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Social Networks and Science Identity: Does Peer Commitment Matter?

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SOCIAL NETWORKS AND SCIENCE IDENTITY: DOES PEER COMMITMENT MATTER?

By

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White men continue to be overrepresented in STEM fields compared to women and minorities, despite several decades of scholarly interest the disparity. Studies have shown that early adolescence is when children begin to lose interest in science. It is also in this period, that children start to develop ideas and stereotypes about *who* should be a scientist. It is essential that youth are able to see themselves as science kinds of people. Students who have strong science identities have been shown to perform better in science classes, retain interest in science and continue on to STEM careers. During adolescence, peer opinions take on increasing importance.. Peer support (or lack thereof) can impact students' science identities.

This work explores how students' peer networks influence their subsequent commitment to a science identity, through the framework of identity theory. Data for this study comes from a multi-wave, longitudinal dataset, collected from a middle school in a mid-sized Midwestern city (The Science Identity Study (SIS)). I examine two aspects of identity commitment, using both survey (affective commitment) and network (relational commitment) measures. I find that both measures of commitment are positively related to science identity. Additionally, I find that identity commitment positively predicts science identity between waves. Race and gender reduce the strength of some of these associations, but largely processes of identity commitment remain significant. These

findings suggest that the friend group is a place where science identity can be fostered. Support from peers can keep youth engaged in science, and help them maintain or strengthen their science identities. Peer networks should not be neglected by educators, policy makers and other STEM stakeholders as they seek to strengthen student science identities. Creating collaborative peer environments may be a key way to educate, mentor, and encourage the scientists of the future.

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Introduction

The number of careers that require STEM education and training are increasing faster than other occupations (Ilumoka 2012). However, the size of the workforce emerging to take part in and advance these sectors has remained largely the same (Wang and Degol 2017). Not only are there numeric deficits in students who chose to pursue STEM careers, there are also remarkable inequities in *who* enters these jobs. Though in recent years organizations (both public and private) have been vocal about promoting diverse workforces, gender and ethnic disparities are a regularity (Hardcastle et al. 2019). These gaps in representation begin early on in a student's educational career and continue throughout secondary and post-secondary education, before they materialize in adulthood.

Studies have pointed to middle school as the time when science interest among students begins to wane, and these inequities begin to arise (Vedder-Weiss and Fortus 2011; Carlone et al. 2014; Caleon and Subramaniam 2008; Blue and Gann 2008). Though less near to actual career training and occupations, middle school students are making decisions that will have long standing effects on their futures. Middle school is a time of early career exploration and decisions about secondary education (Tai et al. 2006). Students who begin to lose interest in science and math in these years may select out of science course tracts in later years- putting themselves at a disadvantage in the STEM career world long before they ever set foot in a job interview or on a college campus. Nonetheless, most research has focused on students who are closer to the transition into a career field. In order to address this gap, the sample of the present study catches youth at a crucial time period.

There have been many explanations as to what factors influence a student's decision to continue in science fields or not. The racialized and gendered inequities in these fields are made apparent not only by employment statistics, but also by studies that show that this phenomenon is rooted much deeper in the fabric of our society. Pervasive STEM stereotypes promote an exclusionary prototype of the typical scientist (Shapiro and Williams 2012; Starr 2018; Tao and Alberta 2018). Previous research argues that within this type of social context, factors such as academic achievement and science interest may not be as important as the ability to see oneself as "a scientist" (Archer et al. 2012; Barton et al. 2013; Packard and Nguyen 2003, Wonch Hill et al. 2017;). In light of this, the present study uses identity theory as a mechanism for understanding how science aspirations and interest can be sustained.

Youth who do not view themselves as scientists are less likely to maintain a long-term science interest, persevere in advanced science classes or pursue a STEM career (Chemers et al. 2011; Seyranian et al. 2018;). Work has shown that although the majority of young students may enjoy science and be interested in it, they perceive differences between "doing science" and "being a scientist" (Archer et al. 2010). Additionally, there are heavily gendered perceptions about who is a "science kind of person" (Nosek et al. 2009; Archer et al. 2010). Even among preadolescent students, there is a bias toward viewing white boys as innately better at science (Carlone et al. 2015). Due to these gendered and racialized perceptions, and the disconnect of enjoying science and possessing a science identity, students may come to believe that being a scientist is not a feasible future. Personal science identity is an important factor in the way students see themselves, and their potential in STEM fields down the road.

