Associations Between Elementary Teachers' Mental Health and Students' Engagement Across Content Areas

Corresponding Author: Leigh McLean[1]
Email: lmclean@udel.edu Phone: (971)-226-7019
https://orcid.org/0000-0001-7983-5497

Kristen L. Granger[2]
Email: Kristen.Granger@Vanderbilt.edu Phone: (814)-574-5105
https://orcid.org/0000-0001-8989-3631

Jason C. Chow[2]
Email: Jason.Chow@Vanderbilt.edu Phone: (301)-405-3964
https://orcid.org/0000-0002-2878-7410

[1]Center for Research in Educational and Social Policy, University of Delaware
Address: 125 Academy Street, Newark, DE 19711

[2]Peabody College, Vanderbilt University
Address: 230 Appleton Place, Nashville, TN 37203

Publication Date: 10/01/2023

Publication URL: https://www.sciencedirect.com/journal/contemporary-educational-psychology

The research reported here was supported by the Institute of Education Sciences, U.S. Department of Education, through Grant R305A200524 to the University of Delaware. The opinions expressed are those of the authors and do not represent views of the Institute or the U.S. Department of Education.

Abstract

Teachers' mental health has been recognized as relevant to teacher effectiveness, with past work identifying impacts of teachers' mental health on teacher, classroom, and student outcomes. However, much still needs to be understood about the extent to which teachers' mental health is associated with students' learning experiences, including in which learning contexts and among which student groups effects might surface most pointedly. We investigated associations among fourth grade teachers' (N=65) self-reported depressive and anxious symptomatology and their students' (N=805) self-reported behavioral engagement in mathematics, science, and English language arts and whether these associations varied for students based on their enrollment status in a Free and Reduced Meal (FARM) program, a broad indicator of economic disadvantage. Multilevel modeling revealed interaction effects such that, among disadvantaged students, teachers' depressive symptoms were associated with decreased mathematics and science engagement. Results highlight the importance of providing mental health support for teachers, as well highlight teachers' well-being as relevant to issues of equity in elementary STEM education.

Keywords: Teacher mental health; student engagement; elementary education; underserved students

Associations Between Elementary Teachers' Mental Health and Students' Engagement Across Content Areas

The field of education has increasingly recognized teachers' well-being as relevant to their effectiveness. Elementary and early-childhood teachers' mental health symptomatology, in particular, has been connected to wide range of teacher, classroom, and student outcomes including teachers' instructional and classroom management practices, classroom quality, classroom relationships, and students' own well-being and social, emotional, and academic development (Hamre & Pianta, 2004; Harding et al, 2019 Maricuțoiu, 2023; McLean & Connor, 2015; 2018; McLean et al., 2018; Roberts et al., 2016; Sandilos et al., 2015). One promising student outcome that has not yet been examined in connection to teachers' mental health is students' self-reported behavioral engagement. Behavioral engagement is defined as a student's participation in learning activities through effort and persistence (Skinner et al., 2008; 2009), and is a high-leverage learning behavior that is strongly predictive of students' development across multiple domains including academic achievement, social/emotional competence, and behavior (Archambault et al., 2009; Lei et al., 2018; Li et al., 2011; Li & Lerner, 2011; Myers et al., 2012). Recent investigations have illustrated that teachers' emotions including teaching-related anxiety, enjoyment, and frustration are associated with students' engagement (Aldrup et al., 2018; de Ruiter et al., 2019, 2020; Frenzel et al., 2018; 2020; Hagenauer et al., 2015; Kunter et al., 2011), and so it would stand to reason that other emotion-relevant teacher experiences including mental health symptomatology would show similar associations. Importantly, past studies have shown that effects of teachers' mental health symptoms on students might surface differently across content areas and student groups (McLean & Connor, 2015; 2018; McLean et al., 2023), and so in the present study we investigate associations among teachers' self-reported

depressive and anxious symptoms and their students' self-reported behavioral engagement across the content areas of mathematics, science, and English language arts (ELA), as well as investigate whether these associations differ between adequately served and underserved students.

This study offers some methodological elaborations on the current body of literature regarding teachers' mental health. First, much of the related work on teachers' mental health, and their emotional experiences more broadly, has relied upon teachers to report both their own experiences and their students' outcomes, for example linking teachers' reports of their own experiences and characteristics to their reports of their students' academic competence or behavior (for example, Aldrup et al., 2018; de Ruiter et al., 2019, 2020; Frenzel et al., 2018; 2020; Hagenauer et al., 2015; Kunter et al., 2011; McLean et al., 2020). While such approaches have produced important results, a single-reporter approach does not capture students' perceptions, experiences, and outcomes as precisely as first-hand student reports. In the present study, we examine associations among teachers' self-reported mental health symptomatology and students' self-reported content area engagement, thus reducing bias inherent in relying on single reporters. Second, the bulk of past work on teachers' mental health has focused on teachers' depressive symptoms and burnout, and teachers' anxious symptoms have seen comparatively less attention. In the present study, we measure both depressive and anxious symptomatology, two experiences that past work has indicated are highly related but that are characteristically different from one another in some notable ways.

Findings can contribute to the compelling body of evidence supporting the consideration of teachers' well-being in education research and policy. This is critically important given that teachers experience higher rates of occupational stress and mental health symptomatology than

do individuals in other professions (Gallup, 2014; 2022; Greenberg et al., 2016), and that teachers and students alike are currently navigating increased barriers to well-being and success in the wake of the COVID-19 pandemic: U.S. teachers' occupational stress and mental health symptomatology have seen dramatic increases during the pandemic (Diliberti et al., 2021; Kaufman & Diliberti, 2021; Pressley, 2021), and recent large-scale evaluations of student achievement have shown stark declines on the whole as well as widening achievement gaps between adequately-served and underserved student groups (NAEP, 2020; 2022). More proximally, findings of the present study can provide more nuanced insights into which contexts and among which students the effects of teachers' mental health surface most pointedly, with this information then guiding the prioritization of supports for teachers and their students.

Theoretical Framework

We draw from Appraisal Theory (Scherer, 1999), Sociocultural Theory (John-Steiner & Mahn, 2011; Vygotsky, 1978) and the Stress Contagion Model (Wethington, 2000) to frame this study. First, Appraisal Theory holds that individuals use the emotional, behavioral, and affective cues from others in their immediate social context to interpret what is happening around them, with these interpretations then informing their behavioral responses (Parkinson & Manstead, 2015). Second, Sociocultural Theory holds that young children largely look to a "more knowledgeable other" for information (both explicit and implicit) to guide these appraisals, with this more knowledgeable other having great potential to influence that child's development. Third, Stress Contagion Model holds that the negative emotional experiences of individuals within a shared social setting, and most especially of figures who are primary points of social reference (i.e., "more knowledgeable others"), can transfer to others both directly and indirectly.

These theoretical tenets can be applied to the classroom, which is a significant developmental context characterized by "close and intense interactions between teachers and students" (Hargreaves. 2000, pg. 819). Students make constant appraisals of the classroom environment (e.g., "am I safe in this environment?" "How should I feel about learning this content?" "Do my classmates and teacher like me?"), and these appraisals guide their behaviors, including engagement (Mendoza & King, 2020). Further, the teacher is the leader of the classroom, providing direct instruction as well as initiating and maintaining classroom routines and values (among many other roles). As such, the teacher assumes the role of the more knowledgeable other within the classroom and as such is a key social reference, with students relying heavily on the intentional (instruction, classroom norms and routines) and perhaps less intentional (social and affective) cues the teacher gives to make their appraisals. These processes may be even more pronounced in early childhood and elementary settings, as younger students in the U.S. are typically taught by a single teacher of record rather than rotating among multiple teachers as would middle or high-school students. This further highlights the important roles of elementary teachers as important social references for their young students. Building from this, an elementary teacher who is experiencing increased mental health symptomatology may display different social/affective cues, may have characteristically different interactions with students, may make different instructional decisions, and may be less able to create and sustain effective classroom routines. These negative emotional experiences, then, may transfer to students through students' appraisals of the teachers' social and affective cues, as well as through changes in teachers' functioning that lead students to have more negative classroom experiences and, ultimately, disengage from learning.

The above is supported by research in the general population showing that mental health symptomatology is associated with changes to individuals' affect, energy, and motivation (Nolen-Hoeksema et al., 2008), all of which would likely impact the social and affective cues a teacher gives as well as the way they lead their classroom. In addition, processes of emotional contagion among teachers and students have been illustrated in the classroom: Burgess et al., (2018) provide a thorough overview of how students' social interactions in school settings, including their interactions with the teacher, can lead to the transfer of emotions among individuals, with a specific focus on the role of motivation in these processes (and we note that motivation is a well-known contributor to engagement; Martin, 2006; Linnenbrink, 2007; Saeed & Zyngier, 2012). More proximal studies of emotional contagion in the classroom have illustrated how these processes can unfold: Bakker (2005) found that teachers' "flow" (a combination of absorption, enjoyment, and motivation) directly predicted their students' "flow" during music lessons; Oberle and Schonert-Reichel (2016) found that when teachers experienced more occupational stress, they tended to use more reactive and punitive classroom management strategies and as a result the classroom climate deteriorated and the emotional needs of students were not met; and most recently Xie et al., (2022) found evidence across cultures that teachers' enjoyment was positively associated with their students' enjoyment, which then resulted in more optimal student achievement. More broadly, others have demonstrated that teachers' mental health symptoms can indeed impact the ways they lead and interact with students within the classroom. Teachers' mental health symptoms have been found to diminish the quality of their interactions with students (Hamre & Pianta, 2004) as well as to surface in the larger systems of classroom quality (McLean & Connor, 2015; Sandilos et al., 2015), classroom instruction (McLean & Connor, 2018; McLean et al., 2018), and classroom management (Li-Grining et al.,

2010). What is less known, though, is whether teachers' mental health symptomatology impacts students' engagement specifically and how such effects might be further driven by students' own characteristics. Importantly, Stress Contagion explicitly recognizes that the above processes are likely more severe among individuals in underserved communities (Milkie & Warner, 2011), supporting our investigation of the moderating effects of student disadvantage on our direct relations of interest.

Together, the above theoretical frameworks illustrate that teachers' negative emotional experiences likely transfer to students both directly through students' immediate appraisals of and responses to teachers' social/affective cues, as well as indirectly through larger classroom processes. While we don't investigate indirect effects via classroom processes in the present study, we acknowledge the potential for them to exist and assert that it is important to first establish a baseline understanding of the associations between teachers' mental health and students' engagement, with promising next steps being to describe in more detail the processes through which these associations unfold.

Teachers' Mental Health

In the present study, we focus on teachers' symptoms of clinical depression and anxiety as predictors of students' content area engagement. Depression is considered a dampening of positive affect, emotions, and energy with symptoms including fatigue and feelings of worthlessness, whereas anxiety is described as an activation of worry or fear to excessive levels that detract from daily functioning (American Psychiatric Association, 2013). While clinical depression and anxiety have been found to co-occur in many individuals (Kircanski et al., 2017; Schoevers et al., 2005), they are characteristically different from one another and include unique sets of symptoms, though both result in an interruption to an individuals' ability to perform daily

tasks (APA, 2013). Multiple large, national surveys of U.S. teachers conducted prior to COVID-19 indicate that teachers report higher rates of work-related stress, mental health symptomatology, and career burnout than do individuals in the general population (American Federation of Teachers, 2017; Whitaker et al., 2013). Further, surveys comparing experiences among multiple professions have consistently highlighted teaching as one of the most stressful occupations (Gallup, 2014; 2022; Greenberg et al., 2016; Johnson et al., 2005). National surveys conducted in the U.S. since March of 2020 have further described declines in teachers' mental health after the onset of the COVID-19 pandemic, with all findings indicating stark increases in depressive and anxious symptomatology, burnout (Kaufman & Diliberti, 2021), and intentions to leave the field (Diliberti et al., 2021). Considered together, the literature on teachers' mental health both before and after the onset of COVID-19 highlights the importance of fully understanding the causes, prevalence, and implications of teachers' mental health through high-quality empirical research, and using this information to guide systems of teacher and student support.

