL designation, as students with the same institutional labels and/or behavioral patterns may be more likely to form ties with each other (McPherson et al., 2001). We included absolute

difference in cumulative grade point average (GPA)—measured on a 0–4.0 scale—as a proxy for education level, which has also been shown to be related to tie formation (McPherson et al., 2001; Siciliano, 2015). Lastly, we modeled sender and receiver effects to see how likely students with disabilities were to send or receive ties compared to peers.

Results

[Figure 2], [Figure 3]

Figures 2 and 3 show the friendship and help-seeking networks, respectively, at both timepoints.[1] The grey nodes are students designated as having a disability and the black nodes are students who have not been designated as having a disability. The nodes in the upper left-hand corner of the map are isolates—students who neither received nor sent ties. Results are in the tables below in log odds. For ease of interpretation, we report results for significant actor-level effects as odds ratios.

Friendship Network

Table 2 shows ERGM and STERGM results for tie formation in the friendship network. Regarding structural effects, reciprocity significantly increased the likelihood that students would send a tie to each other in both the ERGM and STERGM models. In other words, if Student *i* sent a tie to Student *j*, Student *j* was significantly more likely to send a tie in return. The negative coefficient in the two-path STERGM indicates students who sent more ties between T1 and T2 were less likely to receive ties and vice versa. The negative activity spread in both models suggests an even distribution of

[1] All sociograms were created using UCINET (Borgatti, Everett, & Freeman, 2002)

outdegree between students at T1 and between T1 and T2. Thus, in general, students sent ties to each other with similar frequency. The positive coefficient for the transitivity/closed triad in both models indicates a tendency toward triadic closure (a friend of my friend is my friend). Interestingly, the STERGM shows a positive and significant coefficient in the multiple connectivity/open triad effect. This suggests a greater tendency over time for triads to remain open than by chance alone.

[Table 2]

Several actor-level homophily effects were associated with tie formation in the friendship network. At T1, students of the same gender were 40% more likely to form ties (*exp* [.34]=1.40) than would be expected by chance alone. From T1 to T2, same-gender students were 11% more likely to form ties with each other (*exp* [.10]=1.11). At T1, students with a special education designation were almost two times as likely to say they were very good friends with students who also had a special education designation (*exp* [.66]=1.93). From T1 to T2, students with a special education designation were more than two times as likely to name each other as friends (*exp* [.76]=2.14). Students eligible for FRPL were 42% more likely to form friendship ties with each other (*exp* [.35]=1.42) and ELL students were more likely to form ties with other ELL students. For sender/receiver effects, students with disabilities were more likely to send a tie at T1 (*exp* [.87]=2.39), but 85% less likely to receive a tie than their non-special education peers. IEP designation was one of the strongest predictors of tie

formation in both models.

Help-Seeking Network

Table 3 gives tie formation model results for the support network. As above, reciprocity was positively associated with tie formation at T1. The negative two-path effect in both models demonstrates that students who sent more help ties were less likely to receive ties and vice versa. The positive popularity spread in the STERGM model indicates the network was centered around a few students who received significantly more indegree ties than their peers—that is, few students were asked for help more frequently than their peers. The negative activity spread coefficient in the ERGM model indicates students sent help ties at a similar level. The positive transitivity/closed triad effect demonstrates a tendency toward triadic closure at T1 and from T1 to T2. Put another way, if Student *i* asked Student *k* for help, and Student *k* asked Student *j* for help, both models show an increased likelihood of Student *i* asking Student *j* for help.

[Table 3]

Being the same gender accounted for a 46% increase in likelihood of tie formation from T1 to T2 (*exp* [.46]=1.58). Students of the same ethno-racial group were over two times more likely to seek each other out for help from T1 to T2 (*exp* [.78]=2.18). We could not include the IEP homophily effect in our ERGM model, as non-IEP students selected other non-IEP students 100% of the time, creating a perfect correlation. ELLs with the same designation were 65% more likely to seek each other out for help than would

be predicted by chance alone (*exp* [.50]=1.65). Finally, students with disabilities were 75% more likely to send a tie from T1 to T2 and 82% less likely to receive a tie at T1 than would be expected by chance alone.

Discussion

Social network analysis is grounded in the idea that individual actions are based on relationships and positions within a given network (Borgatti et al., 2013). A social network approach privileges the "web of relationships in which actors are embedded that both constrain and provide opportunities" (Borgatti & Ofem, 2010, p. 18). Individuals' observed attributes are understood in terms of ties and social structures, and personal attributes are seen as secondary (Wasserman & Faust, 1994), which deviates from most educational research that examines social participation. As such, we believe social network theory and analysis, and in particular ERGM and STERGM models, provide a valuable lens through which to explore the social participation of students with disabilities. Here, it allowed us to go beyond individual actors to provide insights into how dyads, triads, and networks impact social processes and behaviors. Using ERGMs and STERGMs to explore tie formation over time allowed us to control for structural effects and gain a deeper understanding of underlying social processes.

Similar to past studies (e.g., Lusher & Robins, 2013; Reagans, 2011; Siciliano, 2015), we found several structural effects related to tie formation. In both the ERGM and STERGM models—at T1 and from T1 to T2—reciprocity and triadic closure increased the likelihood of tie formation. Students who

received ties from others were more likely to reciprocate those ties, and if two students had ties with the same peer they were more themselves likely to form a tie, which supports previous literature (e.g., Hendrickx et al., 2017; Krivitsky & Handcock, 2014).

