Learning and Instruction xxx (xxxx) xxx

Contents lists available at ScienceDirect

Learning and Instruction

journal homepage: www.elsevier.com/locate/learninstruc

Adolescents' daily sense of school connectedness and academic engagement: Intensive longitudinal mediation study of student differences by remote, hybrid, and in-person learning modality

Sarah E. McKellar [*], Ming-Te Wang

[a] University of Pittsburgh, Learning Research and Development Center, Pittsburgh, PA, USA

ARTICLE INFO

Keywords:
academic engagement
Adolescence
Learning modality
COVID-19
Connectedness
Belongingness

ABSTRACT

In spring 2020, the COVID-19 pandemic thrust nearly 56 million students in the United States into remote education. By fall 2020, states' and school districts' differing public health measures resulted in the adoption of varying COVID-adapted learning modalities (i.e., in-person, remote, and hybrid). Using daily diary data with a nationally representative sample (N = 517, M_{age} = 14.65 years), we investigated whether adolescents' academic engagement and connectedness to their teachers and classmates differed by COVID-adapted learning modalities. We also assessed whether adolescent connectedness mediated the link between learning modality and academic engagement. Results revealed that academic engagement and connectedness to teachers and classmates were higher for in-person learners than for students in hybrid and remote learning modalities. Moreover, students' connectedness to classmates and teachers explained the relationship between learning modality and academic engagement.

1. Introduction

During adolescence, the school context becomes a primary socialization setting, where interactions with teachers and classmates promote student academic engagement. However, public health measures to mitigate the spread of COVID-19 forced many schools to rapidly transition to remote or hybrid learning (i.e., a combination of in-person and remote learning). This transition, even to adapted in-person learning, potentially altered school-based social interactions that foster students' sense of closeness and academic engagement. Substantial work has documented the initial and projected impact of shifts to remote learning on student achievement (Dorn et al., 2020; Edmunds, 2020), but less is known about the impact of COVID-adapted learning modalities (i.e., in-person, hybrid, remote learning) on adolescents' school engagement.

School or academic engagement is a broad term that includes behavioral (e.g., participation), emotional (e.g., enjoyment), and cognitive (e.g., effort) components (Wang et al., 2017). According to the Self-System Model of Motivational Development, student engagement is the product of interactions between the learning context and the "self," or the fulfillment of developmental needs for competence, autonomy, and connectedness (Skinner et al., 2008). Adolescents' sense of connectedness with peers and their teacher carries particular weight due to the core developmental goal of adolescence—forming independent social identities apart from parents (Ryan et al., 2019). The pandemic altered one of the primary socializing contexts for adolescents: schools. Given this, empirical work is needed to investigate differences across COVID-adapted learning modalities in adolescents' connectedness to peers and teachers, and whether this connectedness may explain differences in student engagement. Using daily diary approaches with a racially and socioeconomically diverse sample, we investigated whether adolescents' daily academic engagement varied by learning modality during the pandemic. We also assessed whether adolescents' connectedness to teachers and classmates explained links between COVID-adapted learning modality and academic engagement.

1.1. Learning modality, connectedness, and engagement during the pandemic

While all learning modalities implemented after March 2020 in the U.S. were meant to reduce the spread of COVID-19, shifts to remote, hybrid, or socially distanced in-person learning modalities have led to questions about whether and how the context of instructional delivery influences student academic engagement in school. In our review of the literature on engagement related to learning modalities, prior work on

* Corresponding author. Learning Research and Development Center, University of Pittsburgh, Murdoch Building, 3420 Forbes Ave., Pittsburgh, PA, 15260, USA.
E-mail address: semckellar@pitt.edu (S.E. McKellar).

https://doi.org/10.1016/j.learninstruc.2022.101659
Received 18 September 2021; Received in revised form 28 June 2022; Accepted 5 July 2022

the justification for remote learning was mainly based on accessibility to students and cost-saving measures by higher education institutions (Santibañez & Guarino, 2021; Yelland et al., 2008). Yet COVID-adapted learning modalities are unique because they were a necessary public health and safety response, and thus, implemented more quickly and with less planning than learning modalities prior to the pandemic.

To date, only one published study has compared aspects of students' academic adjustment in remote versus in-person modalities (Duckworth et al., 2021). This study used one wave of student survey data collected during the outbreak of the pandemic (October 12 to 28, 2020) while controlling for student well-being before the pandemic as a baseline measure. They concluded that high school students' social well-being (Effect Size = 0.10, $p < .001$), emotional well-being (Effect Size = 0.08, $p < .001$), and academic well-being (Effect Size = 0.07, $p < .05$) suffered compared to peers learning in-person in fall 2020. These differences were consistent across gender, race and ethnicity, and socioeconomic status subgroups. However, there have been no longitudinal studies on the differential impact of remote, hybrid, and in-person learning modalities on students' daily academic engagement nor any prior work that investigates the mechanisms of student connectedness that may explain differences in academic engagement across COVID-adapted learning modalities.

Given the relatively little empirical work comparing student engagement across learning modalities in K-12 settings, we draw some information from prior higher education settings about the differences between in-person and remote learning. Namely, comparisons of learning modalities suggest that physical distance limits a shared psychological space and opportunities for prosocial communication (Moore, 1993). Remote or electronic communication has been deemed qualitatively distinct from being in the same physical space with classmates and educators daily (e.g., Fitzpatrick et al., 2020). This distinction between remote learning and in-person learning is most evident in the literature on *social presences* in online education. Social presences is the extent to which students' feel like they are learning with "real" people (i.e., instructors and classmates) and like they can access others' emotions and ideas (Oh et al., 2018). By definition this entire area of research does not exist for in-person learning modalities, as there is an assumption that students in the same physical space as their instructor and classmates feel that they are with "real" people, unlike remote learning context where additional strategies need to be implemented (Delahunty et al., 2014). That is, instructors in remote settings need to dedicate significant time and resources to building a foundation for connectedness—deemed a key component of social presence in the remote learning literature (Oh et al., 2018; Sung & Mayer, 2012). Although limited to higher education settings, extant theoretical and empirical work suggests that barriers to connections to classmates and teachers may contribute to students' inability to engage academically.

However, there is some evidence that remote learning tools may have additional benefits for students and that more technology and internet access can yield more opportunities for students' learning (e.g., more autonomy, personalization, timely feedback, ongoing communication with teachers; Abramson, 2012). According to Roy and colleagues' (2022) findings, many parents of adolescents reported benefits from COVID-adapted remote learning, including more flexibility in students' daily schedules and more options in the way students can access learning content. Yet these parents also reported that lack of social interactions was still a limitation of COVID-adapted remote learning. Given Roy et al.'s study, prior empirical work supporting strong links between engagement and connectedness, and these links being a core part of the Self-System Model of Motivational Development, there is evidence that engagement is higher in settings where students can feel most connected to their teachers and their classmates.

In addition to remote versus in-person learning, some schools opted to create "hybrid" learning conditions to provide students with the ability to interact with their classmates on some days and learn from home on other days. This modality enabled schools to adhere to safe social distancing policies through reduced school capacity. Similar to remote learning conditions, hybrid learning modalities were mainly implemented in higher education prior to the pandemic, often called "blended learning" (Manwaring et al., 2017). In the limited literature on the "blended" learning with secondary students; there were similarly promising outcomes to remote learning. For example, Vidergor and Ben-Amram's (2020) qualitative study found 9th and 10th graders' academic engagement was positively shaped by using Khan Academy, a remote learning tool. However, the use of this program was particularly effective when it is implemented with teacher support and guidance. Thus, hybrid learning modalities may support academic engagement in ways that were limited by traditional in-person instruction and were relatively favorable for students and their parents, especially when their schools did not provide any in-person learning options. However, in the context of the pandemic, hybrid learning placed an incredible additional burden on teachers to simultaneously create both in-person and remote lessons daily (Mason, 2020; North, 2020).

