RELATIONSHIPS BETWEEN PERCEIVED TEACHER AND PEER SUPPORT ON MOTIVATION AND ACHIEVEMENT IN HIGH SCHOOL MATHEMATICS

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One hundred fourteen US students were surveyed to test a model of the relationships among motivational variables resulting from students' first experiences as they transitioned from middle school to high school, and math achievement. Key malleable factors impacting motivation and achievement included perceived supportiveness of respondents' teacher and peers. Longitudinal Path Analysis revealed that teacher support can impact students' beliefs about the supportiveness of their peers, but that these social factors are mediated through students developing personal interest in mathematics to ultimately impact achievement.

INTRODUCTION

Mathematics engagement has been characterized as the attention, interest, investment, and effort students expend in the process of learning mathematical content (Marks, 2000). Psychologically, engagement is associated with a sense of belonging in the social functioning of the classroom, as well as the behavioral, emotional, and cognitive characteristics of one's mathematical thought and actions. Research shows that different aspects of engagement interact with each other.When all aspects of engagement are at optimal levels, students tend to expend more effort (behavioral engagement), enjoy their experiences more (affective engagement), employ more efficient and effective study and problem-solving strategies (cognitive engagement), and both help and receive help from their peers (social engagement) (Middleton, Jansen & Goldin, 2017). Because of this complexity, however, it is still somewhat of a mystery how each of these aspects of engagement contributes to achievement, separately and in conjunction. Not all students who are engaged highly in each or all of these facets achieve at optimal levels, and some students who may lack in one form of engagement may utilize other forms to compensate and achieve (Skilling et al., 2016).

The purpose of this study is to examine aspects of engagement longitudinally, modeling the longer-term effects of these variables on each other—i.e., on "growth" of mathematics engagement in a course, and their mutual influence on achievement. As part of this model, we are also especially concerned with the perceived supportiveness of the teacher, and the perceived supportiveness of peers. These factors are hypothesized to contribute to classroom climate in such a manner that students' engagement may be impacted positively.

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Teacher Support and Student Engagement in High School Mathematics

Recent views about engagement from the motivation literature, as well as from emotion research and teacher education hold that engagement is largely a function of the context within which students learn (Strati, et al., 2017). In mathematics classrooms, the teacher can influence norms of interacting that enhance students' sense of belonging, as well as their cognitive and affective engagement with the mathematics. This is accomplished through the instructional support a teacher provides such as the selection and orchestration of mathematics tasks, scaffolding discussions, and providing assistance and feedback. Strati, et al., term this type of support to be *instrumental* in that it is directly associated with the mathematics content and its experiencing.

When students perceive that their teacher is supportive in this manner, they also tend to report greater efficacy and effort, lower anxiety, and greater intrinsic motivation in math. These motivational effects in turn, appear to directly effect achievement and ongoing commitment to schooling (Klem & Connell, 2004).

In short, when teachers are perceived as helpful, providing feedback, *and* caring with fair, respectful treatment of their students, students seem to respond positively, engage deeper cognitively, emotionally, and behaviorally, and achieve better as a consequence.

Peer Support and Student Engagement in High School Mathematics

Like teacher support, peer social support has been shown to impact students' beliefs about and patterns of engagement in mathematics. In a highly cited report, Mata, et al,, (2012) studied the perceived peer support as reported by 1,719 Portuguese students, from fifth-to-twelfth grade and their interest and enjoyment of the subject, and with their perceived competence in mathematics--a construct nearly identical to mathematical self-efficacy. Across those grade bands, they found that peer social support, measured by items such as "In math class students want me to do my best in math work," was positively associated with their perceived competence, interest and enjoyment in mathematics, and notably, the perceived support of the teacher. These results along with others (Froiland & Davison, 2016) show that peers influences their friends' interest in mathematics and through that, their mathematics achievement (see also Ahmed, et al., 2010).

Variables Making Up Student Engagement

There is considerable evidence that peer support and teacher support together create a learning environment that facilitates the development of self-regulation strategies, positive mathematical self-efficacy, and personal interest in mathematics (Cleary, et al., 2017; Hidi and Renninger, 2006). fThis robust self-efficacy and personal interest in mathematics, in part, influences achievement positively.

The remainder of this manuscript will describe a longitudinal study examining the relationships among social engagement domains--teacher and student support—and student engagement factors in the cognitive and affective domains including

mathematics self-efficacy, interest/enjoyment in mathematics, and mathematics self-regulation.