Science identity is not formed in a social vacuum; identities are constructed and maintained in a social context. For youth in middle schools, the peer group that surrounds them and the friendships they form (both generally and within the academic setting) are inescapable parts of their academic lives (Cook et al. 2007; Crosnoe et al. 2008). The presents work emphasizes how the maintenance of science identity is rooted in interpersonal, peer processes. I situate my research in the theoretical framework of identity theory (Burke and Stets 2009). Whether or not a person views them self as a "science" kind of person, even in early adolescence, can have far ranging consequences on his/her future aspirations and endeavors. Therefore, it is important to consider the factors that influence youth at this early stage of identity development, in order to make truly meaningful interventions in STEM representation (Hazari et al. 2009).

Literature Review

The Importance of Science Identity

Research has found positive correlations between science identity and science related social, emotional, academic, and career related outcomes. Previous research has pointed to links between STEM identity and affective outcomes like flourishing, self-efficacy, belonging and persistence across varied samples. Measures such as "flourishing" (defined by the acronym PERMA- positive emotion, engagement, positive relationships, life meaning, and accomplishment of goals) demonstrate the potentially extensive reverberations of a STEM identity (Seyranian et al. 2018). In a longitudinal study that examined physics identity's effect on psychological outcomes and achievement, it was found that over time physics identity was associated with increases in female student's flourishing. However, this relationship did not persist for the male students in their sample. These findings may demonstrate the amplified significance of science identity for students who are underrepresented in STEM.

Studies have also investigated singular affective measures like self-efficacy (defined as the belief in one's ability to achieve), a sense of student belonging (Trujillo and Tanner 2014) and motivation (Starr 2018) in relation to science identity. Reviewing affective aspects of the science learning environment, the authors concluded that self-efficacy, belonging and science identity all interact and influence one another (Trujillo and Tanner 2014). Science identity can influence a student's feeling of belonging and increase their self-efficacy in science (Trujillo and Tanner 2014). Similarly, science identity has been found to be positively correlated with undergraduate women's STEM motivation (Starr 2018).

These subjective affective measures are also reflected in objective academic outcomes. In a study that examined persistence, academic performance and engagement, final grades and engagement were found to be strongly correlated with science identity among community college students. The stronger the science identity, the higher the grades and engagement (Riccitelli 2015). Similar patterns have been found in four year universities. Among undergraduate students in four year colleges, those who reported a physics identity had significantly better grades than those who did not (Seyranian et al. 2018).

Research has also pointed to the importance of pursuing science beyond the hours of the school day. Many students perceive that classroom science is out of touch with "real science" (Vincent-Ruz and Schunn 2018; Zhai et al. 2013;). Informal science exploration can help students understand how science functions "in the real world" and discover STEM career possibilities. Out of school engagement in after school programs (Tyler-Wood 2012), museums (Chi et al. 2015) and video games (Gilliam et al. 2016) have all been shown to be effective manners of increasing and maintaining student engagement in science. These positive experiences have also been tied to science identity. A recent study found connections between science identity and "choice and home science activity participation" (Vincent-Ruz and Schunn 2018). Science identity predicted increased participation in extracurricular science learning experiences. Additionally, for girls, science identity was a stronger predictor of this additional science activity participation. Though girls in the sample reported lower science identities overall, those who did report a high science identity had higher odds of participating in extracurricular activities than boys who reported high science identity.

In addition to the broad range of outcomes that affect students in the present, research has also found direct connections between science identity and career intentions. Using the same measures of identity commitment as the present study, Merolla and Serpe found science identity among college students influenced planned and realized science career and graduate education intentions (Merolla et al. 2012). In further work using the identity theory framework, STEM identity salience had a significant effect on graduate school student matriculation, as well as college GPA (Merolla and Serpe 2013).

Similarly, among high school and college students, physics identity (measured from a sample of roughly three thousand students from 34 institutions) was found to strongly predict pursuing a career in physics (Hazari et al. 2009). Comparable results have also been found in samples of students who are generally underrepresented in STEM fields (minorities and women). A recent study which sampled 38 diverse college campuses (including public and private schools, multicultural campuses, historically black colleges and Hispanic serving universities) found that the development of a student's science identity within the primary and secondary education systems mapped strongly on to those students entering STEM careers (Stets et al. 2017).

These combined findings illustrate the breadth of beneficial outcomes associated with science identification. The associations found in previous literature demonstrate that identifying as a science kind of person may positively impact a student's academic and emotional wellbeing in the present. Science identity can have far reaching effects on a student's motivation, extracurricular participation, academic outcomes and engagement. Additionally, science identity can help predict the achievement of science career goals in the future.