For the help-seeking network, simple connectivity was negative in both the ERGM and STERGM models: Students who sent out more ties were less likely to receive them, and students who received more ties were less likely to send them. It could be that students who seek ties more often are less likely to be asked for help and vice versa. More research should explore patterns of structural effects on classroom networks.

In both ERGM models, students with IEPs and those without were more likely to form ties with one another (McPherson, et al., 2001). This effect was clear in the friendship network in the ERGM and STERGM models and is in line with previous research (Estell et al., 2009). We did not find a significant homophily effect for students with disabilities in the help-seeking STERGM model, most likely because the effect was so pronounced at T1 (a perfect correlation) that we could not include it in the ERGM model. Since there was perfect correlation at T1 these students would not be more likely to form new ties from T1-T2 because most of the potential ties were already established at T1. In the help-seeking network at T1, non-IEP students only went to other non-IEP students for help, completely excluding peers with disabilities.

In sender/receiver effects in the ERGM models—for both the friendship

network and the help-seeking network—students with disabilities were less likely to receive ties than their non-IEP peers. This aligns with prior research showing that students with disabilities tend to receive fewer nominations than their peers (Avramidis, 2013; Estell et al., 2009; Mamas, 2013; Pijl et al., 2008; Rotheram-Fuller et al., 2010). Frostad and Pijl (2007) suggested this may be because students with disabilities have additional difficulties building relationships with peers. However, students with disabilities were more likely to send very-good-friend ties at T1 and more likely to send help-seeking ties between T1 and T2.

Our findings show the importance of social network structures for tie formation in the classroom, and seem to bolster the notion that a teacher's understanding of social structures in the classroom can have a positive effect on facilitating peer relationships (Hamm et al., 2011). These results support our first hypothesis that students with disabilities would be more likely to turn to each other for help and friendship than to turn to peers in the class without disabilities. However, they both refute and support for our second hypothesis. Contrary to our hypothesis, students with disabilities were more likely to send a tie in the friendship ERGM model and the help-seeking STERGM model. In the ERGM model for both friendship and help-seeking students with disabilities were less likely to receive ties than their peers without disabilities as we predicted. These findings add to the social participation literature, but they also offer insights for the classroom as well as methodological insights for researchers.

Implications for Teachers and Researchers

We found that students with disabilities maintained a lower social participation status than their peers, which supports previous literature about students with disabilities in mainstream classrooms (Avramidis, 2013; Koster et al., 2010; Mamas et al., 2019; Pijl et al., 2008). Our findings, along with the body of research that came before, make the case that teachers should take steps to foster tie formation for all students, thereby facilitating tie formation for students with disabilities. As Small (2009) contended, "people are more likely to form ties when they have opportunities to interact, when they do so frequently, when they are focused on some activity, when they are not competitive, and when they have reason to cooperate" (p. 15).

In classrooms, teachers can play an outsized role in facilitating relationships between students (Farmer et al., 2011; Gest & Rodkin, 2011; Hendrickx et al., 2017). They can disrupt social hierarchies and foster positive relationships between students (Gest & Rodkin, 2011), and students may see them as a social reference for their views on other students. For example, if Student *i* believes a teacher likes Student *j*, Student *j* is more likely to be liked by Student *i* (Hendrickx et al., 2017). Finally, through pedagogy and classroom management, teachers can influence friendship patterns (Gest & Rodkin, 2011, van den Berg et al., 2012). Thus, we contend teachers should take concrete steps to improve social ties for students with disabilities, but we agree with Avramidis (2013) that any intervention should aim to improve the classroom ecology as a whole (Gest & Rodkin, 2011).

Focusing solely on students with disabilities would reinforce a deficit framework (Farmer et al., 1996) and would not be as efficacious.

For example, teachers can improve conditions for all students if are more attuned underlying social structures in their classrooms (Hamm et al, 2011; Zambo, 2010) with accessible and non-complicated software (Mamas et al., 2019; Froehlich, Mamas & Schneider, 2019). The cited browser-based software allows teachers to conduct descriptive social network analysis within their classrooms, without having any knowledge on the technical aspects of such a methodology. Those with a better understanding of the social structure will make better judgments about seating arrangements and groups for cooperative learning experiences for all students. Moreover, they will be better equipped to address the needs of students with disabilities.

In a study by Nowicki and Brown (2013) 36 fifth- and sixth-grade students were asked what things could be done to increase social inclusion of students with learning difficulties. Over one-third of responses talked about the role the teacher plays in facilitating inclusion of students with learning difficulties. For example, teachers should also utilize purposeful seating arrangements and group work to foster social bonds (Nowicki & Brown, 2013). Peers who sit next to each other tend to form positive views of each other (van den Berg et al., 2012), and purposeful seating can improve the classroom ecosystem as a whole (Gest & Rodkin, 2011). That said, it may take more than just seating students together to foster positive ties. Teachers should ensure all students have a chance to showcase their

strengths to their peers and to contribute meaningfully to the group (González et al., 2005; Zambo, 2010). It is incumbent upon teachers to facilitate cooperative learning experiences that are structured to allow all members to participate and contribute (Zambo, 2010). Finally, teachers can model positive and empathetic relationships with all students (Gest & Rodkin, 2011). These positive teacher–student relationships can impact how peers view students and their willingness to form relationships with them (Hendrickx et al., 2017; Hughes & Chen, 2011).