1.2. A daily perspective on academic engagement and sense of connectedness

Prior research stresses that adolescents' academic engagement and sense of connectedness to others change from day to day (Gillen-O'Neel, 2021; Patall et al., 2018). Adolescents' connectedness to classmates and teachers is largely shaped by opportunities to socially engage in their school community (Allen et al., 2021). Teachers who provide a social context characterized by structure and warmth create environments in which students are more emotionally engaged (McKellar et al., 2020; Reyes et al., 2012). Connectedness to classmates and teachers also helps adolescents maintain behavioral engagement in learning tasks, even when they feel bored, anxious, or frustrated (Skinner, 2016).

However, the extent to which connectedness predicts academic engagement is most often studied using longitudinal designs that assess these variables one to a few times per year (e.g., St-Amand et al., 2021). To enhance understanding of the associations between adolescents' sense of connectedness and engagement, researchers have recommended using daily diary methods (e.g., intensive longitudinal studies in which participants report their experiences every day for several days; Bolger & Laurenceau, 2013).

Daily diaries enable researchers to capture psychological processes as they unfold in everyday life, reducing retrospective bias. Despite the evidence that students' sense of connectedness varies daily—and that this daily variation matters for their academic engagement more broadly (Patall et al., 2018; Wang et al., 2021), no studies have assessed adolescents' daily connectedness to classmates and their teachers in relation to academic engagement. Given the rapid changes in students' lives throughout the COVID-19 pandemic, it has become even more critical to understand the potential dynamic relationship between daily connectedness and engagement. Educators and policymakers have grappled with the costs and benefits of implementing different learning modalities at various crossroads throughout the pandemic. Thus, studying students' daily engagement and connectedness across learning modalities may help better inform these decisions.

1.3. Connectedness to teachers as a mediator during COVID-19

During remote learning, instructors may be less likely to engage students because they are less likely to pick up on subtle communication cues (e.g., student body language; Coker, 2020). In turn, educators may fail to notice students' misunderstanding or fatigue during remote learning that they would otherwise sense during face-to-face interactions (Sofianidis et al., 2021). Furthermore, teachers' ability to address students' need for connectedness may be limited by physical distance, even in hybrid spaces where students only have in-person access to their teacher on select days or weeks (Bülow, 2022). One qualitative study during COVID-19 found that teachers overwhelmingly felt

they could not support students in remote settings because they could not use caring gestures or physical proximity (e.g., smiles directed at students from across the room, monitoring peer group discussions (Kraft et al., 2021).

Teachers in a hybrid learning modality are thought to remedy this limitation of remote learning due to students' ability to frequently interact in person with their teachers (Vidergor & Ben-Amram, 2020). However, the quality of interactions during in-person learning may vary depending on resources to support the arduous task of teaching across two different settings (i.e., remote and in-person). This especially may be true in COVID-adapted hybrid learning modalities, where parents and teachers have reported an increase in their students' socioemotional and academic needs, along with juggling the dual tasks of working while supporting their children's at-home learning (Bülow, 2022; North, 2020). Teachers have also reported insufficient time and flexibility to prepare and adapt lessons in COVID-adapted hybrid learning modalities (Bülow, 2022; Mason, 2020). Taken together, there may be evidence that adolescents who are learning in person, as opposed to learning remotely or in hybrid modalities, have greater engagement due to better support of their sense of connectedness.

1.4. Connectedness to classmates as a mediator during COVID-19

Prior work suggests that remote and hybrid learning modalities may create barriers to students' connectedness with classmates. In fact, the highest-ranked pandemic-related stressor for U.S. secondary school students was the inability to see friends in person (Styck et al., 2021). The organic act of turning to the classmate sitting beside them to discuss a concept becomes a process where teachers need to create "breakout" rooms. Upon entering an electronic discussion space, students must break the silence and speak at their computer screen, rather than chat with the classmates in their physical vicinity. Moreover, in-person school spaces (e.g., hallways and gyms) provide additional opportunities for students to interact with classmates outside of instructional time. Ellerbrock and Kiefer's (2013) qualitative study found time outside of classrooms to be instrumental to secondary school students' connectedness, as students' comments about traveling to shared classes with their peers or common lunchtime supported an overall sense of belongingness. Even hybrid learning modalities do not lend themselves to the same continuity of classmates' connections, because students only interact with a fraction of their peers in person for a fraction of the time.

While students report feelings of stress from missing their friends (Styck et al., 2021), prior work on remote learning underscores that interactions with classmates can reduce students' sense of isolation and increase sense of connectedness with classmates (Sung & Mayer, 2012). For example, Tu and McIsaac's (2002) study of online college courses found that students' sense of social presence increased in classes where online exchanges were caring, helpful, and timely. As part of increasing students' social presence, these exchanges fostered students' sense of connectedness, and in turn supported greater student engagement. By extension of this study and Skinner et al.'s Self-System Model of Motivational Development (2008), it is possible that students may be able to develop a strong sense of connectedness to their classmates if they engage in positive exchanges with classmates in remote learning modalities.

Taken together, despite the documented downsides of remote and hybrid learning modalities, there has yet to be published empirical work that confirms the immense media outcry in favor of in-person learning over remote and hybrid learning modalities. In particular, pushes to return to in-person learning during fall 2020 and outcries about the "failure" of remote learning were largely based on the underlying hypothesis that the connectedness that students experience via learning in person is the cause of lack of student engagement. However, no prior studies have assessed adolescents' connectedness in relation to their engagement, and no work has examined daily connectedness across learning modalities.

1.5. The current study

While many studies have explored the links between school context and academic engagement, the COVID-adapted learning modality that emerged during the 2020–2021 school year has presented a unique opportunity to investigate academic engagement for students in different learning contexts (i.e., remote, hybrid, or in-person). Our data collection in the fall 2020 was particularly timely because it fell after spring 2020 (i.e., after stay-at-home mandates relaxed and most districts could select modalities besides fully remote learning) and before late spring 2021 (i.e., before most districts returned to fully in-person learning (Oster et al., 2021; Panorama Education, 2021; U.S. Department of Education, 2021).

We collected 5,211 daily diary entries across 11 *school days* to determine whether adolescents' connectedness to teachers and classmates and their academic engagement differs between school learning modalities. Our longitudinal data enabled us to examine the relationship between connectedness and engagement measured on the same school day and the extent to which connectedness predicted engagement on the following school day. Using an intensive longitudinal design with a large sample size, we hoped to gain insight into how adolescents' daily connectedness and academic engagement vary when they experience different learning modalities in real-time by detangling both within- and between-person processes (Bolger & Laurenceau, 2013). We investigated the following research questions:

1. Does students' daily connectedness to teachers, connectedness to classmates, and academic engagement vary by learning modalities?
2. If so, does students' daily connectedness to teachers and classmates explain the extent to which same- and next-day academic engagement vary by learning modality?

Based on prior literature in higher education (Sung & Mayer, 2012), the Self-System Model of Motivational Development (Skinner et al., 2008, see Fig. 1) and Duckworth et al.'s (2021) study, we hypothesized that adolescents learning in person would have higher academic engagement than their peers in hybrid and remote learning modalities.. Second, we hypothesized that adolescents learning in person would have a greater connectedness than those learning in hybrid and remote modalities. This hypothesis was based on the successful implementation of remote and hybrid learning modalities in higher education settings linked to flexibility pacing, additional time, and greater resources that secondary educators do not have (Baker et al., 2021; Kraft et al., 2021; Sofianidis et al., 2021). Finally, we hypothesized that adolescents' connectedness with teachers and classmates would mediate the relationship between the learning modality and academic engagement. We assess this pattern would be consistent for predicting engagement reported on the same and next day as the sense of connectedness to teachers and to classmates. This hypothesis is based on studies finding that increasing remote and hybrid learners' feelings of connection or closeness to their classmates and their teachers supports student engagement (Oh et al., 2018).