A large body of work has illustrated the far-reaching impacts of teachers' mental health for teachers themselves, for classroom processes, and for students. Regarding teacher outcomes, mental health symptomatology has been found to negatively impact teachers' job satisfaction and performance, and to be positively associated with teacher absences (Ferguson et al., 2012; Fernet et al., 2012; Kyriacou, 2001), likely contributing to the high rates of career exit observed among teachers (Carver-Thomas & Darling-Hammond, 2017). Conversely, when teachers experience higher job satisfaction, they are more likely to enact high-quality instructional practices (Harrison et al., 2023). Regarding classroom processes and student outcomes, teachers with higher rates of mental health symptomatology have been found to have lower-quality classrooms

(McLean & Connor, 2015; Sandilos, 2015), to provide less of certain types of instruction (McLean & Connor, 2018; McLean et al., 2018), and to have fewer positive instructional and relational (including behavior management) interactions with students (Aloe et al., 2014; Hamre & Pianta, 2004; Li-Grining et al., 2010). Regarding student outcomes, teachers' mental health symptoms are associated with students' academic achievement (McLean & Connor, 2015); social/emotional competence (Roberts et al., 2016); and biological stress responses (Oberle & Schonert-Reichl, 2016). In the present study, we focus on how teachers' mental health symptomatology is associated with their students' content-area engagement, and while no past work has examined this specifically, related work has found that teachers' burnout is associated with decreased student engagement (Covell et al., 2009) and learning motivation (Shen et al., 2015). In contrast, teachers' enjoyment - a positive teaching-related emotion that would likely be dampened by increased mental health symptomatology - is associated with increased student engagement (Frenzel et al., 2018).

Although we know that teachers' mental health impacts their teaching behaviors (which in turn have marked implications for students' learning behaviors; Cooper, 2013; Ruzek et al., 2016; Skinner et al., 2008; 2009), direct associations among teachers' mental health symptomatology and students' self-reported learning behaviors have yet to be established. Further still, within the teacher mental health literature relatively little is known about how teachers' anxious symptoms operate in the classroom, with the bulk of teacher anxiety research focusing on teachers' anxiety for teaching certain content areas - namely mathematics. Given that clinical depression and anxiety involve different sets of symptoms, with depression characterized by a general dampening of affect and energy while anxiety is characterized by activation, it is possible these two experiences could present differently from each other in the

classroom. As such, investigations of teachers' mental health that include consideration of anxious symptomatology are important to round out the current body of work.

Student Engagement

We focus on students' self-reported behavioral engagement in mathematics, science, and ELA as outcomes in the present study because prior research has shown that teachers' emotions and emotion-related experiences have implications for students' engagement, and because engagement is a high-leverage learning behavior that predicts many important domains of child development. "Behavioral engagement" (which we refer to simply as "engagement" from here on) is broadly defined as students' participation in learning activities through effort and persistence (Skinner et al., 2008; 2009), and in the case of the present study this definition is applied to each individual content area. Students' engagement, broadly conceived, has been well-established as an important learning behavior that has implications for long-term outcomes including educational persistence, degree attainment, mental health, and substance abuse (Archambault et al., 2009; Li et al., 2011; Li & Lerner, 2011; Myers et al., 2012). More proximally, engagement supports academic achievement from the early childhood through adolescence (Fredricks et al., 2004; Lei et al., 2018; Lindström et al., 2021; NRC, 2003; Wang & Eccles, 2012), as students' engagement in learning opportunities supports their uptake of instructional information. Supporting the instructional environment in a way that sets the stage for high levels of engagement can maximize the impact of teacher instruction (Chow et al., 2020). Engagement is also important for students' social/emotional and behavioral development (Wang & Fredricks, 2014), presumably because highly engaged students have more opportunities in the classroom to observe and interact with their teachers and peers and thus grow their social and emotional skills.

While explicit connections among teachers' mental health symptomatology and students' engagement have not yet been established, related work focusing on teachers' emotions and emotion-related experiences provides ancillary evidence that these relations likely exist: Teachers' provision of emotional support in the classroom and, more broadly, the classroom emotional climate, have been shown to positively predict student engagement (Cooper, 2014; Reyes et al., 2012; Ruzek et al., 2016; Skinner et al., 2008; Strati et al., 2017), and the extent to which teachers are able to provide this emotional support has been shown to be influenced by their mental health (Roberts et al., 2016). By establishing a direct link between teachers' mental health and students' engagement, the present study could better inform the potential mechanisms through which teachers' mental health can influence students. for example, teachers' mental health may lead to reduced emotional support, which then may lead to lower student engagement, which then may lead to less optimal student development. This knowledge could also help identify targets for professional development and supports for teachers - especially those who are experiencing barriers to well-being.

Content-area and Group Differences

An important pattern of note in the literature describing the impacts of teachers' mental health on students is that these teacher factors can surface differently in different content areas and among different student groups. In particular, there is emerging evidence that teachers' mental health appears to surface in science and mathematics, and among disadvantaged and underachieving students, more pointedly than it does in ELA or among adequately served students. For example, McLean & Connor (2015) found that teachers' depressive symptoms negatively influenced their students' mathematics, but not ELA, achievement, and that these effects only surfaced among students already struggling in mathematics. In a later study, McLean

& Connor (2018) further identified teachers' provision of academic feedback as a potential mediator of this initial relation, with teachers who reported more depressive symptoms providing less positive feedback in mathematics, and again with disadvantaged students' mathematics achievement affected. Most recently, McLean et al., (2023) found that teachers' negative emotions for teaching were associated with their disadvantaged students' anxiety for mathematics and science, but not for ELA.

While the reasons for these patterns are still largely unknown, past works illustrating that teachers experiencing more mental health challenges tend to have lower-quality classrooms (McLean & Connor, 2015; Roberts et al., 2016; Sandilos et al., 2015) and also tend to apply different types and amounts of instruction (McLean & Connor, 2018; McLean et al., 2018) might serve to suggest that these classroom elements (quality, instructional support) are particularly crucial for disadvantaged students' mathematics and science learning. Lastly, the current body of work on students' engagement supports our investigation of content-area and group-specific differences in the impacts of teacher mental health on student engagement: prior studies have illustrated that student engagement is likely content-area-dependent (Goetz et al., 2006), and differs among students based on demographic characteristics, with disadvantaged students reporting lower engagement (Marks, 2000).

Research Questions and Hypotheses

We pose the following two research questions:

1. To what extent do teachers self-reported depressive and anxious symptoms directly relate to their students' self-reported engagement in mathematics, science, and ELA?
2. To what extent do these direct relations vary between adequately served and underserved students?

We anticipate that direct, negative associations will exist among teachers' depressive and anxious symptoms and their students' engagement in all content areas, and that moderating effects of student disadvantage will exist for mathematics and science whereby underserved students who are in classrooms with teachers who report more symptoms will report the lowest levels of mathematics and science engagement.

Methods

Procedures

See Table 1 for an overview of the study design and data collection timeline. Data were collected in a federally funded study exploring the roles of emotions in teaching and learning across content areas in elementary classrooms. Data collection occurred from Fall 2018 to Spring 2023, and multiple cohorts of fourth grade teachers and students participated. Each cohort participated for one academic year, and each was comprised of unique participants; no teachers or students participated for more than one academic year. Pooled data from the first three cohorts were used to address the research questions of the present study. Cohort 1 participated during the 2018/2019 academic year, Cohort 2 participated during the 2019/2020 academic year, and Cohort 3 participated during the 2021/2022 academic year. Data collection was paused for the 2020/2021 academic year due to prolonged school closures in the wake of COVID-19, and so no cohort participated that year.

Each cohort underwent similar recruitment, consent, and data collection procedures according to the same timeline in their respective participating year, with some adjustments to data collection procedures made for Cohort 3 in response to policies implemented to mitigate the spread of COVID-19. Teachers were invited to enroll in the summer prior to their participating year, and when introduced to the purpose of the study were told generally that researchers were

"exploring teaching and learning processes across core content areas". Teachers who elected to enroll provided informed consent and reported on their demographics prior to the start of the school year. In the first weeks of the school year, parents/guardians of all students in classrooms of participating teachers were invited to enroll their child to participate in the study via enrollment packets sent home by teachers which contained information about the study, consent documents, and a short paper-and-pencil demographics survey. Guardians who elected to enroll their child provided consent and completed the survey and returned the packet to the child's teacher.

Teachers and students completed two surveys throughout their participating year in which they reported on their emotions and emotion-related experiences, their beliefs, and their teaching and learning behaviors in mathematics, science, and ELA. Survey administrations took place in the fall (Time 1) and winter (Time 2). Within each time point, data collection was scheduled so that teachers completed surveys before their students. At Time 1, teachers completed initial surveys in the first weeks of the school year (August), with the goal of capturing their mental health symptoms before spending a significant amount of time with their current group of students. Teachers in all cohorts received electronic links to surveys housed in the platform Qualtrics and were given two weeks to complete the survey during which they were sent two reminders. Students completed Time 1 surveys in October, after all teacher surveys had been completed. For Cohorts 1 and 2, teachers were asked to schedule a time within a 6-week window for a project member to administer paper-and-pencil surveys to all enrolled students in their classroom. For Cohort 3, because outside parties were no longer allowed into classrooms, teachers were sent electronic links to the student survey housed in Qualtrics and were asked to administer the survey to enrolled students on classroom computers. Cohort 3 teachers were given

6 weeks to administer their student surveys and were instructed to administer all student surveys at the same time (i.e., teachers did not administer student surveys sporadically across the 6-week window, all surveys within a classroom took place on the same day).

The same respective approaches were taken at Time 2 for each cohort, with teachers completing Time 2 surveys in January and students completing Time 2 surveys in late February and early March. All teacher surveys were taken in English, and all students were given the option to take their survey in either English or Spanish, though the vast majority of students elected to take surveys in English. In the case that an enrolled student was absent on the day of student survey administration, project staff worked with teachers to arrange a follow-up visit within one week of the initial administration for these students to complete the survey (for Cohorts 1 and 2) or teachers were instructed to administer the electronic survey as soon as possible after the students' return (for Cohort 3). Teachers were provided monetary compensation for their completion of surveys, and students were provided a small gift.

Participants

Participants were from 28 public elementary schools in 8 districts in a Southwestern U.S. state. All districts were located within the same 50-mile geographic area, and this area spanned rural, urban, and suburban settings. A wide range of student enrollment rates in a Free and Reduced Meal (FARM) program was observed, ranging from 6% (considered an adequately served area) to 94% (considered an underserved area). Student racial/ethnic makeup also varied greatly among schools, with schoolwide percentages of students of color ranging from 96% to 17%. Reflecting the demographics of the state, many schools had high enrollments of Hispanic/Latino/a students, with more than half of schools reporting that over 50% of their students identified as Hispanic/Latino/a.

Fifteen teachers and 198 students participated in Cohort 1, 18 teachers and 245 students participated in Cohort 2, and 32 teachers and 362 students participated in Cohort 3, for a total combined analytic sample of 65 teachers and 805 students. Based on an average class size of 25 students, student enrollment rates in the present study ranged from 10% to 100%, with an average enrollment rate across classrooms of 52% (13 students). The majority of teachers self-reported as female (88%) and White (71%); 21% as Latino/a; 3% as African American; 2% as Native American/Alaska Native/Hawaiian Native; and 2% as multiracial. The remaining 1% of teachers (about 6 teachers) did not report their race. Teachers ranged in age from 22 to 63 years old (mean 39.15 years, SD 10.62 years), and ranged in years of teaching experience from 0 to 38 years (mean = 10.4 years, SD 8.34 years). Fifty-five percent of teachers reported their highest degree as a bachelor's degree; 43% a master's degree; and 1% a doctoral degree. The remaining 1% of teachers did not report their highest degree earned, however teacher licensure policies in place at the time of data collection required at least a bachelor's degree in order for one to hold a position as a teacher of record.