Teachers can also do more to increase awareness of similarities between students with and without disabilities (Nowicki & Brown, 2013). Feelings of similarity between peers and teachers has been shown to have manifold benefits in relationships (Gehlbach et al., 2016; Walton et al., 2012). It can increase tie formation and tie strength in social networks (Mcpherson et al., 2001; Reagans, 2011) and increase feelings of belonging, which are related to increased motivation and positive identity (Walton et al., 2012). Interactions with others who people believe are similar to them support and validate people’s sense of self, values, and identity (Gehlbach et al., 2016; Montoya, 2008). Teachers can take concrete steps to help students recognizes similarities between them and their peers to potentially improve social inclusion of students with disabilities.

For teachers to be able to apply these pedagogical recommendations, more nuanced research findings are needed. This study has shown that ERGM and STERGM models offer a promising methodological approach to

analyze tie formation mechanisms and related social processes within a classroom network. Research in the field of social participation has firmly established that students identified as having disabilities or special educational needs are more likely to maintain a lower social participation status. However, what we need to transform and enhance the social participation of these students is nuanced insights into why this is happening and what social and other processes play into the likely social and academic exclusion of students with disabilities. Advanced network statistics may open a window into these social processes and they can do so in a longitudinal manner. Therefore, the formation, evolution, and/or dissolution of ties may be studied with techniques, such as ERGMs and STERGMs, as well as Simulation Investigation for Empirical Network Analysis (SIENA), which is a set of methods implemented in a computer program that carries out the statistical estimation of models for repeated measures of social networks according to the Stochastic Actor-oriented Model (SAOM) (Snijders, 2001).

Limitations

There are several limitations of this paper. First, this is a single unusual classroom case with only two networks, and the results are not generalizable. Second, the data we collected from students were limited, and some variables that account for tie formation may not have been captured. Third, students may have had close friends or sources of support beyond the boundaries of this classroom. This is a typical limitation of whole social network analysis, as the network must be bounded. Nevertheless, the study

offers a unique methodological approach to looking at social participation and helps fill some methodological and knowledge gaps.

Conclusion

In sum, our study supports earlier findings on social participation and offers new insights into tie formation mechanisms in the friendship and help-seeking networks of students with disabilities in a highly diverse middle school classroom. Although there are some limitations on generalizability, the findings are especially useful to teachers. Understanding the mechanisms of tie formation in individual classrooms can help educators transform and enhance social participation for all students, particularly those with designated disabilities. In addition, our study offers a solid and innovative methodological approach to statistically analyze tie formation mechanisms in classroom social networks. ERGMs and STERGMs have shown to provide a rigorous approach in exploring social participation of students with designated disabilities from a social network perspective.

References

Avramidis, E. (2013). Self-concept, social position and social participation of pupils with SEN in mainstream primary schools. *Research Papers in Education*, *28*(4), 421–442.

Avramidis, E., Strogilos, V., Aroni, K., & Kantaraki, C. T. (2017). Using sociometric techniques to assess the social impacts of inclusion: Some methodological considerations. *Educational research review*, *20*, 68-80.

Bodin, Ö., Nohrstedt, D., Baird, J., Summers, R., & Plummer, R. (2019). Working at the “speed of trust”: Pre-existing and emerging social ties in wildfire responder networks in Sweden and Canada. *Regional Environmental Change*, *19*, 2353–2364.

Borgatti, S. P., Everett, M. G., & Freeman, L. C. (2002). *Ucinet 6 for Windows: Software for social network analysis* [Computer software]. Analytic Technologies.

Borgatti, S. P., Everett, M. G., & Johnson, J. C. (2013). *Analyzing social networks*. Sage.

Borgatti, S. P., & Lopez-Kidwell, V. (2011). Network theory. In J. Scott & P. J. Carrington (Eds.), *The SAGE handbook of social network analysis* (pp. 40–54). Sage.

Borgatti, S. P., & Ofem, B. (2010). Overview: Social network theory and analysis. In A. J. Daly (Ed.), *Social network theory and educational change* (pp. 17–29). Harvard Education Press.

Bossaert, G., Colpin, H., Pijl, S. J., & Petry, K. (2013). Truly included? A

literature study focusing on the social dimension of inclusion in education. *International Journal of Inclusive Education*, *17*(1), 60–79.

Boutot, E. A., & Bryant, D. P. (2005). Social integration of students with autism in inclusive settings. *Education and Training in Developmental Disabilities*, 14-23.

CAASPP (2018) California Assessment of Student Performance and Progress. Available online at https://caaspp-elpac.cde.ca.gov/caaspp/.

Davis, J. A. (1963). Structural balance, mechanical solidarity, and interpersonal relations. *American Journal of Sociology, 68*(4), 444–462.

de Boer, A., Pijl, S. J., & Minnaert, A. (2012). Students' attitudes towards peers with disabilities: A review of the literature. *International Journal of Disability, Development and Education*, *59*(4), 379–392.

Estell, D. B., Jones, M. H., Pearl, R., & Van Acker, R. (2009). Best friendships of students with and without learning disabilities across late elementary school. *Exceptional Children*, *76*(1), 110–124.

Every Student Succeeds Act, 20 U.S.C. § 6301 (2015). https://www.congress.gov/114/plaws/publ95/PLAW-114publ95.pdf

Farmer, T. W., Lines, M. M., & Hamm, J. V. (2011). Revealing the invisible hand: The role of teachers in children's peer experiences. *Journal of Applied Developmental Psychology*, *32*(5), 247–256.