2. Method

2.1. Participants and participant recruitment

Using a national sample of U.S. adolescents, the data were collected as part of an ongoing longitudinal study investigating adolescents' well-being and school experiences. For the original study, we worked with a research company to recruit a nationally representative sample of parents and adolescents (i.e., middle- and high-school-aged youth) via random sampling. The original sample had a purposive oversample of Black/African American participants to ensure sufficient power to identify school-based racial disparities in health and academic achievement. Our initial recruitment process depended on access to an

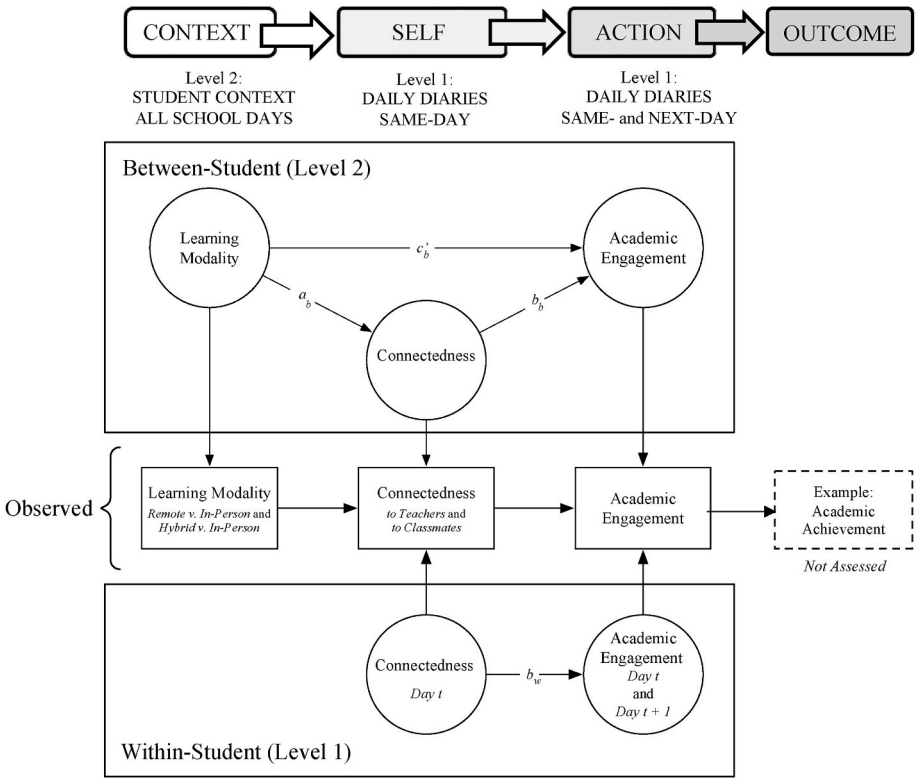

Fig. 1. Illustration of Skinner et al.'s (2008) Self-System Model of Motivational Development and the 2–1–1 Mediated MSEM models with Fixed Effects. Note. This illustration represents the 2–1–1 mediated MSEM models with fixed slopes. There are four mediated MSEM models in the study: two sets of models for each of the two mediating variables (connectedness to teachers and to classmates) and two sets of models for same-day (Day t) and next-day (Day t + 1) academic engagement. For simplicity reasons, our control variables and the covariances between latent variables were not depicted but were estimated in the models.

electronic device and internet given social distancing mandates. When consenting to the study, we asked students if they have regular access to the internet at home and 99.6% of respondents reported "yes," with only two respondents reporting "no," and we were unable to recruit these students for data collected for the present study.

When COVID-19 was declared a national emergency in the United

Table 1
Adolescent participant demographic characteristics.

Characteristics		% for		% for	% for	% for
		All		In-Person	Hybrid	Remote
	(N = 517)	*M*	*SD*	(n = 39)	(n = 171)	(n = 307)
Gender		0.42	0.49			
Girl	58%			44%	60%	58%
Boy	42%			56%	40%	42%
Grade		9.47	1.5			
7th	09%			08%	06%	10%
8th	24%			21%	16%	25%
9th	17%			28%	15%	16%
10th	26%			31%	30%	23%
11th	12%			05%	11%	14%
12th	13%			08%	16%	12%
Race [a]		NA	NA			
Black or African American	33%			15%	35%	35%
White or European American	24%			18%	33%	19%
Latinx, Latin American, or Hispanic	14%			28%	07%	16%
Asian or Asian American	13%			05%	10%	15%
Biracial or Multiracial	15%			33%	14%	13%
GPA		2.13	1.35			
Mostly A (3.5–4.0)	39%			26%	44%	37%
As and Bs (3.0–3.49)	37%			54%	36%	36%
Mostly Bs (2.5–2.99)	07%			05%	06%	08%
Bs and Cs (2.0–2.49)	11%			13%	09%	11%
Mostly Cs (1.5–1.99)	02%			03%	02%	02%
Cs and below (0.0–1.49)	03%			00%	02%	05%
Free Lunch Status		0.58	0.49			
Paid Lunch	55%			59%	47%	60%
Free/Reduced Price Lunch	40%			41%	47%	36%

Note. For race and GPA, there were two or more answer choices that were combined for parsimony to present frequencies.
†$p < .10$, *$p < .05$, **$p < .01$, ***$p < .001$.

[a] The majority adolescents who identified with two or more racial groups identified as Black and White Biracial; and of the adolescents who identified with three or more racial groups, most identified as Native America and two other racial group. Roughly 1% of students marked other or did not report on their race.

States in March 2020, we leveraged relationships with participants from this original longitudinal study and recruited 79% of the original national sample for the present study specifically from 38 states with stay-at-home mandates in the spring 2020. A total of 519 students participated in the daily diary study. Two of the 519 students reported that they did not attend school on any weekdays during the duration of the study; thus, they were excluded from analyses. The analytical sample included 517 adolescents with ages ranging from 13 to 18 ($M_{age} = 14.65$ years, 58% girls, 42% boys; 33% Black/African American, 24% White/European American, 14% Latine/x, 13% Asian American, 15% Biracial or Multiracial, and 1% of students marked "Other" or did not complete the item). This subsample did not differ from the original sample regarding sociodemographic characteristics or academic adjustment (i.e., academic engagement and achievement), but it differed geographically. The subsample had more participants from the Northeast (42%) and South (25%) regions [vs. Midwest (18%) and West (15%)] as compared to the original longitudinal study sample. The increased number of participants from the Northeast and South regions was due to these states implementing state-wide stay-at-home orders prior to the study's recruitment deadline. See Table 1 for a summary of participant demographic information.

2.2. Procedures

Beginning on October 19, 2021, adolescent participants and their parents completed online consent forms and baseline surveys. After completing baseline questionnaires on the first day, all adolescents completed an online daily diary report between 5:00 p.m. and 12:00 a.m. through an electronic device (i.e., cell phones, tablets, or computers) for two consecutive weeks (11 school days and 4 weekend days). Adolescents received between two to four reminders via email or text message each day to complete their survey. The 517 adolescent participants completed a total of 5,211 weekday entries within the 11 school days. Of the 5,211 weekday entries, participants reported their learning modalities, and then were given questions about the schooling experience via skip logic. Skip logic is a feature in the Qualtrics software that allows participants to "skip" items based on how they answer a question (Qualtrics, 2022). We used skip logic, as students who were absent from school instruction cannot answer questions about their engagement in school. Each youth participant received $40 for completing the baseline survey and daily diary entries, and parents received $20 for completing the baseline survey. The institutional review board of the authors' institution approved all procedures for this study.

2.3. Measures

2.3.1. Learning modality

On each of the 11 school days, we assessed each student's learning modality based on their response about whether they had in-person learning and/or remote learning, or neither that day. We then created a student-level category to represent student learning modality (in-person learning = 0 and remote and hybrid learning = 1). Students who only reported remote learning every weekday were designated as *remote learners*. Students who reported in-person learning every day (i.e., learning in school all or much of the day), were designated as *in-person learners*. Students who indicated that they learned in person on some days and remotely on other days were designated as *hybrid learners* (n = 171; $M_{in\text{-}person} = 4.34$ days, $SD_{in\text{-}person} = 2.79$ and $M_{remote} = 4.90$ days, $SD_{remote} = 2.81$). All groups of students had similar missingness in their survey completion rates, though remote learners indicated they attended school on average 1.12 more days than in-person learners. See Supplementary Fig. 1 for a summary of the number of daily entries that comprise each of our student-level learning modalities.