Guardians reported that 46% of students were identified as biologically female at birth; 45% were identified as biologically male at birth; and 9% of guardians did not report on their child's biological sex at birth. No guardians indicated that their child currently held a gender identity that was not consistent with their biological sex assigned at birth. Forty-three percent of guardians identified their child as Hispanic/Latino/a; 20% as White; 15% as Multiracial; 5% as African American; 5% as Native American/Alaska Native/Hawaii Native; 2% as Eastern Asian/Pacific Islander; and the parents/guardians of the remaining 11% either reported "other" or opted not to report their child's race. Fourteen percent of guardians reported their own highest education level as "no high school" or "some high school, but no degree"; 25% as "a high school

degree"; 11% as "technical training/certificate"; 10% as "an associate's degree"; 12% as "a bachelor's degree"; 5% as "some graduate school experience, but no graduate degree"; 6% as "a master's degree", 1% as "a doctoral degree," and the remaining 16% of guardians did not report their highest degree earned. Sixty-eight percent of students were enrolled in their school's FARM program.

Measures

Teacher and Student Demographics. Teachers and parents/guardians of students reported demographics at their respective time of enrollment. Pertaining to the present study, teachers reported their years of teaching experience not including the participating year and parents/guardians reported their child's sex (coded in the data as 0 = male and 1 = female) and FARM status (coded as 0 = not enrolled in FARM and 1 = enrolled in FARM). While past research has indicated that FARM status is not a precise indicator of student socioeconomic status (Domina et al., 2018; Harwell & LeBeau, 2010; Michelmore & Dynarski, 2017; Parsons et al., 2019), recent work has instead described FARM enrollment as a broad indicator of student disadvantage (Fazlul et al., 2023), and so we adopt this broader conceptualized in the present study.

Teacher Mental Health Symptomatology. Teachers reported in the fall (Time 1) and winter (Time 2) how frequently they had experienced depressive and anxious symptoms in the past two weeks. Depressive symptoms were measured using the Center for Epidemiologic Studies Depression Scale – Short Form (CESD-10; Radloff, 1977). In the CESD-10, users indicate on a 4-point likert scale (1= "rarely or none of the time; 4 = "most or all of the time") how frequently they have experienced 10 symptoms of clinical depression. Example items include "*I was bothered by things that don't usually bother me"* and "*I felt that everything I did*

was an effort". This scale showed high internal consistency in the present study with alpha = .85 for fall and .92 for winter. Anxious symptoms were measured using the Generalized Anxiety Disorder Scale (GAD; Spitzer et al., 2006), which asks users to rate on a 4-point likert scale (1 = "not at all"; 4 = "nearly every day") the frequency with which they have experienced seven symptoms of anxiety disorder. Example items include "*I was so restless it was hard to sit still"* and "*I had trouble relaxing".* This scale showed high internal consistency in the present study with alpha = .91 for fall and .95 for winter. For each measure, positively-valanced items were reverse-coded prior to scoring and means for each time point were calculated, with higher values indicating more depressive or anxious symptomatology. Mean scores for depressive and anxious symptoms across time points were calculated by averaging the Time 1 and Time 2 means for each scale.

Student Mathematics, Science, and ELA Engagement. Students reported their mathematics, science, and ELA engagement in the fall (Time 1) and winter (Time 2) using the Behavioral Engagement subscale from the Engagement versus Disaffection with Learning scale (Skinner et al., 2009). The original behavioral engagement subscale contains 5 non-content-area specific items, and these items were adapted to reflect specific content areas in the present study. Items ask users to rate on a 5-point likert scale (1 = "not true at all"; 5 = "very true") the extent to which a given statement is true of them. Example items include "*when I'm in math/science/ELA class, I listen very carefully"* and "*in math/science/ELA class, I work as hard as I can*." The original scale assessing non-content-area specific engagement has shown adequate internal consistency in elementary student samples with alpha coefficients ranging from .61 to .72. The content area-specific versions used in the present study also showed high internal consistency, with alpha coefficients of .90 for both fall and winter ELA engagement, .80 and .82

for fall and winter mathematics engagement, and .87 and .88 for fall and winter science engagement. Mean scores for each content area for each time point were calculated, with higher values indicating more engagement in a content area.

Analytic Approach

Descriptive statistics and zero-order correlations were examined to confirm acceptable variable distributions and explore the nature of baseline relations among variables. Given the nested structure of our data, multilevel modeling in the statistical computing program MPlus (Muthén & Muthén, 2017) was used to address the research questions on the impacts of higher-level predictors on lower-level outcomes. Even though level-2 variance was low and design effects (Peugh, 2010) fell below the recommended threshold of 2 for all outcomes (see below for more details), we still opted to use a multi-leveled approach to address our research questions. While proportions of variance and design effects are useful metrics to assess the need for nested analyses, many argue that they are not the only points to consider when selecting an analytic method for nested data, and that researchers should also consider the study design and levels represented in research questions when determining whether to use a multi-leveled approach. This was confirmed in a rigorous simulation study testing the rigor of relying solely on design effects: Lai & Kwok, (2015) found that design effects should not be used as sole justification for non-nested analyses when researchers are interested in the effects of higher-level predictors, or when some or all clusters have sizes of less than 10, both of which are true in the present study.

Variable distributions, predicted probability plots (p-plots), and scatterplots were examined to confirm that data aligned with the typical assumptions of normality of data, linearity of relationships, and homoscedasticity of errors. An iterative model building approach was then used which informed both the significance of detected effects as well as the proportions of

variance accounted for at each level by covariates and focal predictors. All continuous predictor variables were grand-mean centered prior to analyses in order to provide an interpretable intercept for each outcome, and the grand-mean centered teacher mental health variables and dichotomous FARM variable were multiplied to create teacher-mental-health-by-student-FARM interaction terms. First, unconditional two-level models assessing the variance of each outcome at level-1 (variation between students) and level-2 (variation between classrooms) were run, and design effects were calculated based on these models and on additional study design features. Next, two-level covariates-only models were run that included student sex, FARM enrollment, and the Time 1 measure of content area engagement predicting students' Time 2 content area engagement at level 1, and included pre-vs. post-COVID cohort membership, teacher years of experience, and the classroom aggregated Time 1 measure of content area engagement predicting classroom aggregated Time 2 content area engagement at level 2. Main effects models were then run which included teacher mental health variables (modeled separately) at level 2 as predictors of focal outcomes. Next, interaction models were run which included the teacher-mental-health-by-student-FARM interaction terms as additional predictors at both level 1 and level 2. Interactions were probed even in the absence of significant main effects due to the potential for crossover effects (Lee et al., 2015), whereby slopes for two groups exist in opposite directions and negate the detection of a main effect. R-squared estimates, which quantify the amounts of variance at each level accounted for by the included predictors, were compared between models to ascertain the magnitude of significant effects detected. Depressive and anxious symptoms were modeled separately as predictors of each focal outcome to avoid potential multicollinearity (Alin, 2010; Daoud, 2017), or interdependence among predictors in a multiple regression model (Thompson et al., 2017). Multicollinearity is possible when predictors are highly ($r > .05$)

correlated with each other, potentially leading to inaccurate parameter estimates. Clinical depression and anxiety, while distinct conditions with unique sets of symptoms are typically highly correlated (Kircanski et al., 2017; Schoevers et al., 2005), and these high correlations existed in the present study. Thus, three iterative models were built with depression as a focal predictor (depression predicting student engagement in each content area), and three iterative models were built with anxiety as a focal predictor (anxiety predicting student engagement in each content area).

Some missing data existed: all teachers provided data on their years of teaching experience, and 98% of teachers provided at least one point of data on mental health symptomatology that could be used to create the year average used in analyses (98% provided mental health data at Time 1; 90% at Time 2). Between 88% and 90% of students provided data at Time 1 across content area engagement measures, and between 79% and 82% of students provided data at Time 2. Non-significant correlations between missingness (coded 0 for not missing and 1 for missing) and primary study variables indicated these data were likely missing at random. All statistical models were run using the Full Information Maximum Likelihood (FIML) estimator, which uses each case's available data to compute estimated values for missing data, thus retaining the analytic sample's full power (Hox, 1999). While MPlus automatically provides model fit indices, these indices are not considered in a regression framework (as opposed to structural equation modeling or path analysis frameworks), and so are not reported in the present study.

Lastly, it is possible that teacher and student participants who completed data collection after returning to in-person schooling in the 2021/22 academic year (Cohort 3) may have had very different experiences than those who completed collection prior to prolonged COVID-19

school closures (Cohorts 1 & 2), and these differences could impact the nature of relations among focal variables between the two groups. Since this is not captured by controlling for pre- vs. post-COVID cohort membership, we ran additional non-aim-specific analyses to test whether the above effects differed between groups (Cohorts 1 & 2 compared to Cohort 3). To test for differences in main effects of mental health on students' content-area engagement, we created additional 2-way interaction terms using the mental health predictor variables and the pre- vs. post-COVIVD cohort membership variable and introduced these as additional predictors into all main effects models. To test for differences in mental-health-by-student-FARM interaction effects, we created additional 3-way interaction terms using the mental health predictor variables, the dichotomous FARM enrollment variable, and the pre- vs. post-COVIVD cohort membership and introduced those into all interaction models.

Results

Preliminary Analyses

Examinations of descriptive statistics (see Table 2), p-plots, and scatterplots revealed no notable deviations from regression assumptions (normality, linearity, homoscedasticity). Descriptive statistics revealed estimates for skewness that fell below the threshold of 2 and estimates of kurtosis fell below the threshold of 7 (Fidell & Tabachnick, 2003). In general, average levels of teacher mental health symptomatology were low to moderate, which is consistent with prior research (McLean & Connor, 2015; 2018). Conversely, average levels of student engagement were high in all content areas and across both time points. Students reported similar levels of engagement across content areas, however there was notable variability among students in their self-reported engagement. Independent samples t-tests comparing students' mean levels of content-area engagement between Cohorts 1 and 2 and Cohort 3 revealed no

significant differences between these two groups in average levels of engagement in any content area.

Bivariate correlations among primary continuous study variables (see Table 3) indicated the following: first, teacher years of experience showed small, negative correlations with both depressive ($r = -.22$, $p<.01$) and anxious ($r = -.18$, $p<.01$) symptoms and showed small, positive correlations with students' engagement across most content areas and time points with the exception of students' Time 1 ELA engagement and students' T1 science engagement. Teachers' depressive and anxious symptoms were highly correlated at $r = .75$ ($p<.01$), which is consistent with findings in prior mental health research (Kircanski et al., 2017; Schoevers et al., 2005). Teachers' depressive and anxious symptoms were not significantly correlated with student engagement in any content area, at any time point. Student engagement variables were moderately to highly, and positively, correlated.

Multilevel Models

Unconditional models revealed that the majority of the variance in each focal outcome existed at level-1, or between individual students: level-1 variance estimates were .87 for Time 2 ELA engagement, .65 for Time 2 mathematics engagement, and .70 for Time 2 science engagement while level-2 variance estimates were .05 for Time 2 ELA engagement, .05 for Time 2 mathematics engagement, and .08 for Time 2 science engagement. Design effects calculated based on these variance estimates ranged from 1.6 to 1.9.

The covariates-only model for Time 2 ELA engagement revealed significant effects of FARM status ($B = -.23$, $p < .01$) and Time 1 ELA engagement ($B = .44$, $p < .01$) on students' Time 2 ELA engagement at level-1 such that students enrolled in FARM reported lower engagement, and higher Time 1 engagement was associated with higher Time 2 engagement.

This model also revealed significant effects of the classroom aggregated Time 1 ELA engagement (B = .78, p <. -1) on classroom aggregated Time 2 ELA engagement such that higher classroom average Time 1 engagement was associated with higher classroom average Time 2 engagement. Student sex was not significantly associated with the outcome at level-1, and pre- vs. post-COVID cohort membership and teacher years of experience were not significantly associated with the outcome at level-2.

The covariates-only model for Time 2 mathematics engagement revealed significant effects of sex (B = .16, p < .01), FARM enrollment (B = -.10, p = .05) and Time 1 mathematics engagement (B = .50, p < .01) on students' Time 2 ELA engagement at level-1 such that girls reported higher Time 2 engagement and students enrolled in FARM reported lower Time 2 engagement. As well, higher Time 1 engagement was associated with higher Time 2 engagement. This model also revealed significant effects of the classroom aggregated Time 1 mathematics engagement (B = 1.26, p < .01) such that higher classroom average Time 1 engagement was associated with higher classroom average Time 2 engagement. Pre vs. post-COVID cohort membership and teacher years of experience were not significantly associated with the outcome at level 2.