However, the majority of these findings examine students post the "dropping off" point in student science identity (in the early years of adolescence). Though examining science identity among secondary and post-secondary students is valuable, it is also essential to examine students before the gaps in science identity are fully developed. It is well documented that early adolescence is the time period that science interest falters for many students. Examinations of science identity during this crucial time period merit study. The current work seeks to further the literature by examining science identity among a younger population of middle school students.

Social Networks and Identity Theory

Social networks have substantial influence on identity formation. The social structure that surrounds a person forms a context in which identity develops, both at the micro and macro levels (Stets and Burke 2000). Identity theory argues the meanings and expectations of a person's identity (or identities) are reinforced by the people surrounding them. Social support and interactions with others can facilitate or weaken our individual identities. For adolescents in general and students developing science identities, the approval of others may be a driving force of identity formation (Cook et al. 2007; Crosnoe et al. 2008). I investigate student's science identity recognizing that this identity cannot be separated from a social context.

Identity theory has deepened our understanding of the identity process by disambiguating several distinct concepts. Measures of the different facets of the identity process have been used to empirically demonstrate the complex interdependencies of identity and social networks. The concept I focus on in this work is "identity commitment." Stryker and Burke (2000) define identity commitment as the "degree to which persons' relationships to others in their networks depend on possessing a particular identity and role." There are generally two components to this measure of identity- measuring both "the extent to which a person's social contacts are contingent on the enactment of the identity and how meaningful those contacts are" (Stryker 2002). Identity theory argues that both of these facets are integral to capturing how individuals give their identities meaning.

Work investigating identity commitment generally includes affective commitment (how important the identity is to the individual), as well as relational, network focused operationalizations of this term (Stets and Biga 2003; Stryker and Serpe 1994). Quantitatively, the more ties a person has to others with the same identity, it follows the greater commitment they have to maintain that identity. As put by Stryker "to the degree that one's relationships to specified sets of other person depend on being a particular kind of person, one is committed to being that kind of person" (1980, p. 60-61). In this work, I investigate students' social networks as environments in which science identity may be encouraged or rebuffed. I employ both relational and affective operationalizations of commitment to demonstrate the social network's influence on personal identity.

This research has some precedents, though few explicitly use identity commitment as a measure. Previous work has found that relational factors influence science identity (Lee 2002). This research validated the positive relationship between the number of SME (science, math and engineering) network ties and personal identification with SME. Investigating the experiences of students within the context of science related summer programs, Lee (2002) found that the more relationships a student had premised around the SME "role", the higher the self-identification with SME and reported behaviors connected to SME. I seek to continue this line of research by exploring both the relational and affective aspects of network ties to science identity in my analysis. These commitment measures can help us understand what factors lead to reporting a stronger science identity.

Methods

Data

I use two waves of data from the Science Identity Study (SIS). The main purpose of the study was to understand the factors that contribute to engagement with science in middle school. The study collected data from 6th, 7th, and 8th grade students of a mid-sized Midwestern city from 2013 to 2014. Prior to asking students to participate, Institutional Review Board (IRB) approval was obtained for the study. This data set comes from a school with relatively high poverty rates (78% of the students receive free and reduced lunch), and the school is also ethnically diverse (69.6% of the sample identify as part of a racial/ethnic minority group). All students enrolled in science classes (615 of 663 total students) were asked to participate.

Parents were given a form, distributed in several languages (English, Spanish, Vietnamese, and Arabic). Students who returned this form were able to participate. The waves were collected in the winter and spring the school year. In wave one, the final participation rate was 72%, yielding a sample of 444 students, with 232 girls and 212 boys. About a third of the sample was White (30.1%), roughly a quarter Latino (24.49%) and around a fifth was Black (20.83%). Middle Eastern (7.19%), Asian (6.81%), Other (5.18%) and Native American (5.30%) students made up the rest of the sample. Between waves, the sample size dropped from 444 to 408. Using logistic regression, I found that this attrition (n=36) did not result in a wave two sample that was significantly different from the wave one sample on the variables of interest.

Students were asked a variety of questions about their engagement with science, including measures of science perceptions (e.g. "How much, if at all, do you think science helps people?" and "How much fun do you think a scientist has at work?"), attendance and participation in science related activities, and science identity measures. In the first two waves students were also asked to report network measures. Students were able to nominate up to 14 friends to create personal ego networks. After this, they were asked whether they discussed science with each friend they listed. To conduct analysis, I operationalized measures of identity commitment using measures from both the network and survey portions of the study.