2.3.2. Daily academic engagement

Student engagement was measured using an abbreviated version of the well-validated Academic Engagement Scale (Fredricks et al., 2016; Wang et al., 2016), that assessed behavioral, emotional, and cognitive elements of engagement (six items; e.g., "I stayed focused on my schoolwork," "I had fun with my schoolwork," "I kept trying when I got stuck on my schoolwork". All six items were scored on a five-point Likert scale with responses from (1) "not at all like me" to (5) "very much like me." We followed Bolger and Laurenceau's (2013) steps to calculate the *Rc*, or focal reliability measure, which assessed whether there are reliable within-subject differences in change over time for each of the items in our engagement measure ($Rc = 0.70$). After establishing reliability, we averaged the six items together for to form *daily* composite scores of academic engagements for each student.

2.3.3. Daily connectedness to teachers

We measured whether adolescents felt connected to their teacher each day with the item, "I felt close and connected to my teachers". The item was adapted from Reis and colleagues' (2000) work on daily relatedness, where they rated the extent to which they felt "close and connected" with the people they were with during the interaction.

2.3.4. Daily connectedness to classmates

Similar to our *Daily Connectedness to Teachers* measure, we adapted Reis et al.'s (2000) survey item, and measured whether adolescents felt connected to their classmates using the item "I felt close and connected to classmates".

2.3.5. Covariates

As recommended by Bolger and Laurenceau (2013), we accounted for the passing of time by the number of school days students were administered the survey and excluded weekends and school holidays. We also included student-level covariates collected from the child or parent reports: (a) youth's grade level (5th – 12th), (b) gender (0 = boys and 1 = girls), (c) race (dummy coded with 0 = Black students, and 1 = White, Latinx, and Other racial groups of students), (d) prior years' grade point average (1 = Mostly As to 8 = Mostly Fs), and (e) parent reports of eligibility for free lunch (0 = paid lunch, 1 = free lunch).

2.4. Analytic plan

2.4.1. Multilevel structural equation modeling

Since our study used repeated daily entries as our measurement of student sense of connectedness and engagement across time, we ran a fully unconditional model, or baseline model, with only student daily engagement without any predictors, mediators, or covariates. From this baseline model, we calculated intraclass correlation coefficients (ICC) for same-day engagement (see Supplementary Table 1 for details). The Intraclass Correlation Coefficients (ICC) show that 29% of the same-day academic engagement and 28% of next-day engagement variance were accounted for by daily differences within each student, while 71% of same-day engagement and 72% of next-day engagement were explained by differences between students; therefore justifying our multilevel modeling approach.

This study used multilevel structural equation modeling (MSEM) in Mplus7.4 to examine *same-day* and *next-day* academic engagement with 5,211 daily diary entries (Level 1) nested within 517 adolescents across learning modalities (Level 2; Bolger & Laurenceau, 2013). MSEM provides advantages over conventional multilevel modeling procedures by simultaneously estimating complex models with multiple mediators and outcome variables as well as both direct and indirect effects (Preacher et al., 2010). Specifically, the predictor variable in a 2-level regression can be decomposed into the estimates of between- and within-level components of indirect effects (Lüdtke et al., 2008).

We specifically used 2-1-1 mediation MSEM with fixed slopes to assess our hypotheses (see Fig. 1, Pituch & Stapleton, 2008; Preacher et al., 2010). That is, learning modalities were the independent measure at the between-student level (Level 2), adolescent connectedness to

teachers and classmates were the mediating variables at the within-student level (Level 1), and *same-* and *next-day* academic engagement were the dependent variables at the within-student level (Level 1). Same-day (Day *t*) academic engagement refers to data collected at the same time as daily connectedness data, starting on day 1 of survey administration (Day *t*), and next-day (Day $t + 1$) refers to data collected on the day after our daily connectedness data, starting on day 2 of the survey. Due to the high correlation between averaged daily reports of connectedness to *teachers* and connectedness to *classmates* ($r = 0.75$, $p < .001$), we ran separate MSEM to avoid multicollinearity in our intensive longitudinal designs (Ariens et al., 2020).

For our first research question, we used two MSEMs to examine whether the learning modality (remote v. in-person and hybrid v. in-person) predicted students' *same-day* and *next-day* engagement. Then, we assessed whether learning modalities predicted students' sense of connectedness to their *teachers* and *classmates* on Day *t* in two separate MSEMs. For our second research question, we used four mediated MSEMS to evaluate whether students' connectedness to *teachers* and *classmates* mediated the link between learning modality and students' *same-day* and *next-day* academic engagement. We also calculated coefficients for each of our effects when the mediators (i.e., peer and teacher connectedness) and the outcome (i.e., academic engagement) were standardized to demonstrate the effect size of each MSEM relationship (MacKinnon et al., 2007; Miočević et al., 2018). In each model, we controlled for the effect of student demographics at Level 2 and time (school days of data collection) on academic engagement at Level 1. Our MSEM approach also enabled us to use latent group mean centering for our mediator variables.

In line with recommendations for multilevel models, we employed a model-building approach using nested comparisons to determine whether slopes should be specified as fixed or random (Beal, 2015; Nezlek, 2001). We assessed baseline models of learning modalities predicting within- and between-student engagement. And we compared the model where time predicting daily engagement had a fixed slope and was allowed to randomly vary (see Supplementary Tables 2 and 3). The fit of these nested models with and without a random slope was comparable, and thus we used 2–1–1 mediation MSEMs with fixed slopes, also called upper-level mediation. In this approach, the indirect effects in our models were considered fixed effects—Level-1 intercepts for the relationships between students' daily sense of connectedness and daily engagement were permitted to vary between students but not the slopes (Pituch & Stapleton, 2008).

2.4.2. Missing data

We assessed missingness at the daily and person levels. Of the possible 5,211 daily diary assessments (11 school days, 517 participants), 8.3% of the school day assessments were missing at the daily level ($n = 486$ missing daily assessments). There were also varying levels of missing data by each adolescent: 34% of adolescents did not miss any daily diary entries, 39% missed 1–2 daily entries, 14% missed 3–4 daily entries, 6% missed 5–6 entries, and 6% missed more than 6. On average, adolescents completed over 9 out of 11 daily diary entries.

For Level 2 variables, we obtained demographic information for nearly all participants except for the 5% missing data on eligibility for free lunch collected from parent reports. Overall, the amount of missing data at both the daily and person levels were relatively low. Missing data patterns indicated that adolescents with complete data did not differ from those with missing data on demographic characteristics. We accounted for missing data through full-information maximum likelihood estimation to retain all adolescents in analyses (FIML; Enders, 2001).

3. Results

Table 2 presents the zero-order correlations between the key study variables. Goodness-of-fit indices and results for MSEMs with and without mediation are shown in Tables 3 and 4. Our indirect effects are illustrated in Table 5 and Figs. 2 and 3. Model covariates are depicted in Supplementary Tables 4 and 5, and the intercepts and variance components of our mediated MSEM models are shown in Supplementary Table 6.

3.1. Multilevel structural equation models (MSEM)

3.1.1. Learning modality predicting engagement (RQ 1)

According to Table 3 Models 1 and 2, adolescents in remote learning modality had lower academic engagement than adolescents in in-person learning modality (same-day effect: $b = -0.45$, *S.E.* $= 0.14$, $p < .001$, effect size (β) $= -0.25$; next-day effect: $b = -0.44$, *S.E.* $= 0.14$, $p < .01$, $\beta = -0.24$). We also found that adolescents in hybrid learning modality had lower academic engagement than adolescents learning in person (same-day effect: $b = -0.34$, *S.E.* $= 0.14$, $p < .05$, $\beta = -0.18$; next-day effect: $b = -0.31$, *S.E.* $= 0.15$, $p < .05$, $\beta = -0.16$).