The covariates-only model for Time 2 science engagement revealed a significant effect of Time 1 science engagement (B = .43, p < .01) on students' Time 2 ELA science engagement at level 1 such that higher Time 1 engagement was associated with higher Time 2 engagement. This model no significant effects of sex or FARM enrollment on students' Time 2 engagement at level 1, and no significant effects of pre vs. post-COVID cohort membership, teacher years of experience, or the classroom aggregate Time 1 science engagement on the classroom aggregate Time 2 science engagement.

Research Question #1: Direct Effects of Teachers' Mental Health. See Tables 4 and 5 for all main effects and interaction model estimates. Three main effects models were run assessing the direct effects of teachers' depressive symptomatology on students' engagement in each content area, and three models were run assessing the effects of anxious symptomatology on students' engagement in each content area. All level-1 and level-2 covariates remained in the models, and each mental health focal predictor was introduced at level-2 for each outcome. Across the six main effects models run, no significant direct effects of teachers' depressive or anxious symptoms were detected for any student engagement outcomes.

Research Question #2: Interactions with Student FARM Status. Interaction models were run that introduced teacher mental health-by-student-FARM interaction terms as additional predictors of students' engagement in each content area at both level 1 and level 2. The interaction models for teachers' depressive symptoms and student FARM enrollment predicting students' Time 2 mathematics engagement revealed a significant depressive-symptoms-by-FARM interaction effect on students' Time 2 mathematics engagement at level-1 ($B = -.33$, $p = .03$, with this interaction indicating a negative relation between teachers' depressive symptoms and students' Time 2 mathematics engagement among students enrolled in FARM (see Figure 1). Comparisons of r-squared estimates between the interactions model and the main effects model for depressive symptoms predicting students' Time 2 mathematics engagement revealed that the depressive-symptoms-by-FARM interaction effect accounted for 1% of the variance in the outcome at level 1.

Similarly, the interaction model for teachers' depressive symptoms and student FARM enrollment predicting students' Time 2 science engagement revealed a significant depressive-symptoms-by-student-FARM interaction effect on students' Time 2 science engagement at level-

1 (B = -.29, p = .05), with this interaction indicating a negative relation between teachers' depressive symptoms and student Time 2 science engagement among students enrolled in FARM (see Figure 2). Interaction models for teachers' anxious symptoms and student FARM enrollment predicting students' engagement in each content area revealed no significant anxious-symptoms-by-student-FARM interaction effects on students' Time 2 engagement in any content area. Comparisons of r-squared estimates between the interactions model and the main effects model for depressive symptoms predicting students' Time 2 science engagement revealed that the depressive-symptoms-by-student-FARM interaction effect accounted for 1% of the variance in the outcome at level 1.

Post-Hoc Analyses. 2-way interactions testing for differences between Cohort 1 & 2 (combined) and Cohort 3 in the nature of relations between teachers' depressive and anxious symptoms and students' content-area engagement revealed no significant differences between groups in the main effects tested above. Similarly, 3-way interactions testing for differences in relations between teachers' depressive and anxious symptoms and their disadvantaged students' content-area engagement revealed no significant differences between groups in the above significant depressive-symptoms-by-FARM interaction effects detected.

Discussion

We sought to identify associations among teachers' mental health symptomatology and their students' content-area engagement; a high-impact student learning behavior with strong ties to academic, behavioral, and social/emotional, and behavioral development (Archambault et al., 2009; Lei et al., 2018; Li et al., 2011; Li & Lerner, 2011; Myers et al., 2012). As well, we sought to explore how these relations might differ across content areas and between adequately served and underserved students. Our goal was to highlight an additional student factor, engagement,

which may be influenced by teachers' mental health and to provide more precise information about in which contexts, and among which students, these associations might surface most pointedly. We anticipated that both depressive and anxious symptoms would be negatively associated with students' engagement in all content areas, and that interaction effects with student FARM status would surface in mathematics and science; specifically, that more disadvantaged students who were in classrooms with teachers experiencing higher levels of both depressive and anxious symptomatology would report the lowest mathematics and science engagement. Findings partially aligned with these predictions: although direct effects were not present in any content area, interaction effects indicated that teachers' depressive symptoms were associated with the engagement of disadvantaged students in both mathematics and science.

The field has made notable progress in identifying how teachers' mental health and emotional experiences relate to a wide range of teacher, classroom, and student outcomes. In the present study, we expand on this body of literature by providing novel and nuanced evidence of connections among teachers' mental health and students' engagement using methodological approaches that have been identified as needed in this line of work (Frenzel, 2021), namely incorporating student reports of their own experiences and considering anxious symptoms as well as depression. Moving toward a more complete understanding of how exactly teachers' mental health influences students' learning behaviors can inform systems of teacher training, intervention, and continuing education efforts seeking to support both teachers and their students. Within this, understanding how different mental health conditions surface differently across content areas and student groups could help inform the prioritization and streamlining of emotion-centered supports in contexts where these are most needed (i.e., aligned with specific mental health experiences, with certain content areas and in underserved contexts). Following,

we present immediate conclusions drawn from these findings, as well as a discussion of implications for the fields of educational research and practice.

Conclusions

Analyses revealed that teachers' depressive symptoms were associated with lower mathematics and science engagement among students enrolled in FARM. When considered alongside the current literature on teachers' mental health, these findings suggest (1) that teachers' depressive symptoms might operate through reduced student engagement to impact students' development, and (2) that STEM content areas and disadvantaged student groups are potentially more vulnerable to these processes. Drawing on our founding theories, it could be that teachers with more depressive symptoms displayed more negative outward cues and that their disadvantaged students appraised these cues and responded with reduced engagement. It could also be that teachers' depressive symptoms led to a classroom environment that was less facilitative of students' engagement, potentially due to lower overall classroom quality (McLean & Connor, 2015; Sandilos et al., 2015; Roberts et al., 2016) or differences in the instructional decisions teachers made (McLean et al., 2018). Regardless of the specific causal mechanism(s), findings are in line with past work indicating that teachers' emotions are associated with students' engagement (Cooper, 2014; Reyes et al., 2012; Ruzek et al., 2016; Skinner et al., 2008; Strati et al., 2017); and that the influence of teachers' emotions and emotion-relevant experiences can operate differently depending on both the instructional context (content area) and characteristics of students (McLean & Connor, 2015; McLean et al., 2023).

Findings were detected for depressive, but not anxious, symptoms and surfaced in science and mathematics rather than in ELA. These findings could suggest that teachers experiencing more depressive symptoms may be less likely to utilize types of instruction that have been shown

to promote students' science and mathematics engagement. Some core tenets of engaging science and mathematics instruction include generating students' interest through phenomenon or design-based problems (Edelson et al., 2021; Lee, 2021); applying discourse that engages students in reasoning, modeling, argumentation and problem-solving (Campbell et al., 2015; Chen et al., 2016); and leveraging students' social, cultural, and linguistic resources as tools to encourage engagement and participation (Gillies et al; Lee, 2021). While these specific science and mathematics instructional practices have not yet been studied in relation to teachers' mental health, some past work has established that teachers' depressive symptoms can indeed manifest in their classroom instruction: McLean et al., 2018 found that teachers' depressive symptoms decreased their likelihood of applying types of instruction that require more effort on their part including engaging with many students in the class at once and spending time orienting students to upcoming lessons. Given this more general link between teachers' depressive symptoms and the effort they can put forth in their instruction, it could be that the above tenets of engaging science and mathematics instruction require more effort on the part of the teacher, and that teachers in the present study experiencing more depressive symptoms had less capacity to enact these practices.

Interestingly, results suggest that such processes may have not been occurring for teachers experiencing anxious symptoms. In response to this, we posit that the dampening effects inherent in clinical depression may have more overt implications for students' appraisals of teachers and/or teachers' classroom functioning than the activation inherent in clinical anxiety. Individuals experiencing depressive symptoms are more likely to display flat, disengaged affect and to report fatigue and lack of motivation, whereas individuals experiencing anxiety do not typically exhibit these (APA, 2013). The affective implications of experiencing depressive

symptoms may be more noticeable to students than those associated with experiencing anxious symptoms, and/or the fatigue and lack of motivation inherent in clinical depression may be more likely to surface in teachers' classroom practices.

We now consider our findings that disadvantaged students appeared to be more susceptible to the impacts of their teachers' depressive symptoms, and that these impacts surfaced only in science and mathematics, and not in ELA. First, we consider a large body of research describing the differences in home learning environments experienced by more vs. less-advantaged students: It is well-established that children from disadvantaged backgrounds experience home environments that are less conducive to learning (DeFlorio & Beliakoff, 2015; Munez et al., 2021). Given this, it could be that disadvantaged students in the present study entered the classroom more reliant on their teachers to facilitate their engagement in science and mathematics and were thus more impacted when their teachers experienced barriers (e.g., depressive symptoms) to doing so.

In considering the lack of findings for ELA, we offer that social policies and programs have historically held a stronger relative focus on ELA than other content areas. Many social policies and programs exist promoting high-quality home literacy environments, with particular focus on helping parents from disadvantaged backgrounds support their children's developing literacy (e.g., Let's Talk Dads, Raising a Reader, Reach out and Read, Unite for Literacy). These programs, many of which were active among study communities during data collection, may have bolstered the home learning environment that disadvantaged children in the present study experienced in regard to ELA. It could be that this stronger focus on literacy in social policy and programming leads young students to enter the classroom more familiar with, and thus more likely to engage in, ELA despite their teacher experiencing depressive symptoms.

Lastly, we provide some comments on the sizes of effects detected. Effect sizes were very small at 1%. However, this is in line with past work investigating the impacts of teachers' well-being, emotions, and other affective characteristics and experiences on students, and is not surprising given that the study was underpowered at the teacher level, that studies using multiple-reporter methods tend to have smaller effects (Frenzel, 2021), and that the only effects detected were among a subgroup of students via interaction effects. Thus, we highlight the novelty and significance of effects detected as important guides for future research. Efforts involving more teachers/classrooms or different measurement approaches might yield more robust effects. Conceptually, the small effects detected could also serve to suggest that teachers' mental health operates along with and/or through other factors such as instructional quality or teacher efficacy to impact students, lending more credence to the inclusion of well-being foci to interventions attempting to improve teacher practice.

Limitations and Future Directions

We acknowledge some features of the present study that limit our ability to claim causality in our detected effects and to generalize findings to the larger populations of U.S. teachers and students. First, our sample of 65 teachers and 805 students, while adequately powered at the student level, is underpowered at the teacher level. This increases the risk of type II error or failing to detect an existing association. It is encouraging, then, that some effects were detected, however any lack of effects might be a result of this type II error rather than true null effects. Second, while some temporal precedence existed in our models (teacher variables measured before student outcomes, initial levels of student outcomes controlled for), the analyses conducted here do not prove causality and as such we cannot make definitive claims about the directionality of associations. It is possible that teachers' mental health symptomatology and

students' engagement have bi-directional and/or reciprocal associations which were not captured in our analytic approaches. Further, data were collected among teachers and students from a single U.S. state. States, and the districts within them, vary in their racial/ethnic and socioeconomic makeup as well as in their policies regarding teacher preparation, support, required practices, etc., and these variations could have implications for how teachers and students experience the processes investigated here. We assert that findings should be considered exploratory and used to inform future research that can elaborate and expand upon what was found here. A final element we want to acknowledge is that past studies have cautioned that enrollment in FARM does not precisely capture student and/or family socioeconomic status, with this metric typically overestimating the number of students categorized as having low family SES (Domina et al., 2018; Harwell & LeBeau, 2010; Michelmore & Dynarski, 2017; Parsons, Koedel & Tan, 2019). Recent investigations into the validity of this indicator have led researchers to caution against its use as a metric of SES, and to instead view it as a broader indicator of disadvantage (Fazlul et al., 2023). As such, we have been careful in the present study not to conceptualize FARM enrollment as reflective of socioeconomic status, but instead describe students enrolled in FARM as "disadvantaged" or "underserved".