Farmer, T. W., Pearl, R., & Van Acker, R. M. (1996). Expanding the social skills deficit framework: A developmental synthesis perspective, classroom social networks, and implications for the social growth of

students with disabilities. *The Journal of Special Education*, *30*(3), 232–256.

Froehlich, D.E., Mamas, C. & Schneider, H.W. (2019) Automation and the journey to mixed methods social network analysis, in Froehlich, D. E., Rehm, M., & Rienties, B. C. (Eds.). (2019). *Mixed Methods Social Network Analysis: Theories and Methodologies in Learning and Education*. Routledge.

Frostad, P., & Pijl, S. J. (2007). Does being friendly help in making friends? The relation between the social position and social skills of pupils with special needs in mainstream education. *European Journal of Special Needs Education*, *22*(1), 15–30.

Gehlbach, H., Brinkworth, M. E., King, A. M., Hsu, L. M., McIntyre, J., & Rogers, T. (2016). Creating birds of similar feathers: Leveraging similarity to improve teacher–student relationships and academic achievement. *Journal of Educational Psychology*, *108*(3), 342.

Gest, S. D., & Rodkin, P. C. (2011). Teaching practices and elementary classroom peer ecologies. *Journal of Applied Developmental Psychology*, *32*(5), 288–296.

González, N., Moll, L. C., & Amanti, C. (2005). *Funds of knowledge: Theorizing practices in households, communities, and classrooms.* Routledge.

Hamm, J. V., Farmer, T. W., Dadisman, K., Gravelle, M., & Murray, A. R. (2011). Teachers' attunement to students' peer group affiliations as a source of improved student experiences of the school social–affective

context following the middle school transition. *Journal of Applied Developmental Psychology*, *32*(5), 267–277.

Handcock, M., Hunter, D., Butts, C., Goodreau, S., Krivitsky, P., & Morris, M. (2018). *ergm: Fit, simulate and diagnose exponential-family models for networks* (Version 3.9.4). The Statnet Project. https://CRAN.R-project.org/package=ergm

Hanneman, R.A., & Riddle, M. (2005). *Introduction to social network methods*. University of California, Riverside. http://faculty.ucr.edu/~hanneman/nettext/

Harris, J. K. (2014). *An introduction to exponential random graph models.* Sage.

Hendrickx, M. M., Mainhard, T., Boor-Klip, H. J., & Brekelmans, M. (2017). Our teacher likes you, so I like you: A social network approach to social referencing. *Journal of School Psychology*, *63*, 35–48.

Hughes, J. N., & Chen, Q. (2011). Reciprocal effects of student–teacher and student–peer relatedness: Effects on academic self-efficacy. *Journal of Applied Developmental Psychology*, *32*(5), 278–287.

Humphrey, N., & Symes, W. (2011). Peer interaction patterns among adolescents with autistic spectrum disorders (ASDs) in mainstream school settings. *Autism*, *15*(4), 397–419.

Hunter, D. R., Goodreau, S. M., & Handcock, M. S. (2008b). Goodness of fit of social network models. *Journal of the American Statistical Association*, *103*(481), 248–258.

Hunter D., Handcock, M., Butts, C., Goodreau, S., & Morris, M. (2008a). ergm: A package to fit, simulate and diagnose exponential-family models for networks. *Journal of Statistical Software*, *24*(3), 1–29.

Individuals with Disabilities Education Act, 20 U.S.C. § 1400 (2004).

Kasari, C., Locke, J., Gulsrud, A., & Rotheram-Fuller, E. (2011). Social networks and friendships at school: Comparing children with and without ASD. *Journal of Autism and Developmental Disorders*, *41*(5), 533–544. https://doi.org/10.1007/s10803-010-1076-x

Kennedy, C. H., Cushing, L. S., & Itkonen, T. (1997). General education participation improves the social contacts and friendship networks of students with severe disabilities. *Journal of Behavioral Education*, *7*(2), 167–189.

Kennedy, C. H., Shukla, S., & Fryxell, D. (1997). Comparing the effects of educational placement on the social relationships of intermediate school students with severe disabilities. *Exceptional Children*, *64*(1), 31–47.

Koster, M., Nakken, H., Pijl, S. J., & Van Houten, E. (2009). Being part of the peer group: A literature study focusing on the social dimension of inclusion in education. *International Journal of Inclusive Education*, *13*(2), 117-140.

Koster, M., Pijl, S. J., Nakken, H., & Van Houten, E. (2010). Social participation of students with special needs in regular primary education in the Netherlands. *International Journal of Disability, Development and*

Education, *57*(1), 59–75.

Krivitsky, P. N., & Goodreau, S. M. (2019). STERGM: *Separable temporal ERGMs for modeling discrete relational dynamics with Statnet*. http://www.vps.fmvz.usp.br/CRAN/web/packages/tergm/vignettes/STERGM.pdf

Krivitsky, P. N., & Handcock, M. S. (2014). A separable model for dynamic networks. *Journal of the Royal Statistical Society: Series B (Statistical Methodology)*, *76*(1), 29–46.

Locke, J., Ishijima, E. H., Kasari, C., & London, N. (2010). Loneliness, friendship quality and the social networks of adolescents with high-functioning autism in an inclusive school setting. *Journal of Research in Special Educational Needs*, *10*(2), 74–81. doi:10.1111/j.1471-3802.2010.01148.x

Lomi, A., Lusher, D., Pattison, P. E., & Robins, G. (2014). The focused organization of advice relations: A study in boundary crossing. *Organization Science*, *25*(2), 438–457.