3.1.2. Learning modality predicting connectedness (RQ 1)

Table 3 Models 3 and 4 shows that adolescents felt less connected to their teachers in remote ($b = -0.97$, *S.E.* $= 0.19$, $p < .001$, $\beta = -0.40$) and hybrid learning modalities ($b = -0.69$, *S.E.* $= 0.20$, $p < .001$, $\beta = -0.39$) than adolescents learning in an in-person learning modality. Similarly, adolescents' connectedness to classmates was lower in remote learning modality ($b = -0.90$, S.E. $= 0.18$, $p < .001$, $\beta = -0.27$) and hybrid learning modality ($b = -0.52$, *S.E.* $= 0.19$, $p < .01$, $\beta = -0.22$) than in in-person learning modality.

3.2. Multilevel mediation models (RQ 2)

3.2.1. connectedness to teachers (Fig. 2 and Table 4)

According to our direct effects shown in Fig. 2 and Table 4 Models 1 and 2, learning remotely (versus in-person) predicted higher academic engagement (same-day effects: b = 0.19, S.E. = 0.08, p < .05, β = 0.10; next-day effects: b = 0.24, S.E. = 0.08, p < .001, β = 0.13). Hybrid learning also positively predicted students' next-day academic engagement (b = 0.18, S.E. = 0.08, p < .05, β = 0.09), but not the same-day engagement. Remote and hybrid learning modalities predicted lower levels of connectedness to teachers (remote learning: b = −0.98, S.E. = 0.19, p < .001, β = −0.40; hybrid learning: b = −0.70, S.E. = 0.19, p < .001, β = −0.27) than learning in-person. Students with a higher level of connectedness to teachers also had higher engagement on the same day (between-students—same-day effect: b = 0.64, S.E. = 0.04, p < .001, β = 0.86; next-day effect: b = 0.67, S.E. = 0.02, p < .001, β = 0.90). Higher daily sense of connectedness to teachers also positively predicted higher academic engagement on the same day (within-students—same-day effect: b = 0.30, S.E. = 0.02, p < .001, β = 0.42), but not the next day, as there was only a non-significant trend.

As shown in Fig. 2 and Table 5, learning remotely (versus in-person) had a negative indirect effect on adolescents' academic engagement (same-day effect: b = −0.63, SE = 0.12, p < .001, β = −0.35; next-day effect: b = −0.66, SE = 0.13, p < .001, β = −0.36). Hybrid (versus in-person) learning also had a negative indirect effect on engagement (same-day effect: b = −0.45, SE = 0.10, p < .001, β = −0.24; next-day effect: b = −0.47, SE = 0.13, p < .001, β = −0.24). These patterns indicated that connectedness to teachers fully mediated the negative links between remote and hybrid (versus in-person) learning and student engagement.

3.2.2. Connectedness to classmates (Fig. 3 and Table 4)

As shown in Fig. 3 and Table 4 Models 3 and 4, we did not observe direct effects between learning modality and academic engagement. Remote and hybrid learning modalities negatively predicted students' sense of connectedness to classmates (remote learning: b = −0.91, S.E. = 0.18, p < .001, β = −0.39; hybrid learning: b = −0.53, S.E. = 0.19, p < .01, β = −0.22) when compared to in-person learning. In contrast,

Table 2
Within- and between-person variable means, standard deviations, and correlations.

Within-Person Variables	*M*	*SD*	1	2	3	4									
1. Same-Day Engagement	3.16	1.03													
1. Next-Day Engagement	3.16	1.04	.75**												
3. Connectedness to Teachers	2.59	1.35	.69**	.58**											
3. Connectedness to Classmates	2.41	1.34	.60**	.48**	.75**										
5. School Days (0–10)	6.19	4.36	.00	.01	.00	.01									
Between-Student Variables	***M***	***SD***	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1. Same-Day Engagement	3.13	0.90													
1. Next-Day Engagement	3.12	0.91	–												
3. Connectedness to Teachers	2.55	1.12	–	1.00**											
3. Connectedness to Classmates	2.38	1.08	–	.68**	.85**										
5. Remote = 1 v. In-Person[a]	0.89	0.32	–	−.16**	−.26**	−.24**									
6. Hybrid = 1 v. In-Person[a]	0.81	0.39	–	−.16*	−.25**	−.17*	–								
7. Remote = 1 v. Hybrid[a]	0.64	0.48	–	−.05	−.10*	−.17**	–	–							
8. Gender: Girls = 1	0.42	0.49	–	.04	.08	.08	−.09	−.13	.02						
9. Grade Level (7th – 12th)	9.48	1.51	–	−.17**	−.14**	−.11*	.02	.09	−.07	−.21**					
10. White Students = 1[b]	0.42	0.49	–	−.20**	−.18**	−.10	−.10	−.03	−.14*	−.07	.27**				
11. Latine/x Students = 1[b]	0.29	0.46	–	−.04	−.02	−.05	−.21**	−.43**	.15*	.15*	−.06	–			
12. Other[c] Racial Groups = 1[b]	0.33	0.47	–	−.07	−.06	−.02	−.26**	−.30**	−.01	−.05	.03	–	–		
13. GPA (1 = As to 8 = Fs)	2.13	1.35	–	−.15**	−.03	−.11*	.02	−.05	.08	.06	−.12**	−.21**	−.04	−.02	
14. Free = 1 v. Paid Lunch	0.58	0.49	–	−.05	−.01	−.04	.03	−.06	.12*	.05	−.15**	−.32**	−.03	−.22**	.23**

*$p < .05$. **$p < .01$.

Note. Engagement variables designated as Same-Day and Next-Day are the same variable measured on different days of survey administration. Same-Day = Academic Engagement measured at Day = t or measured simultaneously as connectedness to teachers and classmates. Next-Day = Academic Engagement at Day = t + 1. Between-Student Variables are either an average of the daily student reports or student demographic characteristics. Gender, race, and free v. paid lunch were dummy coded with 0s and 1s.

[a] For each learning modality comparison correlation, we used a subset of two modalities, coded as 0 and 1.

[b] For each racial group comparison correlation, we used a subsample of two racial groups, coded as 0 and 1. Black Students = 0 and White, Latine/x, and Other Racial Groups = 1.

[c] Other Groups variable indicates other racial groups including Asian American and Biracial or Multiracial students most who identify as Black and White multiracial.

higher student-level sense of connectedness to classmates predicted higher academic engagement (between-student—same-day effect: b = 0.57, S.E. = 0.03, p < .001, β = 0.72; next-day effect: b = 0.60, S.E. = 0.03, p < .001, β = 0.75). Similarly, higher daily sense of connectedness to classmates positively predicted higher academic engagement (within-student—same-day effect: b = 0.26, S.E. = 0.02, p < .001, β = 0.39; next-day effect: b = 0.03, S.E. = 0.01, p < .01, β = 0.04).

There was a negative indirect effect between remote (versus in-person) learning modalities and academic engagement (same-day effect: b = −0.52, SE = 0.10, p < .001, β = −0.28; next-day effect: b = −0.54, SE = 0.11, p < .001, β = −0.30). There was also negative indirect effect of hybrid (versus in-person) learning modalities and academic engagement (same-day effect: b = −0.30, SE = 0.11, p < .01, β = −0.16; next-day effect: b = −0.32, SE = 0.11, p < .01, β = −0.16). The relationship between remote learning and hybrid learning, in contrast to in-person learning, and engagement were fully mediated by students' sense of connectedness to classmates.

3.3. Covariates

We examined whether learning modality varied by student characteristics (i.e., youth grade level, gender, race, prior year's grade point average, and eligibility for free school lunch). Supplementary Tables 4 and 5 present all the paths between key variables in our models and our covariates. Only racial differences were found between student learning modality within our 11-day study. Black students were more likely to be in remote learning modalities than White students, and Latine/x students were more likely to be in hybrid learning modalities than White students. Students across learning modalities were similar in their GPA, grade level, and free lunch status.