The findings of the present study provide a starting point upon which future investigations can build, with the goal of fully understanding how teachers' mental health operates to impact students' learning and development. Future studies could attempt to replicate what was discovered here using larger and more robust samples, and could investigate how associations might differ further depending on additional factors such as grade level (i.e., are associations different in early childhood settings? in middle or high-school settings?) or school type (i.e., do associations differ between public, private, or charter schools?). As there is clear

potential for these processes to occur indirectly, future work utilizing mediation frameworks could investigate which teacher, classroom, and student factors mediate the relations between teachers' mental health symptoms and students' development. For example, future studies investigate whether teachers' mental health symptoms impact the quality of the instruction they provide and the extent to which this in turn impacts students' engagement, and/or could investigate the potential mediating role of engagement in some of the previously illustrated relations between teachers' mental health and students' academic and other outcomes. In addition, future studies could extend the measurement of these variables longitudinally to examine how relations might change over time, might be bi-directionally and/or reciprocally related, and/or how the effects of a teachers' negative emotional experiences might extend to impact teachers and students in subsequent years. Lastly, while students' content-area engagement was the focal outcome in the present study, it is likely that teachers' mental health symptomatology is also associated with other relevant student experiences and outcomes that were not studied here, including students' learning-related emotions, their perceptions of the teacher and the classroom environment, and their learning motivation. Future studies exploring how teachers' well-being, emotions, and related experiences are associated with these additional student factors could enrich this currently under-informed area of literature. Lastly, due to the limitations inherent in the use of FARM as an indicator of SES, future studies could seek to replicate and expand upon what was discovered here using more robust indicators of SES such as household income.

Broader Implications and Recommendations

We now turn to broader implications of these findings for the fields of education research, policy, and practice. First, we offer that the findings of the present study serve to

highlight teachers' mental health and related emotional experiences as topics worthy of incorporating into efforts to promote teacher effectiveness. Teacher training and effectiveness interventions have historically focused on increasing teachers' pedagogical and content knowledge and skills, however programs targeting these elements of teaching have shown limited impacts on students (Garet et al., 2016; Gersten et al., 2017; Jayanthi, 2017). This suggests that efforts to inform and improve teacher effectiveness may be excluding consideration of additional elements of teaching that play roles in teachers' ability to translate what they learn in interventions into practice. For example, a teacher struggling with depressive symptoms may be less able to apply new knowledge of pedagogy and instructional practices gained in an intervention because they are also experiencing increased fatigue and a loss of motivation. Thus, interventions targeting teacher effectiveness could better meet their potential by providing explicit training and support for teachers' well-being alongside attempts to improve teacher knowledge and instructional practice.

Findings also serve to highlight teachers' well-being as a topic relevant to educational equity, and specifically equity in elementary STEM education. Large-scale investigations into teacher recruitment and turnover have delineated the challenges that underserved communities face in attracting and retaining effective teachers (Goldhaber & Cowan, 2014; Goldhaber et al., 2015; Ingersoll, 2001) with these challenges especially critical in the STEM teacher workforce (Goldhaber et al., 2022; Ingersoll & May, 2012). As well, investigations into the experiences of elementary teachers suggest that many feel unprepared to support the development of students from underserved communities (Johnston & Young, 2019), and worry that they are unable to foster adequate STEM learning in young students (Weiss, 1994). Additionally, studies have suggested that teachers of younger students are the most uncomfortable with STEM and may

self-select into teaching younger (elementary or early childhood) grades to avoid teaching advanced STEM content (Wilkins, 2008; 2009). Considered together, it would stand to reason that teachers in high-needs contexts may experience mental health symptomatology at higher rates, and that elementary STEM teachers might be at risk for the highest levels of symptomatology. While this alone is enough to warrant the provision of additional supports to teachers of underserved students, the findings of the present study highlight the potential reach of such supports: by providing targeted, well-being-focused supports to elementary teachers who provide regular mathematics and science instruction in high needs contexts, the field could not only improve the personal and professional outcomes of teachers themselves via increased retention, but could support the positive development of underserved students in these communities. Further, given the role of parents/guardians in children's mathematical development, there may be important, consequential opportunities for home-school relationships and partnerships to explicitly focus on improving parent and teacher affect toward STEM content.

Supports for teachers' well-being could come at multiple levels. At the policy level, adjustments to systems of teacher compensation, and within this, approaches to recruitment and retention that attract effective STEM teachers to high-needs contexts and motivate them to remain there could have positive impacts. As well, policies that optimize the structure of teachers' daily routines such as reducing workloads, providing protected time for teachers to engage in lesson planning, and maximizing teachers' time spent engaging with students would also likely result in improved teacher mental health (Jones et al., 2021; Kraft et al., 2021). Similar policy support for children and families could come from social programming that promotes children's development of positive STEM beliefs, knowledge, and motivation, with a

focus on building these capacities among students from more disadvantaged families. These efforts may then lead to young students entering the classroom less reliant on their teacher for socialization to STEM content. We also assert that, within systems of teacher preparation and continuing education, more emphasis should be placed on preparing teachers to effectively engage with the emotional aspects of teaching and learning, including building their knowledge of the roles of emotions in learning, the potential for emotions to transmit among teachers and students in the classroom, the utility of leveraging positive emotions for the benefit of students (Frenzel et al., 2018; 2021), and strategies for emotion regulation in the classroom. We do note some teacher training and continuing education programs that have seen success in centering teachers' emotions and well-being, for example the Cultivating Awareness and Resilience in Educators (CARE; Jennings et al., 2017; 2019) and the Building Resilience in Teacher Education framework (BRiTE; Mansfield et al., 2016). Considering these lines of work in tandem with findings of the present study, such frameworks could be tailored to elementary STEM teachers in high-needs contexts to see maximum benefit among the teachers and students most in need.

Results of the present study should also be considered in the current educational climate, with students, teachers, schools, and education systems navigating unprecedented challenges in the wake of the COVID-19 pandemic. As stated previously, teachers are currently reporting marked struggles with mental health symptomatology, burnout, chronic stress, dampened motivation, and intentions to leave the field (Diliberti et al., 2021; Kaufman & Diliberti, 2021; Pressley, 2021), and recent economic evaluations have indicated that teacher shortages are persisting and/or increasing in communities already strained by an inadequate teacher workforce (Camp et al., 2022). Thus, supporting teachers' well-being in meaningful

ways and at every level of the education system could be a promising approach to promoting student engagement as we work towards academic, social, and emotional learning recovery.

References

Aldrup, K., Klusmann, U., Lüdtke, O., Göllner, R., & Trautwein, U. (2018). Student misbehavior and teacher well-being: Testing the mediating role of the teacher-student relationship. *Learning and Instruction, 58*, 126-136.

Alin, A. (2010). Multicollinearity. Wiley interdisciplinary reviews: computational statistics, 2(3), 370-374.

Aloe, A. M., Amo, L. C., & Shanahan, M. E. (2014). Classroom management self-efficacy and burnout: A multivariate meta-analysis. *Educational Psychology Review, 26*(1), 101-126.

American Federation of Teachers (2017). 2017 Educator Quality of Work Life Survey. Retrieved from https://www.aft.org/sites/default/files/2017_eqwl_survey_web.pdf

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders: DSM-5* Washington, DC: American Psychiatric Association.

Archambault, I., Janosz, M., Fallu, J., & Pagani, L. S. (2009). Student engagement and its relationship with early high school dropout. *Journal of Adolescence, 32*(3), 651-670.

Ayuso-Mateos, J. L., Nuevo, R., Verdes, E., Naidoo, N., & Chatterji, S. (2010). From depressive symptoms to depressive disorders: The relevance of thresholds. *The British Journal of Psychiatry, 196*(5), 365-371.

Bakker, A. B. (2005). Flow among music teachers and their students: The crossover of peak experiences. Journal of vocational behavior, 66(1), 26-44.

Burgess, L. G., Riddell, P. M., Fancourt, A., & Murayama, K. (2018). The influence of social contagion within education: A motivational perspective. Mind, Brain, and Education, 12(4), 164-174.

Camp, A., Zamarro, G., & McGee, J. B. (2022). Changes in Teachers' Mobility and Attrition in Arkansas During the First Two Years of the COVID-19 Pandemic. *Education Reform Faculty and Graduate Students Publications.* Retrieved from https://scholarworks.uark.edu/edrepub/138.

Campbell, T., Oh, P. S., Maughn, M., Kiriazis, N., & Zuwallack, R. (2015). A review of modeling pedagogies: Pedagogical functions, discursive acts, and technology in modeling instruction. *Eurasia Journal of Mathematics, Science and Technology Education, 11*(1), 159-176.

Carter, A. S., Martínez-Pedraza, F. d. L., & Gray, S. A. (2009). Stability and individual change in depressive symptoms among mothers raising young children with ASD: Maternal and child correlates. *Journal of Clinical Psychology, 65*(12), 1270-1280.

Chen, Y., Hand, B., & Park, S. (2016). Examining elementary students' development of oral and written argumentation practices through argument-based inquiry. *Science & Education, 25*(3), 277-320.

Chetty, R., Friedman, J. N., & Rockoff, J. E. (2011). The long-term impacts of teachers: Teacher value-added and student outcomes in adulthood. Retrieved from https://www.nber.org/papers/w17699.

Chow, J. C., Cunningham, J. E., & Wallace, E. S. (2020). Interaction-centered model of language and behavioral development. *Handbook of research on emotional and behavioral disorders* (pp. 83-95) Routledge.

Cooper, K. S. (2014). Eliciting engagement in the high school classroom: A mixed-methods examination of teaching practices. *American Educational Research Journal, 51*(2), 363-402.

Covell, K., McNeil, J. K., & Howe, R. B. (2009). Reducing teacher burnout by increasing student engagement: A children's rights approach. *School Psychology International, 30*(3), 282-290.

Daoud, J. I. (2017, December). Multicollinearity and regression analysis. In Journal of Physics: Conference Series (Vol. 949, No. 1, p. 012009). IOP Publishing.

Davey, A., Halverson Jr, C. F., Zonderman, A. B., & Costa Jr, P. T. (2004). Change in depressive symptoms in the baltimore longitudinal study of aging. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 59*(6), P270-P277.

de Ruiter, J. A., Poorthuis, A. M. G., Aldrup, K., & Koomen, H. M. Y. (2020). Teachers' emotional experiences in response to daily events with individual students varying in perceived past disruptive behavior. *Journal of School Psychology, 82*, 85-102.

de Ruiter, J. A., Poorthuis, A. M. G., & Koomen, H. M. Y. (2019). Relevant classroom events for teachers: A study of student characteristics, student behaviors, and associated teacher emotions. *Teaching and Teacher Education, 86*, 102899.

Del Río, M. F., Strasser, K., Cvencek, D., Susperreguy, M. I., & Meltzoff, A. N. (2019). Chilean kindergarten children's beliefs about mathematics: Family matters. *Developmental Psychology, 55*(4), 687.

Diliberti, M., Schwartz, H. L., & Grant, D. M. (2021). *Stress topped the reasons why public school teachers quit, even before COVID-19*. RAND.

Domina, T., Pharris-Ciurej, N., Penner, A. M., Penner, E. K., Brummet, Q., Porter, S. R., & Sanabria, T. (2018). Is free and reduced-price lunch a valid measure of educational disadvantage? *Educational Researcher*, *47*(9), 539-555.

Edelson, D. C., Reiser, B. J., McNeill, K. L., Mohan, A., Novak, M., Mohan, L., . . . Deutch Noll, J. (2021). Developing research-based instructional materials to support large-scale transformation of science teaching and learning: The approach of the OpenSciEd middle school program. *Journal of Science Teacher Education, 32*(7), 780-804.

Fazlul, I., Koedel, C., & Parsons, E. (2023). Free and reduced-price meal enrollment does not measure student poverty: Evidence and policy significance. *Economics of Education Review*, *94*, 102374.

Ferguson, K., Frost, L., & Hall, D. (2012). Predicting teacher anxiety, depression, and job satisfaction. *Journal of Teaching and Learning, 8*(1).