Lusher, D. (2011). Masculinity, educational achievement and social status: A social network analysis. *Gender and Education*, *23*(6), 655–675.

Lusher, D., & Robins, G. (2013). Formation of social network structure. In D. Lusher, J. Koskinen, & G. Robins (Eds.), *Exponential random graph models for social network analysis: Theory, methods, and applications* (pp. 16–28). Cambridge University Press.

Mamas, C. (2013). Understanding inclusion in Cyprus. *European Journal of*

Special Needs Education, *28*(4), 480–493.

Mamas, C., Daly, A. J., Struyve, C., Kaimi, I., & Michail, G. (2019). Learning, friendship and social contexts. *International Journal of Educational Management*, *33*(6), 1255–1270.

Mamas, C., Schaelli, G. H., Daly, A. J., Navarro, H. R., & Trisokka, L. (2019). Employing social network analysis to examine the social participation of students identified as having special educational needs and disabilities. *International Journal of Disability, Development and Education*. https://doi.org/10.1080/1034912X.2019.1614153

McPherson, M., Smith-Lovin, L., & Cook, J. M. (2001). Birds of a feather: Homophily in social networks. *Annual Review of Sociology*, *27*(1), 415–444.

Montoya, R. M., Horton, R. S., & Kirchner, J. (2008). Is actual similarity necessary for attraction? A meta-analysis of actual and perceived similarity. *Journal of Social and Personal Relationships*, *25*(6), 889-922.

National Center for Education Statistics. (2019). https://nces.ed.gov/ccd/elsi/

Nowicki, E. A., & Brown, J. D. (2013). “A kid way”: Strategies for including classmates with learning or intellectual disabilities. *Intellectual and developmental disabilities*, *51*(4), 253-262.

Peltier, G. L. (1997). The effect of inclusion on non-disabled children: A review of the research. *Contemporary Education*, *68*(4), 234–238.

Petry, K. (2018). The relationship between class attitudes towards peers with a disability and peer acceptance, friendships and peer interactions of

students with a disability in regular secondary schools. *European Journal of Special Needs Education*, *33*(2), 254–268.

Pijl, S. J., Frostad, P., & Flem, A. (2008). The social position of pupils with special needs in regular schools. *Scandinavian Journal of Educational Research*, *52*(4), 387–405.

Qi, J., & Ha, A. S. (2012). Inclusion in physical education: A review of literature. *International Journal of Disability, Development and Education*, *59*(3), 257–281.

Reagans, R. (2011). Close encounters: Analyzing how social similarity and propinquity contribute to strong network connections. *Organization Science*, *22*(4), 835–849.

Reagans, R., & McEvily, B. (2003). Network structure and knowledge transfer: The effects of cohesion and range. *Administrative Science Quarterly*, *48*(2), 240–267.

Robins, G., & Lusher, D. (2013a). A simplified account of an exponential random graph model as a statistical model. In D. Lusher, J. Koskinen, & G. Robins (Eds.), *Exponential random graph models for social network analysis: Theory, methods, and applications* (pp. 29–36). Cambridge University Press.

Robins, G., & Lusher, D. (2013b). Illustrations: Simulation, estimation, and goodness of fit. In D. Lusher, J. Koskinen, & G. Robins (Eds.), *Exponential random graph models for social network analysis: Theory, methods, and applications* (pp. 167–185). Cambridge University Press.

Robins, G., Pattison, P., Kalish, Y., & Lusher, D. (2007). An introduction to exponential random graph (p*) models for social networks. *Social Networks*, *29*(2), 173–191.

Rotheram-Fuller, E., Kasari, C., Chamberlain, B., & Locke, J. (2010). Social involvement of children with autism spectrum disorders in elementary school classrooms. *Journal of Child Psychology and Psychiatry*, *51*(11), 1227–1234.

Schaefer, D. R., & Marcum, C. S. (2017, August 15). Modeling network dynamics. *SocArXiv Papers*. https://doi.org/10.31235/osf.io/6rm9q

Shazi, R., Gillespie, N., & Steen, J. (2015). Trust as a predictor of innovation network ties in project teams. *International Journal of Project Management*, *33*(1), 81–91.

Siciliano, M. D. (2015). Advice networks in public organizations: The role of structure, internal competition, and individual attributes. *Public Administration Review*, *75*(4), 548–559.

Small, M. L. (2009). *Unanticipated gains: Origins of network inequality in everyday life*. Oxford University Press.

Small, M. L., & Adler, L. (2019). The role of space in the formation of social ties. *Annual Review of Sociology*, *45*, 111–132.

Snijders, T. A. B. (2001). The statistical evaluation of social network dynamics. *Sociological Methodology*, 31:361–395.

Snijders, T. A., Pattison, P. E., Robins, G. L., & Handcock, M. S. (2006). New specifications for exponential random graph models. *Sociological*

Methodology, *36*, 99–153.

Snijders, T. A. (2011). Statistical models for social networks. *Annual Review of Sociology*, *37*, 131–153.

Spillane, J. P., Kim, C. M., & Frank, K. A. (2012). Instructional advice and information providing and receiving behavior in elementary schools: Exploring tie formation as a building block in social capital development. *American Educational Research Journal*, *49*(6), 1112-1145.