3.4. Sensitivity analysis (Reverse directionality model)

We also tested two alternative models to examine directionality/causality with our findings. First, we examined whether prior-day academic engagement mediated the relationship between remote and hybrid (versus in-person) learning and students' sense of connectedness.

Table 3
MSEM: Learning modalities predicting same- and next-day academic engagement and connectedness to teachers and students with demographic variables as covariates.

	Model 1		Model 2		Model 3		Model 4	
	Same-Day Engagement		Next-Day Engagement		Connectedness to Teachers		Connectedness to Classmates	
	b (*SE*)	95% CI	b (*SE*)	95% CI	*b* (*SE*)	95% CI	*b* (*SE*)	95% CI
Between-Student Paths Coefficients								
Remote ➔ Teachers					−0.97 (0.19)***	[-1.28, −0.67]		
Hybrid ➔ Teachers					−0.69 (0.20)***	[-1.01, −0.37]		
Remote ➔ Classmates							−0.90 (0.18)***	[-1.19, −0.61]
Hybrid ➔ Classmates							−0.52 (0.19)**	[-0.83, −0.21]
Remote ➔ Engagement	−0.45 (0.14)***	[-0.68, −0.23]	−0.44 (0.14)***	[-0.67, −0.20]				
Hybrid ➔ Engagement	−0.34 (0.14)*	[-0.57, −0.11]	−0.31 (0.15)*	[-0.55, −0.06]				
	M or Variance (*SE*)	95% CI	M or Variance (*SE*)	95% CI	M or Variance (*SE*)	95% CI	M or Variance (*SE*)	95% CI
Intercepts (Means)								
Remote	0.61 (0.16)***	[0.35, 0.87]	0.61 (0.16)***	[0.35, 0.87]	0.61 (0.16)***	[0.35, 0.87]	0.61 (0.16)***	[0.35, 0.87]
Hybrid	0.31 (0.15)*	[0.07, 0.55]	0.31 (0.15)*	[0.07, 0.55]	0.31 (0.15)*	[0.07, 0.55]	0.31 (0.15)*	[0.07, 0.55]
Teachers					4.44 (0.42)***	[3.75, 5.12]		
Classmates							4.16 (0.39)***	[3.51, 4.80]
Engagement	4.97 (0.32)***	[4.45, 5.49]	4.93 (0.33)***	[4.39, 5.46]				
Between-Student Residual Variance								
Remote	0.23 (0.01)***	[0.22, 0.24]	0.23 (0.01)***	[0.22, 0.24]	0.23 (0.01)***	[0.22, 0.24]	0.23 (0.01)***	[0.22, 0.24]
Hybrid	0.21 (0.01)***	[0.20, 0.22]	0.21 (0.01)***	[0.20, 0.22]	0.21 (0.01)***	[0.20, 0.22]	0.21 (0.01)***	[0.20, 0.22]
Teachers					1.08 (0.06)***	[0.98, 1.17]		
Classmates							0.99 (0.06)***	[0.89, 1.08]
Engagement	0.67 (0.04)***	[0.60, 0.73]	0.69 (0.04)***	[0.63, 0.76]				
Within-Student Residual Variance								
Teachers					0.62 (0.03)***	[0.58, 0.67]		
Classmates							0.70 (0.03)***	[0.65, 0.75]
Engagement	0.30 (0.02)***	[0.28, 0.33]	0.29 (0.02)***	[0.26, 0.32]				
Model Fit Statistics								
LL H0 (SCF)	−5024.84 (1.11)		−4544.72 (1.10)		−6551.11 (1.04)		−6767.19 (1.02)	
LL H1 (SCF)	−4713.76 (1.24)		−4233.64 (1.24)		−6240.03 (1.17)		−6456.11 (1.16)	
AIC	10111.68		9151.44		13164.22		13596.37	
BIC	10312.97		9352.73		13365.51		13797.66	
Chi-Square (df, SCF)	116.70 (1, 5.33)***		116.70 (1 5.34)***		116.72 (1, 5.33)***		116.72 (1, 5.33)***	

Note. Learning Modalities were dummy coded; In-Person = 0; Remote and Hybrid Learning Modalities = 1. Classmates = Connectedness to Classmates and Teachers = Connectedness to Teachers. Engagement = Same-Day Engagement in Models 1 and 3 and Next-Day Engagement in Models 2 and 4. Same-Day Engagement was run in a separate model from Next-Day Engagement with both on the same row labeled by column heading. SCF = Score Factor Correlation. All models included the following covariates: Time (group-mean centered) at the Within-Student Level. Gender, grade level, race, prior year GPA, and free/paid lunch at the Between-Student Level (see Supplementary Table 4 for covariate path results).
†$p < .10$, *$p < .05$, **$p < .01$, ***$p < .001$.

Prior-day academic engagement partially mediated the relationship between learning modality and connectedness to teachers and to classmates, yet the effect sizes in this alternative model were smaller than in our hypothesized models. Moreover, each student's daily engagement did not predict their connectedness to teachers or classmates the following day (see Supplementary Tables 7–9 and Supplementary Fig. 3).

Second, we ran two additional 2-1-1 mediated MSEM models, including an autoregressive path controlling for prior-day engagement; thus, engagement (Day t) predicted next-day engagement (Day t + 1) with students' sense of connectedness with teachers and classmates as mediators. While there is some prior concern about using autoregressive paths (Allison, 2015), they are appropriate when latent group mean centering the lagged outcome variable and allowing this autoregressive path to vary randomly within each student (Zhou et al., 2021). Our findings were similar for teacher and student connectedness mediating the relationship between learning modalities and engagement when we controlled for engagement the prior day, supporting the directional claims in our models (see Supplementary Tables 10–12).

4. Discussion

The COVID-19 pandemic led to dramatic, prolonged changes in adolescents' learning contexts, including shifts from in-person learning to remote and hybrid learning modalities. These shifts raised concerns about students' academic engagement in COVID-adapted learning modalities. Using intensive daily diary data with a national sample of adolescents over two consecutive weeks in fall 2020, we examined whether students' daily connectedness to their teachers and classmates mediated the link between their learning modalities and their same- and next-day engagement. Compared to other learning modalities, in-person learners reported the highest academic engagement and felt the most connected to classmates and teachers, while remote learners reported the lowest levels of academic engagement and connectedness to teachers and classmates. We also found that students' sense of connectedness with teachers partially explained the relationship between learning

Table 4
Direct effects and model fit of mediated MSEM: Learning modalities predicting same- and next-day engagement mediated by connectedness.