Fernet, C., Guay, F., Senécal, C., & Austin, S. (2012). Predicting intraindividual changes in teacher burnout: The role of perceived school environment and motivational factors. *Teaching and Teacher Education, 28*(4), 514-525.

Fidell, L. S., & Tabachnick, B. G. (2003). Preparatory data analysis. *Handbook of Psychology: Research Methods in Psychology, 2*, 115-141.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*(1), 59-109.

Frenzel, A. C., Becker-Kurz, B., Pekrun, R., Goetz, T., & Lüdtke, O. (2018). Emotion transmission in the classroom revisited: A reciprocal effects model of teacher and student enjoyment. *Journal of Educational Psychology, 110*(5), 628.

Frenzel, A. C., Daniels, L., & Burić, I. (2021). Teacher emotions in the classroom and their implications for students. *Educational Psychologist, 56*(4), 250-264.

Garet, M. S., Heppen, J. B., Walters, K., Parkinson, J., Smith, T. M., Song, M., . . . Borman, G. D. (2016). Focusing on mathematical knowledge: The impact of content-intensive teacher professional development. *National Center for Education Evaluation and Regional Assistance,* NCEE 2016-4010.

Gersten, R., Jayanthi, M., & Dimino, J. (2017). Too much, too soon? unanswered questions from national response to intervention evaluation. *Exceptional Children, 83*(3), 244-254.

Gillies, R. M., Nichols, K., Burgh, G., & Haynes, M. (2014). Primary students' scientific reasoning and discourse during cooperative inquiry-based science activities. *International Journal of Educational Research, 63*, 127-140.

Goldhaber, D., & Theobald, R. (2022). Teacher attrition and mobility in the pandemic. *Educational Evaluation and Policy Analysis,* 01623737221139285.

Goldhaber, D., Theobald, R., & Fumia, D. (2022). The role of teachers and schools in explaining STEM outcome gaps. *Social Science Research,* 102709.

Greenberg, M. T., Brown, J. L., & Abenavoli, R. M. (2016). Teacher stress and health effects on teachers, students, and schools. *Edna Bennett Pierce Prevention Research Center, Pennsylvania State University*, 1-12.

Hagenauer, G., Hascher, T., & Volet, S. E. (2015). Teacher emotions in the classroom: Associations with students' engagement, classroom discipline and the interpersonal teacher-student relationship. *European Journal of Psychology of Education, 30*(4), 385-403.

Hamre, B. K., & Pianta, R. C. (2004). Self-reported depression in nonfamilial caregivers: Prevalence and associations with caregiver behavior in child-care settings. *Early Childhood Research Quarterly, 19*(2), 297-318.

Harding, S., Morris, R., Gunnell, D., Ford, T., Hollingworth, W., Tilling, K., . . . Kidger, J. (2019). Is teachers' mental health and wellbeing associated with students' mental health and wellbeing? *Journal of Affective Disorders, 242*, 180-187.

Harrison, M. G., King, R. B., & Wang, H. (2023). Satisfied teachers are good teachers: The association between teacher job satisfaction and instructional quality. British Educational Research Journal.

Harwell, M., & LeBeau, B. (2010). Student eligibility for a free lunch as an SES measure in education research. *Educational researcher*, *39*(2), 120-131.

Hazel, N. A., McDonell, M. G., Short, R. A., Berry, C. M., Voss, W. D., Rodgers, M. L., & Dyck, D. G. (2004). Impact of multiple-family groups for outpatients with schizophrenia on caregivers' distress and resources. *Psychiatric Services, 55*(1), 35-41.

Hox, J. J. (1999). A review of current software for handling missing data. *Kwantitatieve Methoden, 20*, 123-138.

Jamieson, B. (2006). State of the teaching profession 2006: Back in the day. *Retrieved October, 22*, 2013.

Jayanthi, M., Gersten, R., Taylor, M. J., Smolkowski, K., & Dimino, J. (2017). Impact of the developing mathematical ideas professional development program on grade 4 students' and teachers' understanding of fractions. *Regional Educational Laboratory Southeast, .* REL 2017-256.

Jennings, P. A., Brown, J. L., Frank, J. L., Doyle, S., Oh, Y., Davis, R., . . . Greenberg, M. T. (2017). Impacts of the CARE for teachers program on teachers' social and emotional competence and classroom interactions. *Journal of Educational Psychology, 109*(7).

Jennings, P. A., Doyle, S., Oh, Y., Rasheed, D., Frank, J. L., & Brown, J. L. (2019). Long-term impacts of the CARE program on teachers' self-reported social and emotional competence and well-being. *Journal of School Psychology, 76*, 186-202.

Johnson, S., Cooper, C., Cartwright, S., Donald, I., Taylor, P., & Millet, C. (2005). The experience of work-related stress across occupations. *Journal of managerial psychology*, *20*(2), 178-187.

Kaufman, J. H., & Diliberti, M. K. (2021). Divergent and inequitable teaching and learning pathways during (and perhaps beyond) the pandemic: Key findings from the American educator panels spring 2021 COVID-19 surveys. data note: Insights from the American educator panels. *RAND Corporation,* RR-A168-6.

Kircanski, K., LeMoult, J., Ordaz, S., & Gotlib, I. H. (2017). Investigating the nature of co-occurring depression and anxiety: Comparing diagnostic and dimensional research approaches. *Journal of Affective Disorders, 216*, 123-135.

Kraft, M. A., Simon, N. S., & Lyon, M. A. (2021). Sustaining a sense of success: The protective role of teacher working conditions during the COVID-19 pandemic. *Journal of Research on Educational Effectiveness, 14*(4), 727-769.

Kunter, M., Frenzel, A., Nagy, G., Baumert, J., & Pekrun, R. (2011). Teacher enthusiasm: Dimensionality and context specificity. *Contemporary Educational Psychology, 36*(4), 289-301.

Kyriacou, C. (2001). Teacher stress: Directions for future research. *Educational Review (Birmingham), 53*(1), 27-35.

Laborde-Lahoz, P., El-Gabalawy, R., Kinley, J., Kirwin, P. D., Sareen, J., & Pietrzak, R. H. (2015). Subsyndromal depression among older adults in the USA: Prevalence, comorbidity, and risk for new-onset psychiatric disorders in late life. *International Journal of Geriatric Psychiatry, 30*(7), 677-685.

Lee, S., Lei, M., & Brody, G. H. (2015). Confidence intervals for distinguishing ordinal and disordinal interactions in multiple regression. Psychological Methods, 20(2), 245–258.

Lee, O. (2021). Asset-oriented framing of science and language learning with multilingual learners. *Journal of Research in Science Teaching, 58*(7), 1073-1079.

Lei, H., Cui, Y., & Zhou, W. (2018). Relationships between student engagement and academic achievement: A meta-analysis. *Social Behavior and Personality: An International Journal, 46*(3), 517-528.

Li Grining, C., Raver, C. C., Champion, K., Sardin, L., Metzger, M., & Jones, S. M. (2010). Understanding and improving classroom emotional climate and behavior management in the "real world": The role of head start teachers' psychosocial stressors. *Early Education and Development, 21*(1), 65-94.

Linnenbrink, E. A. (2007). The role of affect in student learning: A multi-dimensional approach to considering the interaction of affect, motivation, and engagement. In Emotion in education (pp. 107-124). Academic Press.

Li, Y., & Lerner, R. M. (2011). Trajectories of school engagement during adolescence: Implications for grades, depression, delinquency, and substance use. *Developmental Psychology, 47*(1), 233.

Li, Y., Zhang, W., Liu, J., Arbeit, M. R., Schwartz, S. J., Bowers, E. P., & Lerner, R. M. (2011). The role of school engagement in preventing adolescent delinquency and substance use: A survival analysis. *Journal of Adolescence, 34*(6), 1181-1192.

Lindström, E. R., Chow, J. C., Zimmerman, K. N., Zhao, H., Settanni, E., & Ellison, A. (2021). A systematic review and meta-analysis of the relation between engagement and achievement in early childhood research. *Topics in Early Childhood Special Education, 41*(3), 221-235.

Mansfield, C. F., Beltman, S., Broadley, T., & Weatherby-Fell, N. (2016). Building resilience in teacher education: An evidenced informed framework. *Teaching and Teacher Education, 54*, 77-87.

Maricuțoiu, L. P., Pap, Z., Ștefancu, E., Mladenovici, V., Valache, D. G., Popescu, B. D., ... & Vîrgă, D. (2023). Is Teachers' Well-Being Associated with Students' School Experience? A Meta-analysis of Cross-Sectional Evidence. Educational Psychology Review, 35(1), 1.

Marks, H. M. (2000). Student engagement in instructional activity: Patterns in the elementary, middle, and high school years. *American Educational Research Journal, 37*(1), 153-184.

Marsh, H., Hau, K., & Craven, R. (2004). The big-fish-little-pond effect stands up to scrutiny. *American Psychologist*, *59*(4).

Martin, A. J., Nejad, H., Colmar, S., & Liem, G. A. D. (2012). Adaptability: Conceptual and empirical perspectives on responses to change, novelty and uncertainty. *Journal of Psychologists and Counsellors in Schools, 22*(1), 58-81.

Martin, A. J. (2007). Examining a multidimensional model of student motivation and engagement using a construct validation approach. British Journal of Educational Psychology, 77(2), 413-440.

McCarthy, J. M., Trougakos, J. P., & Cheng, B. H. (2016). Are anxious workers less productive workers? it depends on the quality of social exchange. *Journal of Applied Psychology, 101*(2), 279.

McLean, L., & Connor, C. M. (2015). Depressive symptoms in third-grade teachers: Relations to classroom quality and student achievement. *Child Development, 86*(3), 945-954.

McLean, L., Abry, T., Taylor, M., & Connor, C. M. (2018). Associations among teachers' depressive symptoms and students' classroom instructional experiences in third grade. *Journal of School Psychology, 69*, 154-168.

McLean, L., & Connor, C. M. (2018). Relations between third grade teachers' depressive symptoms and their feedback to students, with implications for student mathematics achievement. *School Psychology Quarterly, 33*(2), 272-282.

McLean, L., Sparapani, N., Connor, C. M., & Day, S. (2020). Students' problem behaviors and teachers' warmth and demand as predictors of students' classroom instructional experiences in first grade. *Contemporary Educational Psychology, 61*, 101863.

McLean, L., Janssen, J., Espinoza, P., Lindstrom Johnson, S., & Jimenez, M. (2023). Associations between teacher and student mathematics, science, and literacy anxiety in fourth grade. *Journal of Educational Psychology, 115*(4), 539–551.

McLeod, J. D., Lively, K. J., & DeLamater, J. (2003). Handbook of social psychology.

Mendoza, N. B., & King, R. B. (2020). The social contagion of student engagement in school. *School Psychology International*, 41(5), 454-474.

Michelmore, K., & Dynarski, S. (2017). The gap within the gap: Using longitudinal data to understand income differences in educational outcomes. *AERA Open*, *3*(1), 2332858417692958.

Milkie, M. A., & Warner, C. H. (2011). How does the classroom learning environment affect children's mental health? *Journal of Health and Social Behavior, 52*(1), 3.

Muthén, B., & Muthén, L. (2017). Mplus. *Handbook of item response theory* (pp. 507-518) Chapman and Hall/CRC.

National Center for Education Statistics, National Assessment of Educational Progress: The Nation's Report Card (2020). Washington, D.C: National Center for Education Statistics, Office of Educational Research and Improvement, U.S. Dept. of Education.

National Center for Education Statistics, National Assessment of Educational Progress: The Nation's Report Card (2022). Washington, D.C: National Center for Education Statistics, Office of Educational Research and Improvement, U.S. Dept. of Education.

National Research Council. (2003). *Engaging schools: Fostering high school students' motivation to learn.* National Academies Press.

Nolen-Hoeksema, S., Wisco, B. E., & Lyubomirsky, S. (2008). Rethinking rumination. *Perspectives on Psychological Science, 3*(5), 400-424.

Nye, B., Konstantopoulos, S., & Hedges, L. V. (2004). How large are teacher effects? *Educational Evaluation and Policy Analysis, 26*(3), 237-257.