Measures

Affective Commitment

To capture the affective aspects of identity commitment for the individual, I used the question "How much do you like science?" with answer choices "I like it a lot" "I like it some" "I like it a little" "I don't like it at all." This is referred to as *personal affective commitment*. I examined the respondent's perception of their *friends' affective commitment* with a similar question ("How much do your friends like science?" with response choices of "A lot", "Some", "A little", and "Not at all"). Both measures were reverse coded, so that higher scores indicated liking science more. For some analysis, these questions were dichotomized into "Low" (for those who responded "A little," and "Not at all") and "High" (comprised of "A lot" and "Some") affective commitment.

Relational Commitment

I operationalized relational identity commitment using friendship nominations and a relationship interpreter that asked the respondents whether or not they talked about science with each of the youths they nominated as friends. I use a binomial measure for whether the student talked to any friends about science (1 for yes, 0 for no).

Science Identity

Science identity is my dependent variable. Science identity is an ordinal variable, captured by the question "How much do you think you are a science kind of person?" The question was asked in both waves of data. Students were provided 4 answer choices, "Totally," "Somewhat," "A little," "Not at all." The variable was recoded so that the higher numbers correlated with higher ratings of science identification. There is also a binary measure of identity. In this variable, those who report high science identification (being "Totally" a science kind of person) in either wave are coded as 1. The remaining scores are coded as 0.

Controls

The demographic controls within this study include gender and race. Gender is a binary variable with categories of "Male" and "Female". Race was originally a seven category variable, including answer choices of "White", "Latino", "Middle Eastern", "Black", "Asian", "Native American" and "Other". For analysis, these designations were collapsed into four categories, "White", "Hispanic", "Black" and "Other". Due to the existing literature surrounding the "ideal type" of a scientist, white is used as the reference category in the models presented (Shapiro and Williams 2012; Starr 2018; Tao and Alberta 2018; Wonch Hill et al. 2017). Descriptive statistics for these variables can be found in Appendix A (see Table 1).

Hypotheses

Based on identity theory, the following hypotheses reflect the expected relationships between both affective and relational commitment measures with science identity. Additionally, I explore changes between waves.

Affective Commitment

H1: There will be a positive association between *personal affective commitment* and *Science Identity*.

H2: There will be a positive association between *perception of friends' affective commitment* and *Science Identity*.

H3: *Affective commitment* will be positively associated with *Science Identity* over time.

Relational Commitment

H4: Talking to friends about science (*relational commitment)* will be positively associated with *Science Identity*.

H5: Talking to friends about science *(relational commitment)* in the fall will be positively associated with *Science Identity* in the spring.

Analysis

To explore the initial associations between my measures of commitment and science identity, I employed a series of binomial logistic regressions. These models utilize the binary measure of science identity ("totally" identifying as a science kind of person) to examine commitment's associations with high science identification. This method of analysis is appropriate for the categorical, binary nature of the variable.

Affective Commitment

Results for Hypothesis 1 (presented in Table 2) support the proponents of identity theory. The baseline models find a significant relationship between individual affective commitment and a higher science identity (Table 2, Model 1). Students who report liking science are significantly more likely to report high science identities. I also conducted models with race and gender, to explore the effects of these variables, which are added in the subsequent models (Table 2: Models 2 and 3). The strong positive association between personal affective commitment and science identity remains when these controls are added.

Table 2. The relationship between High Science Identity and Personal Affective Commitment and Controls (Odds Ratios)

	(Model 1)	(Model 2)	(Model 3)
Personal Affective Commitment	9.590*** (4.118)	9.529*** (4.116)	9.860*** (4.287)
Gender (Male)	-	1.740 (.539)	-
Race (White)			
Hispanic	-	-	.512 (.219)
Black	-	-	.409 (.201)
Other	-	-	.973 (.382)
Constant	.000 (.000)	.000 (.000)	.000 (.000)
N	385	385	385
AIC	274.663	273.410	267.794
F	55.69***	58.94***	59.33**

P<.05; **P<.01; ***P<.001** ***Note: Standard errors given in parentheses

Table 3 shows the analysis of hypothesis two, regarding friend's affective commitment and science identity. Consistent with my second hypothesis, perceptions of friend's affective commitment are also positively correlated with science identity, though to a lesser extent (see Table 3). After exploring the baseline correlation I added control variables in models 2 and 3. When gender is added to models of perceived friend's commitment, the association between commitment and identity is weakened. I did not find significant differences in race in this association.