	Connectedness to Teachers as a Mediator				Connectedness to Classmates as a Mediator			
	Model 1		Model 2		Model 3		Model 4	
	Same-Day Engagement		Next-Day Engagement		Same-Day Engagement		Next-Day Engagement	
	b (*SE*)	95% CI	*b* (*SE*)	95% CI	*b* (*SE*)	95% CI	b (*SE*)	95% CI
Between-Student Direct Effects								
DV ➔ IV								
Remote ➔ Engagement	0.19 (0.08)*	[0.06, 0.31]	0.24 (0.08)***	[0.11, 0.37]	0.07 (0.10)	[-0.09, 0.23]	0.13 (0.10)	[-0.03, 0.29]
Hybrid ➔ Engagement	0.12 (0.08)	[-0.02, 0.26]	0.18 (0.08)*	[0.05, 0.32]	−0.03 (0.10)	[-0.20, 0.13]	0.03 (0.10)	[-0.14, 0.20]
DV ➔ M								
Remote ➔ Teachers	−0.98 (0.19)***	[-1.29, −0.68]	−0.98 (0.19)***	[-1.29, −0.68]				
Hybrid ➔ Teachers	−0.70 (0.19)***	[-1.02, −0.38]	−0.70 (0.20)***	[-1.02, −0.38]				
Remote ➔ Classmates					−0.91 (0.18)***	[-1.20, −0.62]	−0.91 (0.18)***	[-1.20, −0.62]
Hybrid ➔ Classmates					−0.53 (0.19)**	[-0.84, −0.22]	−0.53 (0.19)**	[-0.84, −0.22]
M ➔ IV								
Teachers ➔ Engagement	0.64 (0.02)***	[0.61, 0.68]	0.67 (0.02)***	[0.64, 0.71]				
Classmates ➔ Engagement					0.57 (0.03)***	[0.52, 0.62]	0.60 (0.03)***	[0.55, 0.64]
Within-Student Direct Effects								
M ➔ IV								
Teachers ➔ Engagement	0.30 (0.02)***	[0.27, 0.32]	0.03 (0.02)†	[0.00, 0.05]				
Classmates ➔ Engagement					0.26 (0.02)***	[0.23, 0.29]	0.03 (0.01)*	[0.01, 0.05]
Model Fit Statistics								
LL H0 (SCF)	−10296.20 (1.16)		−10197.10 (1.16)		−10660.44 (1.16)		−10510.53 (1.15)	
LL H1 (SCF)	−9985.12 (1.25)		−9886.02 (1.25)		−10349.36 (1.25)		−10199.45 (1.24)	
AIC	20684.39		20486.2		21412.88		21113.06	
BIC	20983.08		20784.88		21711.56		21411.75	
Chi-Square (df, SCF)	116.65 (1, 5.53)***		116.57 (1, 5.34)***		116.70 (1, 5.33)***		116.69 (1, 5.33)***	

Note. Learning Modalities were dummy coded; In-Person = 0; Remote and Hybrid Learning Modalities = 1. Classmates = Connectedness to Classmates and Teachers = Connectedness to Teachers. Engagement = Same-Day Engagement in Models 1 and 3 and Next-Day Engagement in Models 2 and 4. Same-Day Engagement was run in a separate model from Next-Day Engagement with both on the same row labeled by column heading. SCF = Score Factor Correlation. All models included the following covariates: Time (group-mean centered) at the Within-Student Level. Gender, grade level, race, prior year GPA, and free/paid lunch at the Between-Student Level (see Supplementary Table 5 for covariate path results).
† p < .10, *p < .05, **p < .01, ***p < .001.

Table 5
Between-student indirect effects of mediated MSEM: Learning modalities predicting same- and next-day engagement mediated by connectedness.

	Connectedness to Teachers as a Mediator				Connectedness to Classmates as a Mediator			
	Model 1 Same-Day Engagement		Model 2 Next-Day Engagement		Model 3 Same-Day Engagement		Model 4 Next-Day Engagement	
	b (*SE*)	95% CI	*b* (*SE*)	95% CI	*b* (*SE*)	95% CI	b (*SE*)	95% CI
Remote ➔ Teachers ➔ Engagement	−0.63 (0.12)***	−0.83, −0.43	−0.66 (0.13)***	−0.87, −0.45				
Hybrid ➔ Teachers ➔ Engagement	−0.45 (0.13)***	−0.66, −0.24	−0.47 (0.13)***	−0.69, −0.25				
Remote ➔ Classmates ➔ Engagement					−0.52 (0.10)***	−0.69, −0.35	−0.54 (0.11)***	−0.72, −0.37
Hybrid ➔ Classmates ➔ Engagement					−0.30 (0.11)**	−0.48, −0.12	−0.32 (0.11)**	−0.50, −0.13

Note. Learning Modalities were dummy coded; In-Person = 0; Remote and Hybrid Learning Modalities = 1. Classmates = Connectedness to Classmates and Teachers = Connectedness to Teachers. Engagement = Same-Day Engagement in Models 1 and 3 and Next-Day Engagement in Models 2 and 4. Same-Day Engagement was run in a separate model from Next-Day Engagement with both on the same row labeled by column heading. SCF = Score Factor Correlation. All models included the following covariates: Time (group-mean centered) at the Within-Student Level. Gender, grade level, race, prior year GPA, and free/paid lunch at the Between-Student Level (see Supplementary Table 5 for covariate path results).
†$p < .10$, *$p < .05$, **$p < .01$, ***$p < .001$.

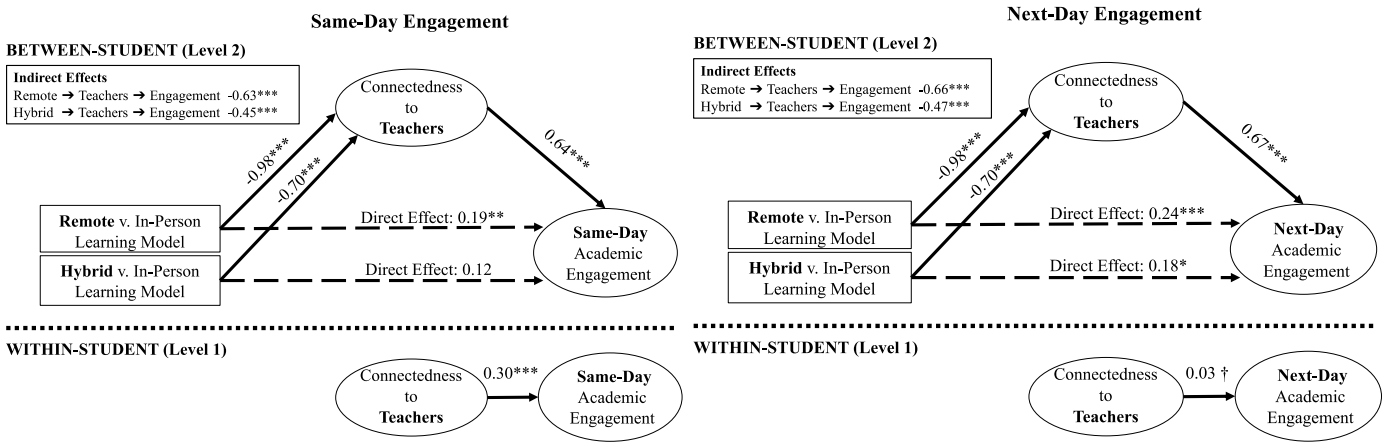

Fig. 2. Mediated MSEM: Connectedness to teachers as a mediator.

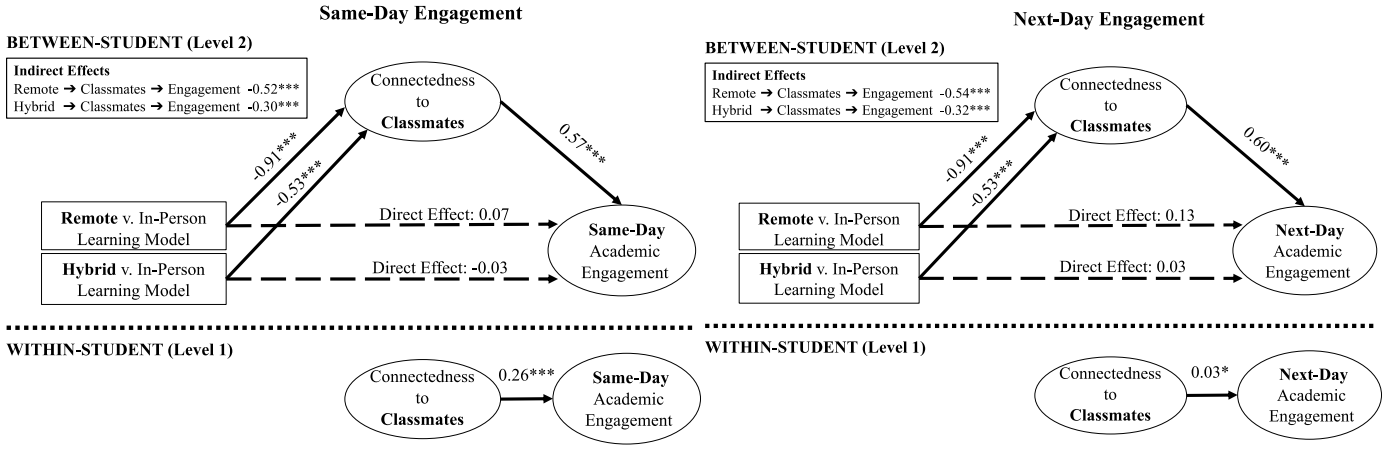

Fig. 3. Mediated MSEM: Connectedness to classmates as a mediator.

modalities and same- and next-day academic engagement, and sense of connectedness with peers fully explained this relationship.