Oberle, E., & Schonert-Reichl, K. A. (2016). Stress contagion in the classroom? the link between classroom teacher burnout and morning cortisol in elementary school students. *Social Science & Medicine (1982), 159*, 30-37.

Parsons, E., Koedel, C., & Tan, L. (2019). Accounting for student disadvantage in value-added models. *Journal of Educational and Behavioral Statistics*, *44*(2), 144-179.

Plaisier, I., Beekman, A. T., de Graaf, R., Smit, J. H., van Dyck, R., & Penninx, B. W. (2010). Work functioning in persons with depressive and anxiety disorders: The role of specific psychopathological characteristics. *Journal of Affective Disorders, 125*(1-3), 198-206.

Pressley, T. (2021). Factors contributing to teacher burnout during COVID-19. *Educational Researcher, 50*(5), 325-327.

Radloff, L. S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement, 1*(3), 385-401.

Reyes, M. R., Brackett, M. A., Rivers, S. E., White, M., & Salovey, P. (2012). Classroom emotional climate, student engagement, and academic achievement. *Journal of Educational Psychology, 104*(3), 700.

Roberts, A., LoCasale-Crouch, J., Hamre, B., & DeCoster, J. (2016). Exploring teachers' depressive symptoms, interaction quality, and children's social-emotional development in head start. *Early Education and Development, 27*(5), 642-654.

Ruzek, E. A., Hafen, C. A., Allen, J. P., Gregory, A., Mikami, A. Y., & Pianta, R. C. (2016). How teacher emotional support motivates students: The mediating roles of perceived peer relatedness, autonomy support, and competence. *Learning and Instruction, 42*, 95-103.

Saeed, S., & Zyngier, D. (2012). How motivation influences student engagement: A qualitative case study. *Journal of Education and Learning*, 1(2), 252-267.

Sandilos, L. E., Cycyk, L. M., Scheffner Hammer, C., Sawyer, B. E., López, L., & Blair, C. (2015). Depression, control, and climate: An examination of factors impacting teaching quality in preschool classrooms. *Early Education and Development, 26*(8), 1111-1127.

Schoevers, R. A., Deeg, D., Van Tilburg, W., & Beekman, A. (2005). Depression and generalized anxiety disorder: Co-occurrence and longitudinal patterns in elderly patients. *The American Journal of Geriatric Psychiatry, 13*(1), 31-39.

Schonfeld, I. S. (1992). A longitudinal study of occupational stressors and depressive symptoms in first-year female teachers. *Teaching and Teacher Education, 8*(2), 151-158.

Shen, B., McCaughtry, N., Martin, J., Garn, A., Kulik, N., & Fahlman, M. (2015). The relationship between teacher burnout and student motivation. *British Journal of Educational Psychology, 85*(4), 519-532.

Shimazu, A., & Schaufeli, W. B. (2008). Work engagement: An emerging concept in occupational health psychology. *Biosci Trends, 2*(1), 2.

Skinner, E. A., Kindermann, T. A., & Furrer, C. J. (2009). A motivational perspective on engagement and disaffection. *Educational and Psychological Measurement, 69*(3), 493-525.

Skinner, E., Furrer, C., Marchand, G., & Kindermann, T. (2008). Engagement and disaffection in the classroom: Part of a larger motivational dynamic? *Journal of Educational Psychology, 100*(4), 765.

Spitzer, R. L., Kroenke, K., Williams, J. B., & Löwe, B. (2006). A brief measure for assessing generalized anxiety disorder: The GAD-7. *Archives of Internal Medicine, 166*(10), 1092-1097.

Stewart, W. F., Ricci, J. A., Chee, E., Hahn, S. R., & Morganstein, D. (2003). Cost of lost productive work time among US workers with depression. *JAMA, 289*(23), 3135-3144.

Strati, A. D., Schmidt, J. A., & Maier, K. S. (2017). Perceived challenge, teacher support, and teacher obstruction as predictors of student engagement. *Journal of Educational Psychology, 109*(1), 131.

Thompson, C. G., Kim, R. S., Aloe, A. M., & Becker, B. J. (2017). Extracting the variance inflation factor and other multicollinearity diagnostics from typical regression results. Basic and Applied Social Psychology, 39(2), 81-90.

Vygotsky, L. S., & Cole, M. (1978). *Mind in society: Development of higher psychological processes.* Harvard University Press.

Wang, M., & Fredricks, J. A. (2014). The reciprocal links between school engagement, youth problem behaviors, and school dropout during adolescence. *Child Development, 85*(2), 722-737.

Wang, M., Eccles, J. S., & Kenny, S. (2013). Not lack of ability but more choice: Individual and gender differences in choice of careers in science, technology, engineering, and mathematics. *Psychological Science, 24*(5), 770-775.

Wethington, E. (2000). Contagion of stress. *Advances in group processes*. Emerald Group Publishing Limited.

Whitaker, R. C., Becker, B. D., Herman, A. N., & Gooze, R. A. (2013). The physical and mental health of head start staff: The Pennsylvania head start staff wellness survey, 2012. *Preventing Chronic Disease, 10*, E181.

Xie, Q., King, R. B., & Cai, Y. (2022). Emotional contagion: A cross-cultural exploration of how teachers' enjoyment facilitates achievement via students' enjoyment. Current Psychology, 1-4.

Table 1. Study design and data collection overview.

	Study Year 1		**Study Year 2**		**Study Year 3 (Data collection paused)**		**Study Year 4**	
	Fall 2018	*Winter 2019*	*Fall 2019*	*Winter 2020*	*Fall 2020*	*Winter 2021*	*Fall 2021*	*Winter 2022*
Cohort 1	• Demographics • Teacher MH • Student Engagement	• Teacher MH • Student Engagement						
Cohort 2			• Demographics • Teacher MH • Student Engagement	• Teacher MH • Student Engagement				
Cohort 3							• Demographics • Teacher MH • Student Engagement	• Teacher MH • Student Engagement

Note: "MH" = "Mental Health".

Table 2. Descriptive statistics.

	N	Min	Max	Mean	SD	Skewness	Kurtosis
1. T Years Experience	64	0	38	9.79	8.37	.95	.32
2. T Anxious Symptoms	64	0	2.86	.77	.79	1.14	.46
3. T Depressive Symptoms	64	0	2.60	.49	.50	1.16	3.52
4. S T1 ELA Engagement	710	1	5	4.11	1.02	-1.29	.91
5. S T2 ELA Engagement	640	1	5	4.08	.96	-1.10	.56
6. S T1 Math Engagement	728	1.2	5	4.13	.82	-1.11	.68
7. S T2 Math Engagement	661	1	5	4.10	.83	-1.12	.90
8. S T1 Science Engagement	721	1	5	4.17	.96	-1.36	1.29
9. S T2 Science Engagement	649	1	5	4.18	.88	-1.14	.65

Note: 'T' = Teacher; 'S' = Student; 'T1' = Time 1; 'T2' = Time 2.

Table 3. Correlations among continuous study variables.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1. T Years Experience	**1**								
2. T Anxious Symptoms	-.18**	**1**							
3. T Depressive Symptoms	-.22**	.75**	**1**						
4. S T1 ELA Engagement	.06	.01	.05	**1**					
5. S T2 ELA Engagement	.12*	.01	-.01	.49**	**1**				
6. S T1 Math Engagement	.09*	.03	.06	.65**	.41**	**1**			
7. S T2 Math Engagement	.10*	.06	.04	.48**	.63**	.53**	**1**		
8. S T1 Science Engagement	.06	.01	.06	.66**	.42**	.60**	.45**	**1**	
9. S T2 Science Engagement	.08*	.03	.04	.42**	.66**	.37**	.63**	.50**	**1**

*Note: 'T' = Teacher; 'S' = Student; 'T1' = Time 1; 'T2' = Time 2; * indicates p is significant at <.05; ** indicates p is significant at <.01*

Table 4. Main effects and interactions models for teacher anxious symptoms predicting student engagement in each content area.

ELA Main Effects				**Mathematics Main Effects**				**Science Main Effects**			
	Intercept				**Intercept**				**Intercept**		
T2 ELA Engagement	4.17			T2 Math Engagement	4.09			T2 Sci Engagement	4.23		
	B	**SE**	**P**		**B**	**SE**	**P**		**B**	**SE**	**P**
Level 1				*Level 1*				*Level 1*			
Sex	.07	.06	.21	Sex	.16	.06	<.01	Sex	.01	.06	.90
FARM	-.23	.07	<.01	FARM	-.10	.05	.05	FARM	-.08	.07	.24
T1 ELA Engagement	.44	.05	<.01	T1 Math Engagement	.50	.04	<.01	T1 Sci Engagement	.43	.04	<.01
Level 2				*Level 2*				*Level 2*			
Pre vs. Post COVID	.02	.10	.83	Pre vs. Post COVID	.01	.08	.99	Pre vs. Post COVID	-.05	.08	.50
Years Experience	.01	.01	.10	Years Experience	.01	.01	.41	Years Experience	.01	.01	.48
T1 ELA Engagement	.77	.24	<.01	T1 Math Engagement	1.21	.32	<.01	T1 Sci Engagement	1.13	.28	<.01
Anxious Symptoms	.03	.06	.59	Anxious Symptoms	.05	.05	.33	Anxious Symptoms	.07	.05	.13
ELA Interaction Effects				**Mathematics Interaction Effects**				**Science Interaction Effects**			
	Intercept				**Intercept**				**Intercept**		
T2 ELA Engagement	4.18			T2 Math Engagement	4.09			T Sci Engagement	4.28		
	B	**SE**	**P**		**B**	**SE**	**P**		**B**	**SE**	**P**
Level 1				*Level 1*				*Level 1*			
Sex	.08	.06	.18	Sex	.16	.06	<.01	Sex	.01	.06	.88
FARM	-.25	.07	<.01	FARM	-.11	.05	.04	FARM	-.09	.07	.20
T1 ELA Engagement	.44	.05	<.01	T1 Math Engagement	.50	.04	<.01	T1 Sci Engagement	.43	.04	<.01
Anxiety-by-FARM	-.04	.11	.75	Anxiety-by-FARM	-.03	.10	.77	Anxiety-by-FARM	-.02	.09	.81
Level 2				*Level 2*				*Level 2*			

Pre vs. Post COVID	.02	.10	.84	Pre vs. Post COVID	.01	.08	.97	Pre vs. Post COVID	-.05	.08	.50
Years Experience	.01	.01	.12	Years Experience	.01	.01	.44	Years Experience	.01	.01	.51
T1 ELA Engagement	.76	.23	<.01	T1 Math Engagement	1.23	.31	<.01	T1 Sci Engagement	1.14	.27	<.01
Anxious Symptoms	.11	.09	.26	Anxious Symptoms	.10	.08	.20	Anxious Symptoms	.11	.07	.10
Anxiety-by-FARM	-.12	.11	.25	Anxiety-by-FARM	-.08	.11	.45	Anxiety-by-FARM	-.08	.07	.30

Note: 'ELA' = English language arts; 'Math' = Mathematics; 'Sci' = Science; 'FARM' = Free and Reduced Meal program; 'T1' = Time 1; 'T2' = Time 2

Table 5. Main effects and interactions models for teacher depressive symptoms predicting student engagement in each content area.