Spillane, J. P., Shirrell, M., & Sweet, T. M. (2017). The elephant in the schoolhouse: The role of propinquity in school staff interactions about teaching. *Sociology of education*, *90*(2), 149-171.

UNESCO. (1994). *The Salamanca statement and framework for action on special needs education*. https://unesdoc.unesco.org/ark:/48223/pf0000098427

van den Berg, Y. H., Segers, E., & Cillessen, A. H. (2012). Changing peer perceptions and victimization through classroom arrangements: A field experiment. *Journal of Abnormal Child Psychology*, *40*(3), 403–412. https://doi.org/10.1007/s10802-011-9567-6

Van Mieghem, A., Verschueren, K., Petry, K., & Struyf, E. (2018). An analysis of research on inclusive education: A systematic search and meta review. *International Journal of Inclusive Education*. https://doi.org/10.1080/13603116.2018.1482012

Wainscot, J. J., Naylor, P., Sutcliffe, P., Tantam, D., & Williams, J. V. (2008).

Relationships with peers and use of the school environment of mainstream secondary school pupils with Asperger syndrome (high-functioning autism): A case-control study. *International Journal of Psychology and Psychological Therapy*, *8*(1), 25–38.

Walton, G. M., Cohen, G. L., Cwir, D., & Spencer, S. J. (2012). Mere belonging: The power of social connections. *Journal of personality and social psychology*, *102*(3), 513.

Wasserman, S., & Faust, K. (1994). *Social network analysis: Methods and applications* (Vol. 8). Cambridge University Press.

Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th ed.). Sage.

Zambo, D. M. (2010). Strategies to enhance the social identities and social networks of adolescent students with disabilities. *Teaching Exceptional Children*, *43*(2), 28–35.

TABLES AND FIGURES

Figure 1: *Structural Effects Included in ERGM and STERGM Models*

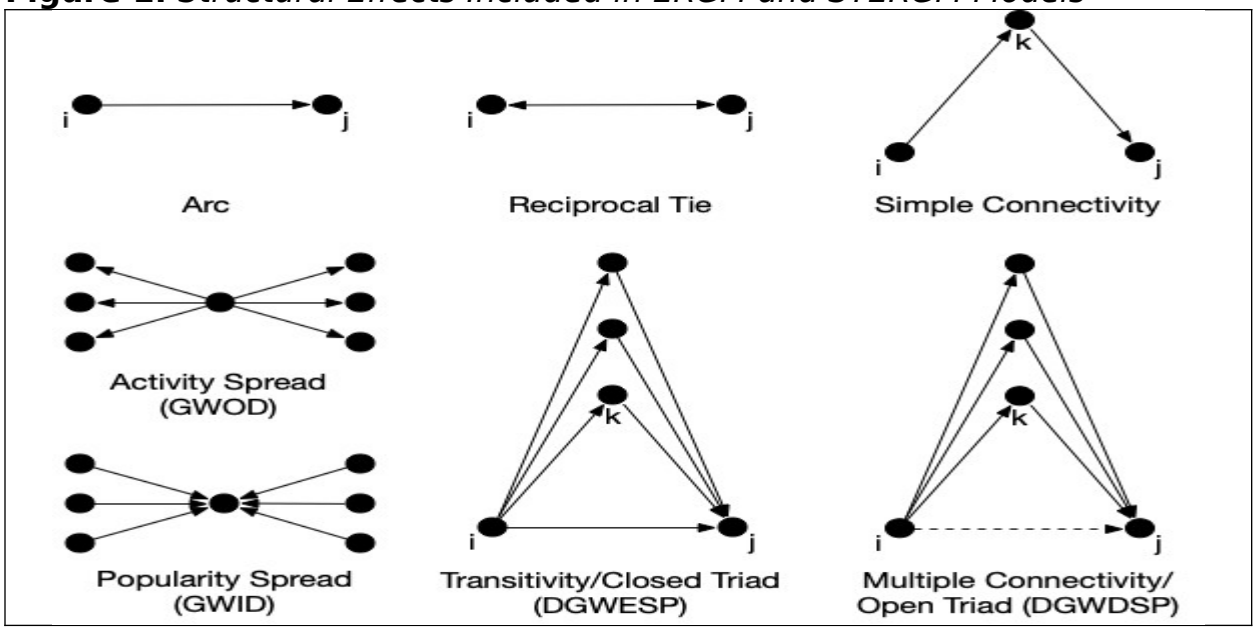
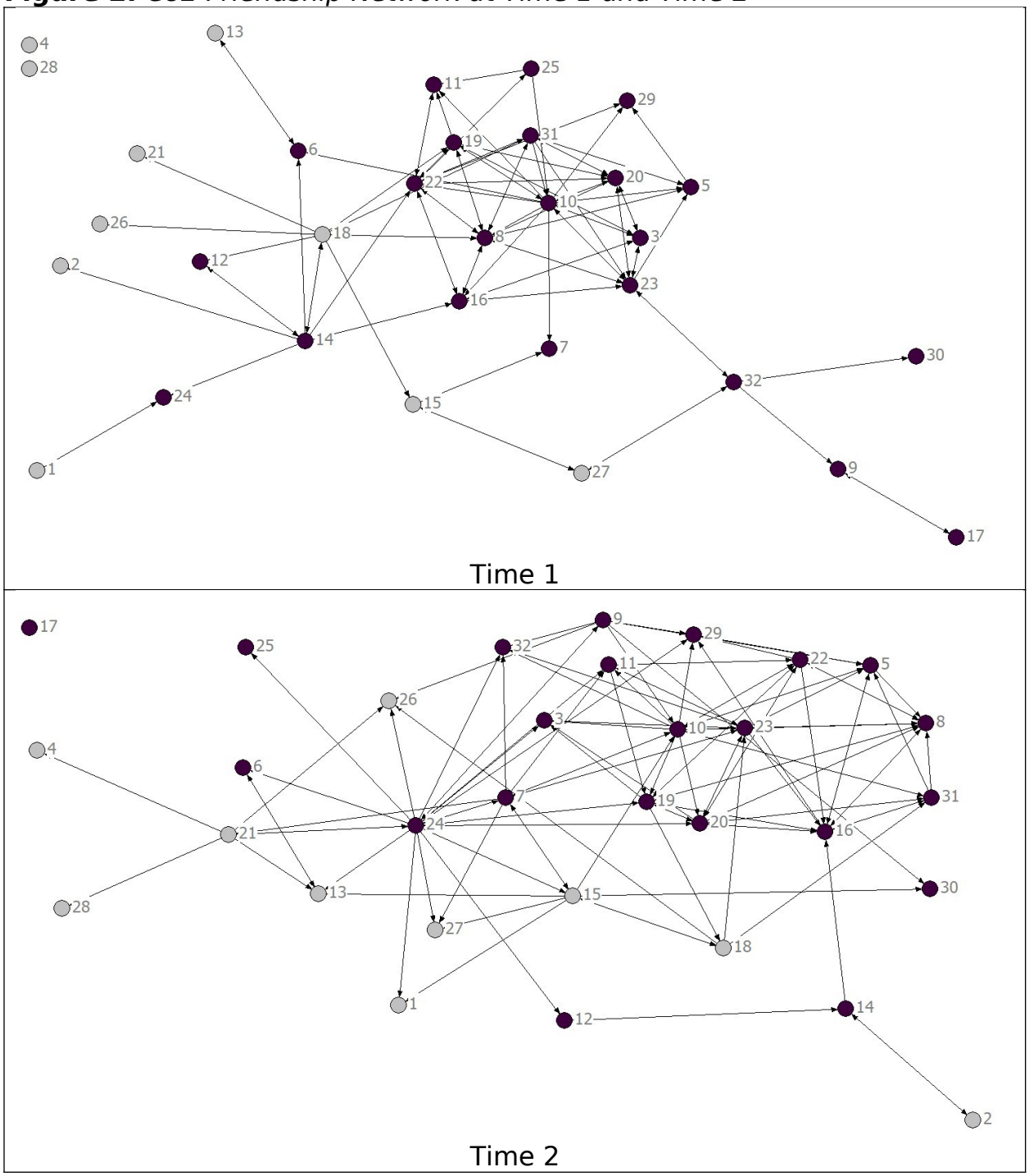