Table 3. The relationship between High Science Identity and Perceived Friend's Affective Commitment and Controls (Odds Ratios)

	(Model 1)	(Model 2)	(Model 3)
Friend's Affective Commitment	1.578* (.329)	1.473† (.307)	1.529* (.331)
Gender (Male)	-	1.773† (.524)	-
Race (White)			
Hispanic	-	-	.635 (.257)
Black	-	-	.498 (.233)
Other	-	-	1.064 (.387)
Constant	.050 (.031)	.025 (.018)	.031 (.022)
N	385	385	385
AIC	325.252	323.438	318.038
F	5.10*	8.91*	6.90*

†P<0.1;*P<.05; **P<.01; ***P<.001 ***Note:*** Standard errors given in parentheses

To assess if affective commitment in wave one was associated with subsequent science identity (Hypothesis 3), I employed ordinal logistic regressions. When examining this association, I wanted to capture the full range of student answer choices (not just those of students who identified as "totally" science kinds of people). In these models, the dependent variable (wave two science identity) is an ordered categorical variable. As mentioned in the methods section, science identity is comprised of the question "How much do you see yourself as a science kind of person?" The possible answer choices of this variable include "Not at all", "A little", "Somewhat", and "Totally". Thus, this regression format is appropriate. A Brant test confirmed that the data comply with the proportional odds assumption (Long and Freese 2014), These ordinal models use a lagged dependent variable (LDV) to explore the correlation of wave one commitment variables and later Science Identity. In the following analysis, these commitment measures are used to predict the outcome variable of wave 2 Science Identity, controlling for the baseline of Science Identity in wave 1. Due to the usage of a LDV in the following models, this analysis is subject to some of the limitations of lagged dependent variable analysis (Johnson 2005). Correlated error terms and shared covariance among independent variables may bias estimates (Johnson 2005).

However, there are some strengths to LDV models. These models can be employed with only two waves of longitudinal data. Though the present data set collected 4 waves of data, only 2 include complete network data. For this reason, LDV analysis is appropriate. Additionally, because the dependent variable follows the independent variables, casual time ordering is established. Theoretically, there is also a strong reason to believe that science identity in the spring is in part a function of science identity reported earlier in the school year. This is why the consideration of wave one identity in the form of a LDV is warranted.

Table 4 shows the results of these regressions, stepping in controls for each model. In support of my third hypothesis, I find that perceived affective commitment of friends significantly increases the odds of reporting higher science identity over time. For each increase in friend's affective commitment (for example, from "Some" to "A lot"), the odds of increasing to the next category of science identity increase by a factor of 2.446 (all else constant). This association persists when adjusting for science identity at the previous wave. I did not find significant effects of race and gender.

Table 4. Coefficients for Ordinal Regression predicting Wave 2 Science Identity by Friend's Affective Commitment and Controls (Odds Ratios)

	(Model 1)	(Model 2)	(Model 3)	(Model 4)
Friend's Affective Commitment	2.446*** (.497)	1.697** (.365)	1.683** (.364)	1.450** (.210)
Science Identity *(Wave 1)*	-	2.864*** (.269)	2.852*** (.268)	5.369*** (.799)
Gender	-	-	1.083 (.217)	-
Race (White)				
Hispanic	-	-	-	.927 (.250)
Black	-	-	-	.710 (.204)
Other	-	-	-	.730 (.196)
N	379	379	379	379
AIC	983.325	831.444	833.384	816.881
F	19.81***	170.31***	170.47***	171.94***

P<.05; **P<.01; ***P<.001** ***Note: Standard errors given in parentheses

Due to the inherent complexity in interpretation of ordinal logistic regression, I also examined this relationship in terms of probabilities. As perceived friend's commitment increases, the probabilities of reporting the two lowest categories of science identity ("not at all" a science kind of person or "a little") decrease. Correspondingly, as perceived friend commitment increases, so does the probability of a student reporting the two highest categories of science identity (identifying as "somewhat" or "totally" a science kind of person). Figures 1 and 2 show these probabilities in more categorical detail.