METHOD

Participants

One hundred fourteen students assented and received parental consent to participate in the study during the 2018-2019 academic year. All students were drawn from schools in a large urban school district in the Southwest US. 47 percent of the students identified as male, 53% identified as female. 82% of the students identified as Hispanic/Latinx, 18% identified as Caucasian/White, 5% identified as Black/African/African American, 4% identified as American Indian/Alaska Native, 3% identified as Asian or Asian-American. sAll students were enrolled in a mathematics course designated as "first-year high school mathematics," focused on traditional Algebra 1 content.

Instrument

The Long-Term Engagement Survey consists of items that assess many aspects of student engagement. A full description of the psychometric properties of this instrument can be found in (Zhang, et al., 2019).

Four scales were utilized as indicators of mathematics motivation: (1) math *personal interest* (comprised of thirteen 7-point Likert scale items, $\alpha = 0.91$). (2) mathematics *self-regulation*, (comprised of thirteen 7-point Likert scale items, $\alpha = 0.84$; and (3) mathematics *self-efficacy*, i.e., the extent to which students feel capable of doing math (comprised of eighteen 7-point Likert scale items $\alpha = 0.87$).

A teacher support scale consisted of 12 Likert items assessing instrumental and emotional support, and care. Example items included "My math teacher tries to understand how I see things before suggesting a new strategy" (instrumental support), and "My math teacher recognizes us for trying hard" (emotional support).

The student support scale consisted of 7 Likert items assessing belonging and classmates' interest and caring. Example items included "My classmates in my math class care about how well I learn." Reliability of the teacher and peer support scales were high (Teacher Support $\alpha = 0.95$, Student Support $\alpha = 0.84$).

The Achievement Measure consisted of the state-mandated, multiple-choice, high school mathematics proficiency examination, administered at or near the end of the Spring Semester, 2019. The measure covered content from the traditional High School Curriculum through second year Algebra.

Procedure

The Long-Term Engagement Survey was administered twice in the students' first-year high school mathematics course: Once near the beginning of the course to assess

students' incoming sense of engagement, peer and teacher support, and once near the end of course, but prior to state-level achievement testing.

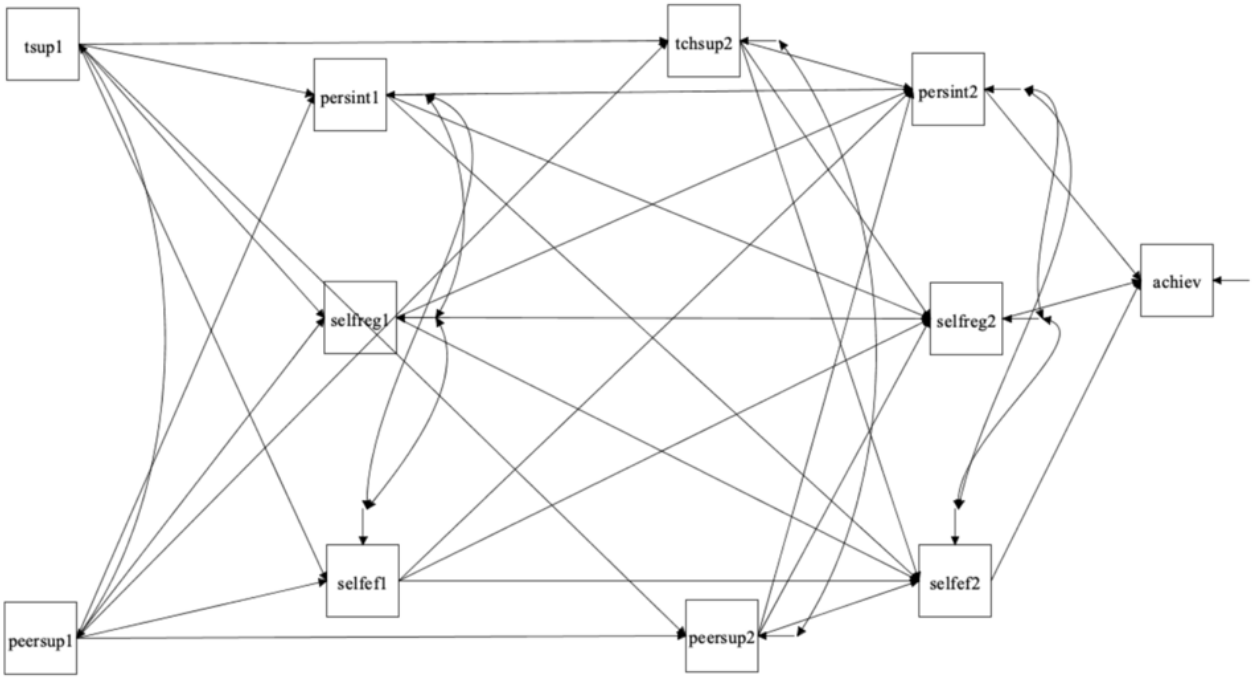

Figure 1: Hypothesized relationships among teacher and student support, mathematics engagement, and achievement over time.