Table 1: *Demographic Variables*

Gender	Disability/IEP	Race/Ethnicity	Free or Reduced-Price Lunch	English-Language Learner
12 girls 20 boys	SLD: 8 (5 boys) OHI: 2 (2 boys)	HL: 21 BAA: 1 WAW: 7 AA: 3	Free: 15 Reduced-Price: 4	EO: 22 EL: 2 R: 8

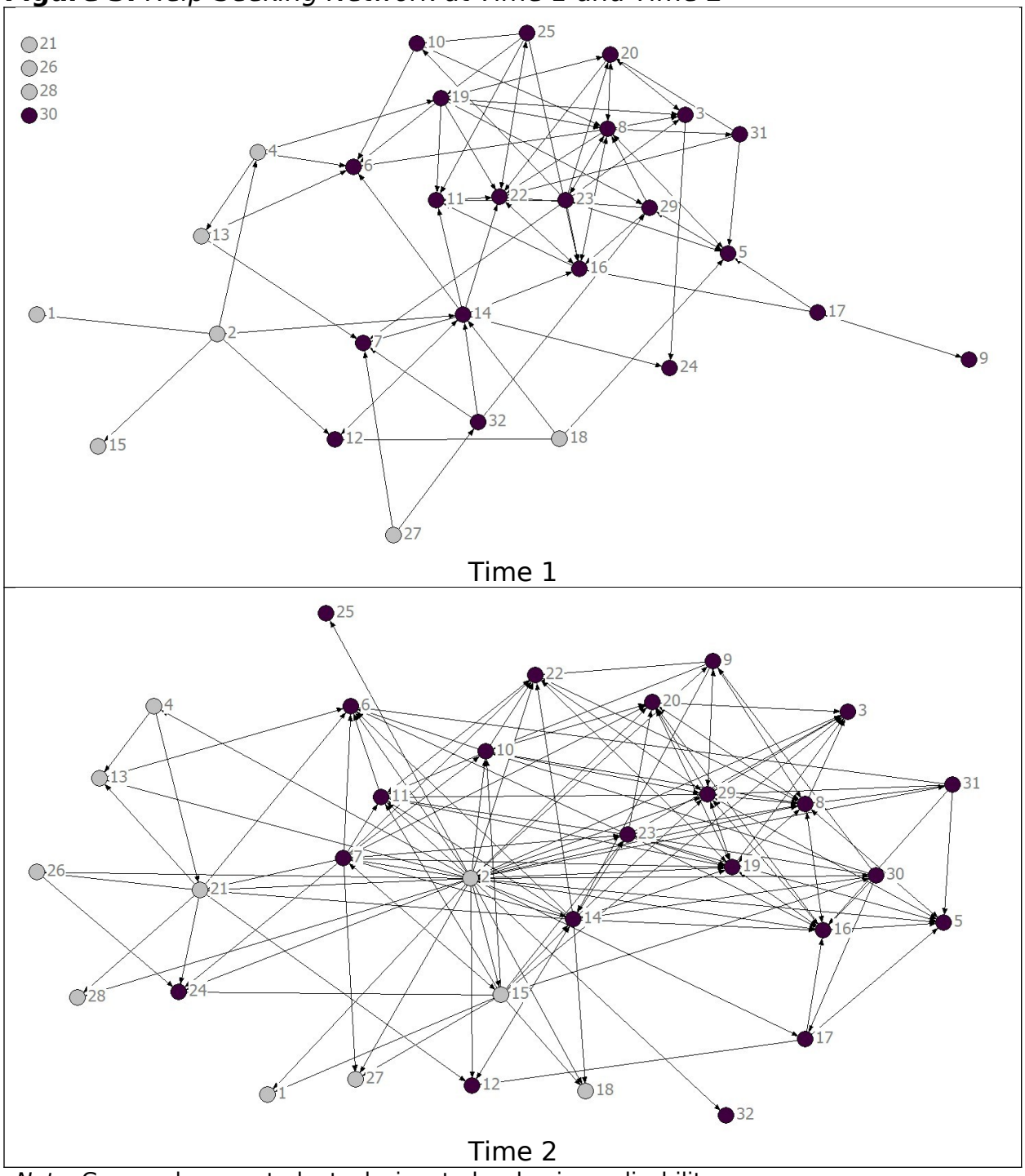
Note. N = 32; SLD = specific learning disability; OHI = other health impairment; HL = Hispanic or Latino; BAA = Black or African American; WAW = White American/White; AA = Asian American; EO = English only; EL = English learner; R = redesignated.