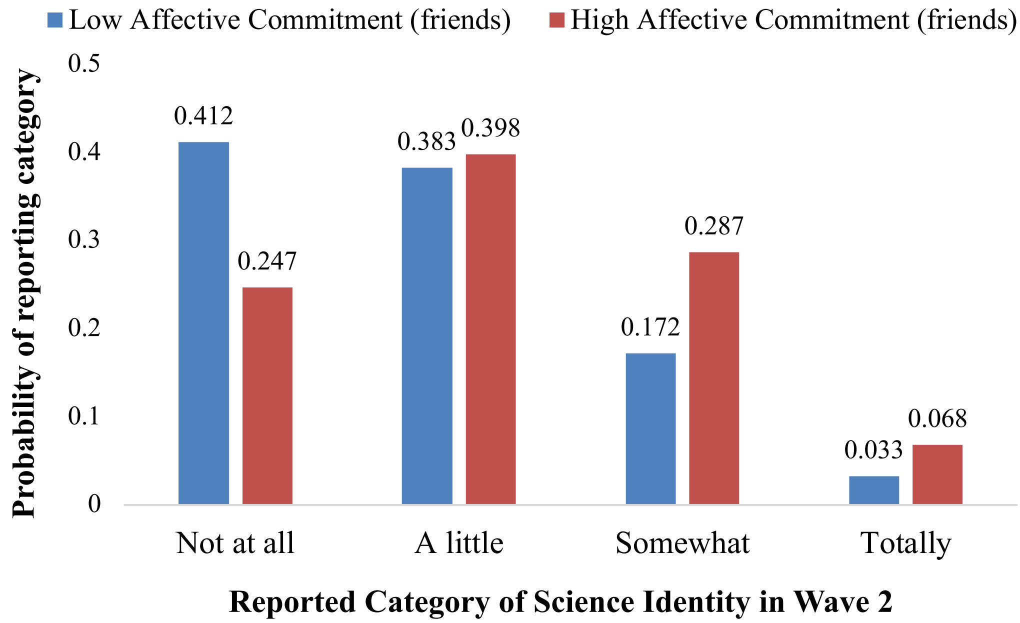
This analysis uses the dichotomized measure of friend's affective commitment and predicts the probability of students choosing each category of science identity in wave two. This simplification clarifies the illustration and is substantively similar to what would be seen with the full range of values. Figure 1 shows probabilities for students who *do* talk to friends about science (see Appendix B for those who do not). Compared to students who report low perceived support from friends, students who perceive high support have almost double the probability of reporting the two highest categories of science identity. The probabilities shown in Figures 1-3 were predicted from the ordinal regression shown in Table 5. Appendix B contains descriptive statistics and additional information on probabilities.

Table 5. Coefficients for Ordinal Regression predicting Wave 2 Science Identity by Relational and Affective Commitment (Odds Ratios)

Relational Commitment	1.743** (.366)
Affective Commitment	1.635** (.352)
Science Identity (Wave 1)	2.711*** (.260)
N	379
AIC	827.592
F	177.37***

***P<.05; **P<.01; ***P<.001** *Note:* Standard errors given in parentheses

Figure 1. Probability of Wave 2 Science Identity (varying Friend's Affective Commitment)



Relational Commitment

As with Affective Commitment, results for Hypothesis 4 (*Talking to friends about science, relational commitment, will be positively associated with Science Identity*) are calculated using the dichotomized measure of Science Identity. Table 6 shows the models for Hypothesis 4. I find strong support for this hypothesis. Students who talk to their friends about science are more likely to report "totally" being a science kind of person. Gender is also significant. Compared to girls, boys are more likely to report "totally" identifying as science kinds of people. The indicator for race/ethnicity has a fairly large coefficient but the p-value does not reach the conventional significance cut off of .05. These findings are consistent with existing literature. (Shapiro and Williams 2012; Starr 2018; Tao and Alberta 2018)

Table 6. The relationship between High Science Identity and Relational Commitment with Controls (Odds Ratios)

	(Model 1)	(Model 2)	(Model 3)
Relational Commitment	2.859*** (.872)	3.028*** (.935)	3.190*** (1.017)
Gender (Male)	-	2.101** (.625)	-
Race (White)			
Hispanic	-	-	.552 (.226)
Black	-	-	.415 (.196)
Other	-	-	.931 (.345)
Constant	.0978*** (.024)	.0305*** (.017)	.037*** (.021)
N	385	385	385
AIC	317.578	313.167	307.521
F	12.77***	19.18***	16.07***

†P<0.1;***P<.05; **P<.01; ***P<.001** ***Note**:* Standard errors given in parentheses

To assess Hypothesis 5 (Talking to friends about science, relational commitment, in the fall will be positively associated with science identity in the spring), I use the ordinal, four category variable of wave 2 science identity as my dependent variable. Similar to the models of affective commitment, I employ ordinal logistic regressions for this analysis, adding in controls for each model. Results are presented in Table 7.

I find support for this hypothesis. Talking to friends about science in wave one is positively associated with subsequent science identity. Higher relational commitment is associated with an increase in the odds of reporting a higher science identity by a factor of 3.242 (all else constant). This association remains significant when controlling for race and gender, as well as when adjusting initial science identity. Race and gender were not found to have significant effects in these models.