RESULTS

Our model of the relationships and flow of effect of engagement factors maps the hypothesized influence of students' perceptions of their earlier experiences in mathematics with variables labeled with subscript 1, on their later experiences, labeled with subscript 2 (see Figure 1). The flow of time in Figure 1 is from left to right, with prior beliefs impacting subsequent beliefs. Achievement is hypothesized to be dependent primarily on engagement as it is manifest at the end of the year, just prior to the state-level assessment being administered (see Davis, 1985). Teacher and peer support are hypothesized to be reciprocal effects in both time periods (e.g., Klem & Connell, 2004), and engagement variables are hypothesized to influence each other and are therefore modeled as covariates.

Longitudinal Path analysis was performed with the proposed model defining the regression paths. With the relatively small ratio of sample size to parameters being estimated, this facilitates model convergence at the price of lost sensitivity. With the excellent reliability and factor structure of our instrument, we assess this to be an acceptable tradeoff. All models were estimated in MPlus Version 8 (Muthen & Muthen, 2017).

Table 1 shows the standardized regression coefficients for the hypothesized path model. Figure 2 illustrates the significant paths for the model, with coefficient estimates and their respective standard errors.

	Dependent Variables										
	Fall 2018					Spring 2019					
Independent Variables	Teach Supp 1	Peer Supp 1	Pers Int 1	Self Reg 1	Self-Eff 1	Teach Supp 2	Peer Supp 2	Pers Int 2	Self Reg 2	Self Eff 2	Ach
Teach Supp 1		0.96*	0.23*	0.11	0.06						
Peer Supp 1			0.21	0.29*	0.07						
Pers Interest 1								0.58*	-0.05	0.04	
Self Reg 1			0.38*					-0.06	0.41*	-0.03	
Self-Eff 1			0.20*	0.22*				-0.16	-0.12	0.28*	
Teach Supp 2	0.63*	-0.16					0.50*	0.02	0.08	0.09	
Peer Supp 2	0.23*	0.32*						0.47*	0.34*	0.21*	
Pers Interest 2											6.56*
Self Reg 2								0.15*			-3.70
Self Eff 2								0.10*	0.10*		-8.94

*Significant $p<0.05$.

Table 1: Standardized Regression Coefficients for Hypothesized Paths.

With regards to the impact of students incoming feelings of math engagement on their feelings at the end of the year, we can see significant direct effects of Personal Interest, Math Self-Regulation, and Math Self-efficacy on their respective counterparts at the end of the year. Within each time point, these variables are strongly correlated, but across time, they appear to primarily impact within-variable change.