Figure 2: *C82 Friendship Network at Time 1 and Time 2*



Note. Grey nodes are students designated as having a disability.

Figure 3: *Help-Seeking Network at Time 1 and Time 2*



Note. Grey nodes are students designated as having a disability.

Table 2: *ERGM/STERGM Friendship Network*

	ERGM formation (T1)	Odds ratios for significant actor-level effects	STERGM formation (T1–T2)	Odds ratios for significant actor-level effects
Structural Effects				
Arcs	-3.92*** (.72)		-3.32*** (.70)	
Reciprocity	3.37*** (.51)		2.49*** (.45)	
Simple connectivity	-.10+ (.06)		-.13** (.05)	
Popularity spread (DGWID)	2.22+ (1.19)		-.04 (1.64)	
Activity spread (DGWOD)	-2.26** (.78)		-1.82* (.80)	
Transitivity/closed triad (DGWESP)	.63*** (.63)		.34* (.16)	
Multiple connectivity/open triad (DGWDSP)	.01 (.05)		.07* (.03)	
Actor-Level Homophily Effects				
Same gender	.34* (.16)	1.40	.10** (.26)	1.11
Same ethno-racial group	-.22 (.19)		-.35 (.27)	
Same disability designation	.66* (.33)	1.93	.76* (.76)	2.14
Same free/reduced-price lunch	.35* (.17)	1.42	.41 (.27)	
Same English-language fluency	.39* (.18)	1.48	-.21 (.25)	
Absolute difference in cumulative GPA	-.20 (.12)		-.07 (.32)	
Sender/Receiver Effects				
Sender: Special education	.87* (.37)	2.39	-.07 (.32)	
Receiver: Special education	-1.92* (.77)	.15	.02 (.41)	

Note. Standard errors in parentheses.
***p<.001. **p<.01. *p<.05. +p<.1.

Table 3: *ERGM/STERGM Help-Seeking Network*

	ERGM formation (T1)	Odds ratios for significant actor-level effects	STERGM formation (T1–T2)	Odds ratios for significant actor-level effects
Structural Effects				
Arcs	-1.93*** (.41)		-3.28*** (.51)	
Reciprocity	1.44** (.46)		.17 (.40)	
Simple connectivity	-.37*** (.11)		-.16*** (.05)	
Popularity spread (DGWID)	-.35 (.76)		6.04** (2.97)	
Activity spread (DGWOD)	-1.47** (.55)		-.80 (.77)	
Transitivity/closed triad (DGWESP)	.67*** (.16)		.69*** (.11)	
Multiple connectivity/open triad (DGWDSP)	.21 (.13)		-.07 (.07)	
Actor-Level Homophily Effects				
Same gender	.31+ (.19)	1.36	.46* (.19)	1.58
Same ethno-racial group	.04 (.19)		.78*** (.21)	2.18
Same disability designation	pc[a]		.11 (.21)	
Same free/reduced-price lunch	.13 (.20)		.03 (.22)	
Same English-language fluency	.50** (.18)	1.65	.02 (.18)	
Absolute difference in cumulative GPA	-.23+ (.13)	.79	-.27+ (.15)	.76
Sender/Receiver Effects				
Sender: Special education	-.33 (.23)		.56** (.21)	1.75
Receiver: Special education	-1.74*** (.61)	.18	-.44 (.29)	

Note. Standard errors in parentheses.
[a] Not included in model because it had perfect correlation with tie formation.
***p<.001. **p<.01. *p<.05. +p<.1.