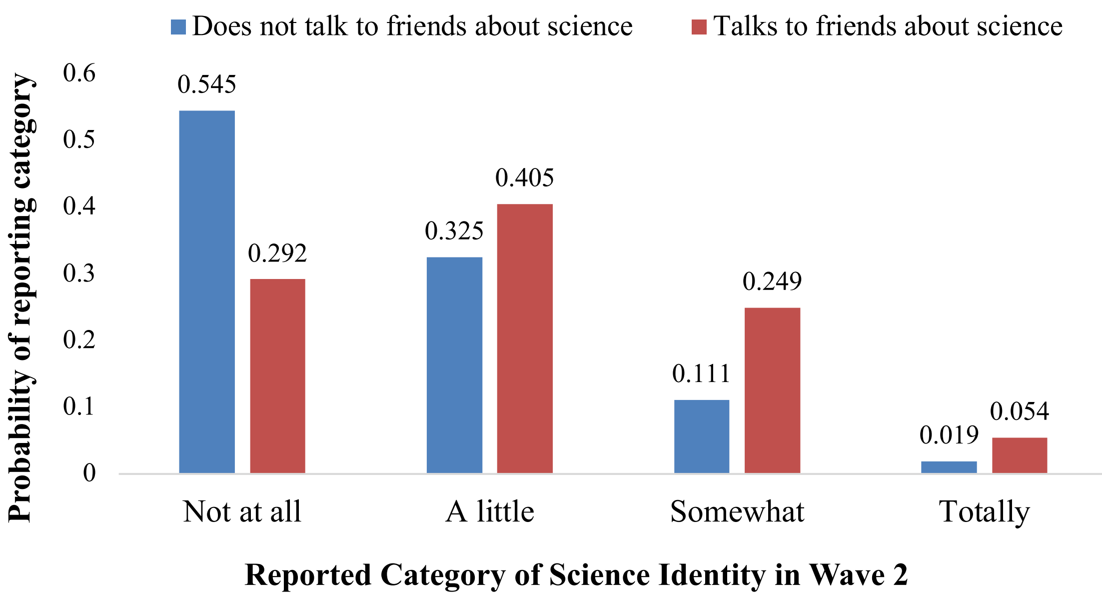
Table 7. Coefficients for Ordinal Regression predicting Wave 2 Science Identity by Relational Commitment and Controls (Odds Ratios)

	(Model 1)	(Model 2)	(Model 3)	(Model 4)
Relational Commitment	3.242*** (.636)	1.797** (.376)	1.837** (.387)	1.832** (.386)
Science Identity *(Wave 1)*	-	2.784*** (.267)	2.745*** (.265)	2.750*** (.263)
Gender	-	-	1.212 (.244)	-
Race (White)				
Hispanic	-	-	-	.802 (.215)
Black	-	-	-	.606 (.174)
Other	-	-	-	.664 (.178)
N	379	379	379	379
AIC	974.71	833.406	834.471	815.204
F	37.47***	172.13***	173.04***	175.67***

P<.05; **P<.01; ***P<.001** ***Note: Standard errors given in parentheses

Talking to friends about science is associated with decreases in the probability of reporting "Not at all" or "A little" as wave two science identity and increases in the probability of reporting "Somewhat" or "Totally" as science identity. Figure 2 shows these probabilities in detail. On average, students who talk to friends about science have nearly double the probability of reporting the two highest categories of science identity.

Figure 2. Probability of Wave 2 Science Identity (varying Relational Commitment)



Discussion

This study examined science identity through the theoretical lens of identity commitment, and explored the effects of students' social networks on their identity. Overall, I find that both theorized components of identity commitment (affective and relational measures) are related to science identity. Students' individual science identities are likely to be affected by friend's feelings toward that identity and being able to share their identity among friends.

These findings are in line with the tenants of identity theory. In the vein of past work using identity theory, my work demonstrates how the theoretical conceptualization of identity commitment can be translated into empirical work. The more relationships are premised around an identity, the stronger the individual's reported identity. Whether this support is perceived (as with friend's affective commitment) or enacted (relational commitment), an individual's network cannot be disentangled from their identity.

In the context of science identity specifically, network based identity commitment seems to help encourage and predict personal science identity. In fact, this work finds that students whose friends talk to their friends about science or feel supported by their friend group are more likely to report higher science identities over time.

While gender and race were found to be significant predictors of some of the relationships found in this research, the processes of identity commitment endure. Though there are initial disparities in who reports being a science kind of person and talking to friends about science, gender and race are insignificant in the hypotheses explored in this paper. This suggests that peer groups can perhaps mediate some of the pervasive stereotypes around being a “scientist”, and allow for all students to see themselves as science kinds of people. Future research may be able to clarify how these peer processes operate for underrepresented STEM students. In spite of the many gender and racial inequities found in science identity literature, my work shows how friendships premised around the science identity can have beneficial influence on *all* student’s science identities.