ELA Main Effects

	Intercept		
T2 ELA Engagement	4.12		
	B	**SE**	**P**
Level 1			
Sex	.08	.06	.18
FARM	-.24	.07	<.01
T1 ELA Engagement	.44	.05	<.01
Level 2			
Pre vs. Post COVID	.08	.09	.39
Years Experience	.01	.01	.21
T1 ELA Engagement	.79	.24	<.01
Dep Symptoms	-.08	.08	.28

Mathematics Main Effects

	Intercept		
T2 Math Engagement	4.07		
	B	**SE**	**P**
Level 1			
Sex	.16	.06	<.01
FARM	-.12	.05	.05
T1 Math Engagement	.50	.04	<.01
Level 2			
Pre vs. Post COVID	.04	.08	.63
Years Experience	.01	.01	.57
T1 Math Engagement	1.26	.32	<.01
Dep Symptoms	.01	.07	.98

Science Main Effects

	Intercept		
T2 Sci Engagement	4.19		
	B	**SE**	**P**
Level 1			
Sex	.01	.06	.82
FARM	-.08	.07	.25
T1 Sci Engagement	.43	.04	<.01
Level 2			
Pre vs. Post COVID	-.01	.09	.89
Years Experience	.01	.01	.67
T1 Sci Engagement	1.25	.36	<.01
Dep Symptoms	.03	.08	.74

ELA Interaction Effects

	Intercept		
T2 ELA Engagement	4.13		
	B	**SE**	**P**
Level 1			
Sex	.08	.06	.18
FARM	-.24	.08	<.01
T1 ELA Engagement	.44	.05	<.01
Depression-by-FARM	-.29	.24	.24
Level 2			
Pre vs. Post COVID	.08	.09	.38
Years Experience	.01	.01	.20
T1 ELA Engagement	.77	.23	<.01
Depressive Symptoms	-.13	.13	.35

Mathematics Interaction Effects

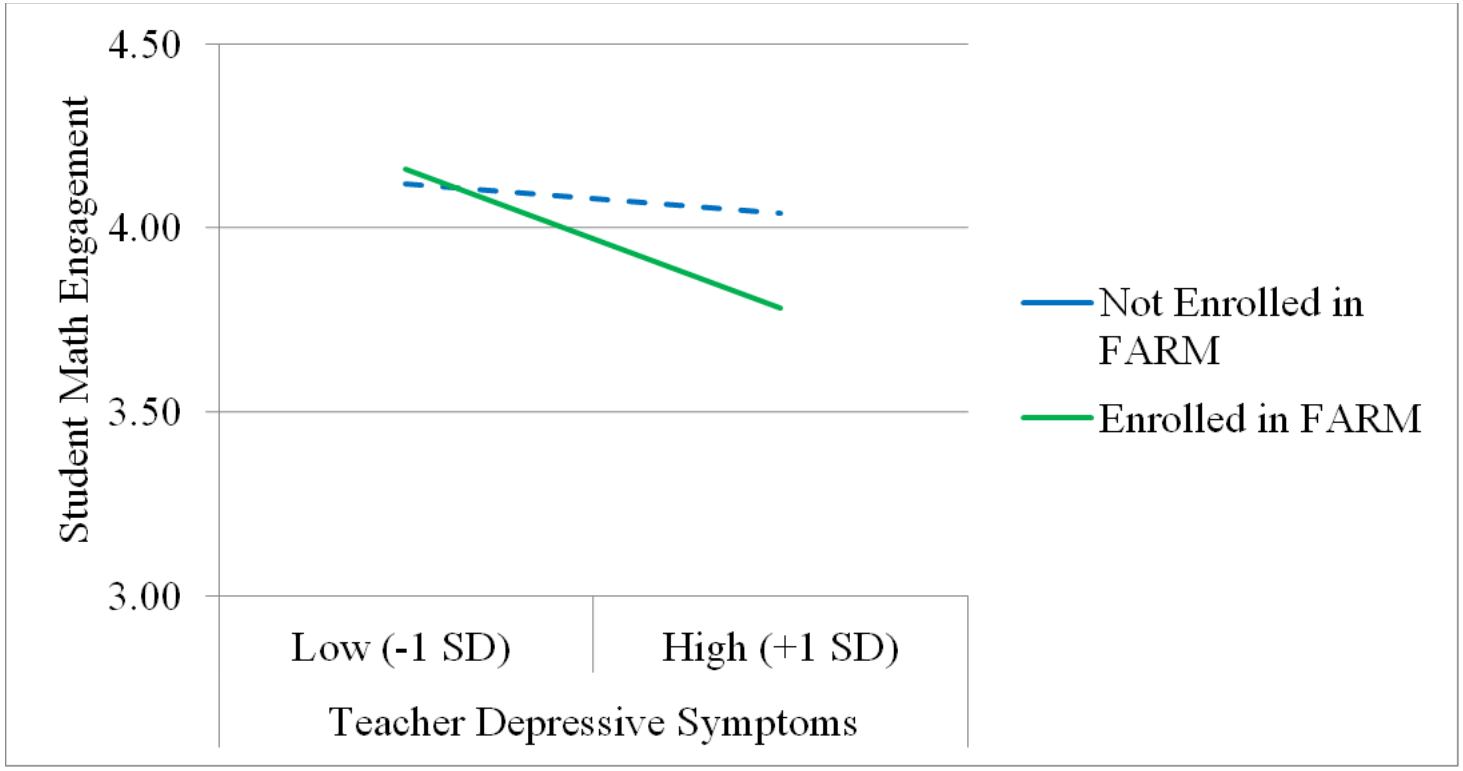
	Intercept		
T2 Math Engagement	4.08		
	B	**SE**	**P**
Level 1			
Sex	.16	.06	<.01
FARM	-.11	.05	.05
T1 Math Engagement	.50	.04	<.01
Depression-by-FARM	-.33	.15	.03
Level 2			
Pre vs. Post COVID	.04	.08	.59
Years Experience	.01	.01	.54
T1 Math Engagement	1.19	.31	<.01
Depressive Symptoms	-.09	.17	.61

Science Interaction Effects

	Intercept		
T2 Sci Engagement	4.21		
	B	**SE**	**P**
Level 1			
Sex	.02	.06	.78
FARM	-.15	.07	.02
T1 Sci Engagement	.43	.05	<.01
Depression-by-FARM	-.29	.14	.05
Level 2			
Pre vs. Post COVID	-.01	.09	.99
Years Experience	-.01	.01	.66
T1 Sci Engagement	1.47	.43	<.01
Depressive Symptoms	-.02	.18	.90

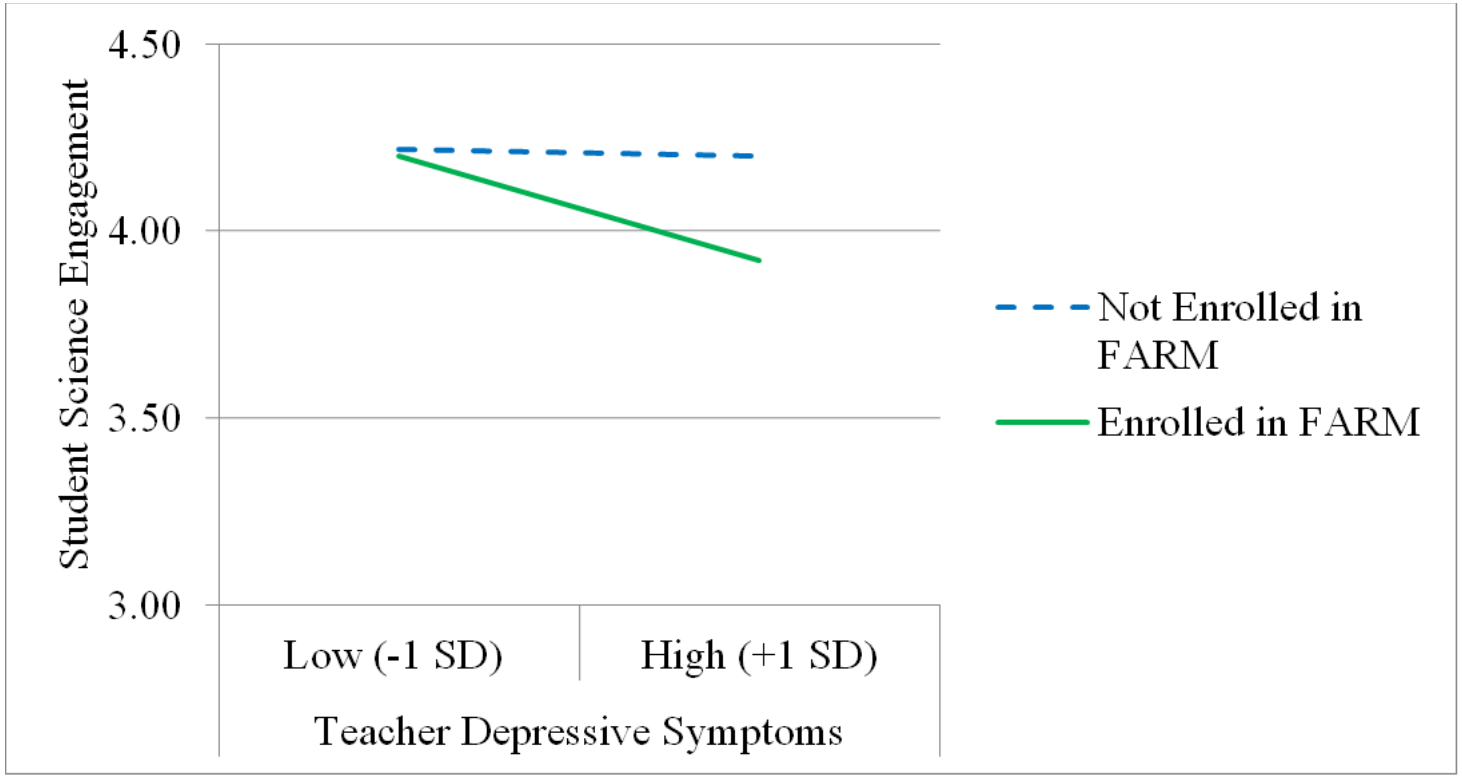
Depression-by-FARM	.06	.15	.71	Depression-by-FARM	.12	.21	.55	Depression-by-FARM	.10	.29	.74

Note: 'ELA' = English language arts; 'FARM' = Free and Reduced Meal program; 'T1' = Time 1; 'T2' = Time 2



Note: FARM = Free and Reduced Meal program.

Figure 1. Teacher-depression-by-student-FARM interaction.



Note: FARM = Free and Reduced Meal program.

Figure 3. Teacher depression-by-student FARM interaction.

Optional ERIC Coversheet — Only for Use with U.S. Department of Education Grantee Submissions

This coversheet should be completed by grantees and added to the PDF of your submission if the information required in this form **is not included on the PDF to be submitted**.

INSTRUCTIONS

- Before beginning submission process, download this PDF coversheet if you will need to provide information not on the PDF.
- Fill in all fields—information in this form **must match** the information on the submitted PDF and add missing information.
- Attach completed coversheet to the PDF you will upload to ERIC [use Adobe Acrobat or other program to combine PDF files]—do not upload the coversheet as a separate document.
- Begin completing submission form at https://eric.ed.gov/submit/ and upload the full-text PDF with attached coversheet when indicated. Your full-text PDF will display in ERIC after the 12-month embargo period.

GRANTEE SUBMISSION REQUIRED FIELDS

Title of article, paper, or other content

Using an Observational Measure of Elementary Teachers' Emotional Expressions During Mathematics and Engli

All author name(s) and affiliations on PDF. If more than 6 names, ERIC will complete the list from the submitted PDF.

Last Name, First Name	Academic/Organizational Affiliation	ORCID ID
McLean, Leigh	University of Delaware	0000-0001-7983-5497
Granger, Kristen	Vanderbilt University	0000-0001-8989-3631
Chow, Jason	Vanderbilt Univeristy	0000-0002-2878-7410

Publication/Completion Date—(if *In Press,* enter year accepted or completed) 10/01/2023

Check type of content being submitted and complete one of the following in the box below:

- ☑ If article: Name of journal, volume, and issue number if available
- ☐ If paper: Name of conference, date of conference, and place of conference
- ☐ If book chapter: Title of book, page range, publisher name and location
- ☐ If book: Publisher name and location
- ☐ If dissertation: Name of institution, type of degree, and department granting degree

Contemporary Educational Psychology

DOI or URL to published work (if available) https://doi.org/10.1016/j.cedpsych.2023.102231

Acknowledgement of Funding— Grantees should check with their grant officer for the preferred wording to acknowledge funding. If the grant officer does not have a preference, grantees can use this suggested wording (adjust wording if multiple grants are to be acknowledged). Fill in Department of Education funding office, grant number, and name of grant recipient institution or organization.

"This work was supported by U.S. Department of Education **[Office name]** Institute of Education Scie through **[Grant number]** R305A2005 to **Institution]** University of D. The opinions expressed are those of the authors and do not represent views of the **[Office name]** Institute of Education Scie or the U.S. Department of Education.