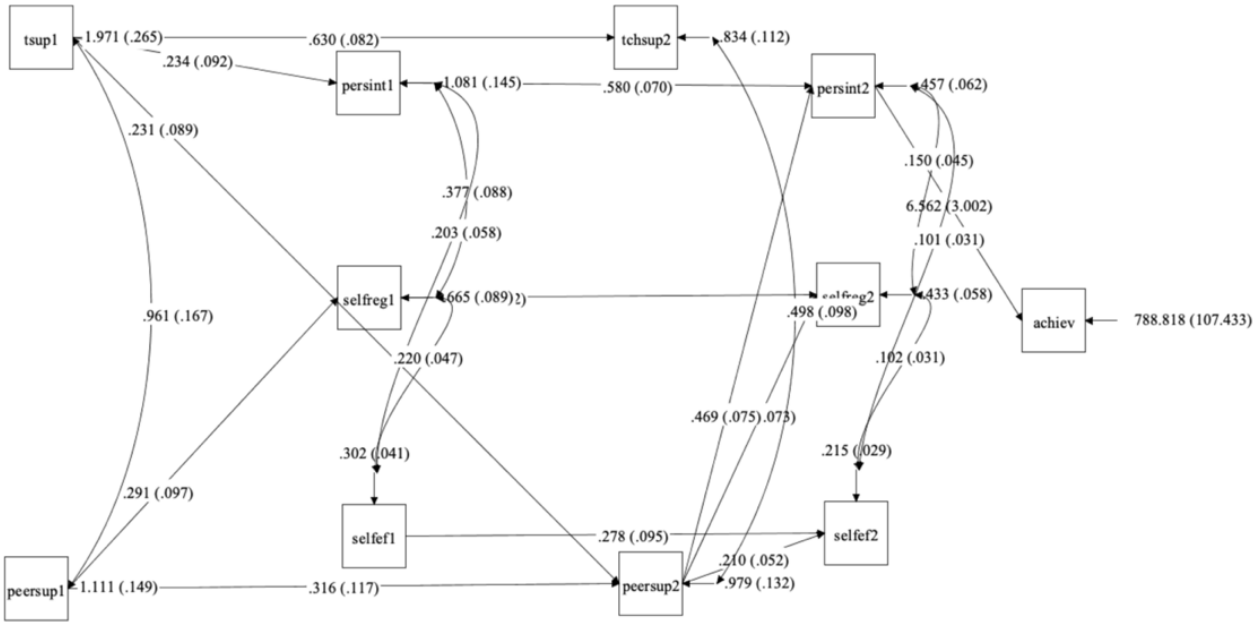

Figure 2: Final Path Model showing significant paths.

The impact of perceived Teacher Support and Peer Support shows strong evidence of mediation effects. The regression coefficients between Teacher Support and Peer Support at each time are very high. At the beginning of the Fall semester, teacher support showed a moderate impact on Personal Interest and Math Self-efficacy, with

non-significant relationships for Self-Regulation. For its part, Peer Support in the Fall Semester appeared to impact Self-Regulation primarily. With the strong relationship between Peer and Teacher Support, it is unclear exactly how direct these paths may be.

Likewise in the Spring of 2019, we find a strong relationship between feelings of Peer and Teacher Support. But in Spring, 2019, it is apparent that Teacher Support is mediated through Peer Support. Peer Support shows strong relationships with Personal Interest and Self-Regulation, with a moderate relationship with Self-Efficacy.

Finally, with respect to mathematics Achievement, Personal Interest in Mathematics appears to be the strongest impact, of the measured variables. This is consistent with prior research showing that Personal Interest in mathematics is among the most influential determinants of math Achievement.

The model tested showed excellent fit (see Hu & Bentler, 1999). The Chi-square to degrees of freedom ratio was 1.49. CFI was estimated at 0.98, and TLI was estimated at 0.95. RMSEA was a bit high for this analysis at 0.066. However, this measure becomes inflated at lower degrees of freedom. When the standardized coefficients are assessed, the SRMSR is within acceptable limits at 0.049.

DISCUSSION

Taken together, results indicate that teacher and peer support are mutually impactful in the high school classroom, interacting with each other to create a classroom climate that can be facilitative or obstructive to the development of productive mathematics engagement. The impact of these variables are mediated in a number of ways as students negotiate the first year of high school, but Peer Support especially appears to become more important over time as a potential determinant of mathematics engagement.

Achievement as an outcome in freshman mathematics is impacted in a highly complex manner by these interacting facets of the classroom climate. Evidence from this study supports earlier reports that as students transition into the comprehensive high school, their attention to peers, their status, and the social aspects of schooling become more important than the perceived influence of the teacher (Reindl et al., 2015). Our results suggest that teacher support can impact students' beliefs about the supportiveness of their peers, but that these social factors are mediated through students developing personal interest in mathematics to ultimately impact achievement.

At this time in students' lives, it appears that math Self-efficacy appears to mediate teacher support, influencing subsequent mathematics achievement as well as interest. The current study adds to our understanding of how these incoming beliefs play out as the new norms of high school mathematics are introduced and reinforced in students' first year. Yu & Singh (2018) suggest that positive interactions among teacher and students influence students building stronger beliefs about their cognitive capability (i.e., self-efficacy), and enhancing their personal interest in the subject matter. This

increase in efficacy in turn further reinforces interest, which directly supports their achievement in mathematics.

Some caveats must be stated about the interpretation of these results. First, we modeled the variables in this study as measured variables, not as latent variables. This was for practical reasons due to low sample size relative to the number of parameters we estimated in the model. Inevitably due to this lack of power, some of the hypothesized paths may not have been detected, constituting Type II errors. Second, the sample itself is unique, reflecting urban classrooms in large public high schools in the Southwest US and may not reflect the motivation or classroom culture evidenced in other regions.

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