Limitations:

I recognize that identities are not all encompassing and multiple identities may be important to students. Unfortunately, this study is limited by the scope of available data, which only includes identity measures regarding the science identity. As such, this study cannot capture the full array of identities that may be important to students. Previous work has found that middle school is a time when other identities (such as gender) become especially salient (Wonch Hill et al. 2017). Future work may want to examine the intersections of multiple identities, in order to get a more complete picture of the factors that influence science success.

The study is also limited with the range of time data were collected. My data follows students throughout their middle school experience, but does not extend past this. It is well established that the transition into high school can change the social landscape and thus the identities of students (Barber and Olsen 2004). Subsequent work should investigate transition from middle school to high school, and its effect on science friendships and identity.

Despite these limitations, I believe the associations I find can still be beneficial and meaningful for students. Broadly, friendship networks related to the science identity can positively shape students' own science identities. The friend group can be a place where the science identity is incubated. These findings may be able to inform educators, policy makers and science professionals as they seek to diversify and advance STEM fields. In a time where peer opinions are monumentally important, students who see themselves as science kinds of people can influence their peers. This influence can lead to students seeing themselves as science kinds of people, which in turn can lead to confidence, persistence and performance in science. All these factors can keep youth engaged in science and foster the scientists of tomorrow.

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APPENDIX A

Descriptive Statistics

Table 1. Means, Standard Deviations, and Descriptions for Variables Used in Analysis

Variable Name	Description	Metric	Mean	S.D.
Science Identity (Wave 1)	How much do you think you are a science kind of person?	1=Not at all; 4=Totally	2.455	0.844
(Wave 2)			2.317	.929
Science Identity (Combined)	How much do you think you are a science kind of person?	0=Not at all, A little, Somewhat; 1=Totally (in either wave)	.151	.358
Relational Commitment	For each nominated friend: Do you talk to this person about science?	0 = No to all; 1= Yes to any	.475	.500
Personal Affective Commitment	How much do you like science?	1 = I don't like it at all; 4 = I like it a lot.	3.314	.776
Friend's Affective Commitment	How much do your friends like science?	1= Not at all; 4= A lot	2.699	.741
Gender	Are you a boy or a girl?	0= Female; 1= Male	.465	.499
Race	What is your race/ethnicity?	0= Non-white; 1= White	.304	.461
				(N=385)

Table 8. Descriptive Statistics of Relational Commitment & Science Identity over waves

	Talks to friends about science				**Does not talk to friends about science**			
	Second Wave Science Identity							
First Wave Science Identity	*Not at all*	*A little*	*Somewhat*	*Totally*	*Not at all*	*A little*	*Somewhat*	*Totally*
Not at all	60.0%	40.0%	0.0%	0.0%	70.0%	25.0%	2.5%	2.5%
A little	20.0%	45.5%	34.5%	0.0%	26.3%	49.6%	23.3%	0.8%
Somewhat	3.3%	27.8%	55.6%	13.3%	5.1%	32.8%	49.6%	12.4%

Table 9. Descriptive Statistics of Affective Commitment & Science Identity over waves

	High Affective Commitment *(Friend)*				**Low Affective Commitment** *(Friend)*			
	Second Wave Science Identity							
First Wave Science Identity	*Not at all*	*A little*	*Somewhat*	*Totally*	*Not at all*	*A little*	*Somewhat*	*Totally*
Not at all	54.2%	37.5%	4.2%	4.2%	77.8%	22.2%	0.0%	0.0%
A little	25.3%	46.2%	28.6%	0.0%	30.9%	49.1%	18.2%	1.8%
Somewhat	5.4%	28.6%	53.6%	12.5%	5.3%	36.8%	47.4%	10.5%

APPENDIX B
Predicted Probabilities

Table 10. Change in Probability of Wave 2 Science Identity (Friend's Affective Commitment)

Wave 2 Science Identity

Not at all	*A little*	*Somewhat*	*Totally*
-0.088	-0.073	0.088	0.073

*For a one unit increase in Friend's Affective Commitment, holding other variables at their means, predicted from Table 4, Model (1)

Table 11. Change in Probability of Wave 2 Science Identity (Relational Commitment)

Wave 2 Science Identity

Not at all	*A little*	*Somewhat*	*Totally*
-0.132	-0.149	0.127	0.154

*Moving from not talking to friends to talking to friends, holding other variables at their means, predicted from Table 6. Model (1)

Figure 3. Probability of Wave 2 Science Identity (varying Friend's Affective Commitment, students who do *not* talk to friends about science)