Our results were consistent for same- and next-day engagement, as we found that connectedness to teachers and classmates predicted engagement assessed on the same day and the following school day. As expected, the links between connectedness and same-day engagement were stronger than the links between connectedness and next-day engagement. Nonetheless, both models demonstrated good statistical fit and our next-day engagement results paralleled our cross-sectional, same-day results.

Students' sense of connectedness to teachers and to classmates also mediated the paths between learning modalities and engagement measured cross-sectionally (same-day) and longitudinally (next-day). Our findings suggest that in-person learning supports adolescents' need for connectedness, which in turn bolsters their academic engagement as well as how COVID-adapted hybrid and remote learning might not have been implemented in ways that were conducive to fulfilling adolescents' need for connectedness. These findings provide some evidence that in-person learning supports adolescents' need for connectedness, which in turn bolsters their academic engagement. Moreover, COVID-adapted hybrid and remote learning might not have been implemented in ways that were as conducive for fulfilling adolescents' need for connectedness as COVID-adapted in-person learning.

4.1. Connectedness to teachers across learning modalities and as a mediator

Our findings align with extant literature suggesting that students' connectedness to teachers and sense of community are crucial for facilitating student engagement during times of crisis (Sonuga-Barke, 2021). Consistent with Skinner et al.'s (2008) Self-System Model of Motivational Development, COVID-adapted remote learning may have introduced new obstacles in instructors' and students' abilities to connect, as both students and instructors struggled to read each other's communication cues (Coker, 2020) and teachers have reported feeling psychological distance from their students when they are not in the same physical space (Baker et al., 2021; Kraft et al., 2021).

However, this does not mean that connectedness cannot be cultivated in hybrid and online learning contexts (Sonuga-Barke, 2021). Prior research suggests that remote instructors can increase social presence through certain teaching practices. For example, allowing students to share their opinions, asking students about aspects of their lives, or acknowledging students using their names at some time during each remote learning lesson are all recommended strategies that support students' sense of connectedness and their social presence in remote learning environments (Oh et al., 2018). In addition, when students receive timely, positive, and constructive feedback from classmates and teachers, students feel like their time and contributions are respected and their sense of connectedness increases (Sung & Mayer, 2012).

Another potential reason for the reduced connectedness in remote learning is that teachers are more likely to provide students with a sense of connectedness when they feel a sense of connectedness with other faculty and administration in their schools. Unfortunately, a majority of secondary teachers implementing COVID-adapted remote and hybrid learning modalities reported that they lacked the time, resources, and flexibility to facilitate practices needed to promote connectedness

(Coker, 2020). Teachers were also being given more responsibilities, including a push to support students' mental, emotional, and physical well-being (Hanno et al., 2022; Miller, 2021). U.S. teachers have reported feeling torn between devoting time to supporting students' socioemotional needs during the pandemic versus time to cover more content to mitigate potential "learning loss" (Baker et al., 2021; Dorn et al., 2020; Edmunds, 2020; Kraft et al., 2021). Administrators and policymakers can potentially increase students' sense of connectedness via enhancing teacher support. For example, teachers were more likely to maintain their sense of success and enjoyment of teaching following the onset of the pandemic when their schools had "strong communication, targeted training, meaningful collaboration, fair expectations, and authentic recognition" (Kraft et al., 2021, p. 1). To increase connectedness in any learning modality, and especially in remote modalities, teachers need time, resources, and flexibility to effectively implement strategies to support students' psychological and academic needs.

4.2. Connectedness to classmates across learning modalities and as a mediator

Our study highlights the importance of daily in-person interaction with classmates for adolescents' academic engagement in school (Ryan et al., 2019). When engaging in remote instruction, teachers can leverage online platforms in ways that offset students' lack of connectedness; however, there are few strategies to replace being in the same physical space as classmates, especially in K-12 settings. Our findings parallel prior work showing that distance learners experience a greater sense of isolation than in-person learners attending courses on campus (Abou-Khalil et al., 2021). As students often learn better when academic activities promote peer collaboration (Lin et al., 2015; Parr & Townsend, 2002), there have been barriers to peer collaboration in current remote and hybrid learning modalities, especially when teachers lack the training, tools, and time to create a proximal social presence in a digital space (Sung & Mayer, 2012).

In addition to teachers' role in promoting connectedness, research suggests students' interactions with one another can foster a sense of community and connectedness among classmates. Namely, prior work underscores the importance of students' relationships with their classmates in remote and hybrid learning modalities to foster social presence (Oh et al., 2018; Sung & Mayer, 2012). However, unlike interactions with teachers, which mainly develop within classrooms, a sense of connectedness with classmates is often developed in-between or outside of class time. Ellerbrock and Kiefer's (2013) research stressed that middle and high school students' interactions with peers at school but outside of their classrooms (e.g., lunch time, after school) is instrumental for students' sense of connectedness. COVID-adapted learning modalities may limit these interactions for all students, but mostly for remote learners.

According to Salmela-Aro and colleagues' (2021) study, students who were resilient to burnout in remote learning had better socio-emotional skills, and it was suggested that these students may be resourceful in fulfilling their need for connectedness. Student academic engagement may increase when teachers dedicate time to activities that develop emotional regulation and social skills (McKellar et al., 2020; Styck et al., 2021) and when students are provided mental health support to reduce stress and burnout (Haig-Ferguson et al., 2021). These strategies to support students' sense of connectedness to classmates may be particularly important in order to maintain student engagement during the ongoing global pandemic.

4.4. Remote and hybrid benefits

Notably, a sense of connectedness to teachers fully mediated the relationship between remote learning and student academic engagement, and the effect of connectedness was so strong that it facilitated a positive link between remote learning and engagement. Prior literature points to two possible reasons that could explain our findings. First, the accessibility and flexibility of remote learning may supplement engagement alongside connectedness (Ewing & Cooper, 2021). In Vidergor and Ben-Amram's (2020) study of hybrid learning, students were highly engaged when learning remotely because they had opportunities to select the appropriate rigor, to control the pace, and to solicit teacher support in their online daily instruction. Per Skinner's (2016) Self-System Model of Motivational Development, the autonomy and competence that students can gain from this type of remote learning experience may offset the potential disengagement from not interacting with their classmates daily in person.

Second, remote and hybrid learning modalities may be especially beneficial to enable students to attend class when there are extenuating circumstances, such as days students need to quarantine due to possible exposure to the virus. In our study, students in remote learning modalities reported being absent almost a day less on average than in-person learners, with hybrid attendance falling in-between. Despite our study only offering a rough indicator of attendance, prior research done with college students suggests that remote learning also supports greater accessibility, especially if there are transportation issues or care-giving responsibilities (Yelland et al., 2008). Future studies need to examine the link between learning modalities and attendance. The potential benefits of higher attendance in remote and hybrid learning modalities than in-person may offset the potential cost of students having a lower sense of connectedness in these modalities (Santibañez & Guarino, 2021).

4.4. Limitations and future directions

While the present study examined adolescent academic engagement using rigorous, daily diary methods in the context of the COVID-19 pandemic, there are several limitations worth noting. First, our students' connectedness and academic engagement measures were both collected from student reports. While our model supported the direction of our paths, there was some evidence that engagement also supports students' connectedness to teachers when comparing remote and in-person learning modalities. Future studies should investigate the reciprocal relationship between students' sense of connectedness to teachers and engagement across learning modalities.

Second, students' learning modality may have been related to various demographic and situational factors. However, we were unable to assess why some groups of students participated in a particular learning modality. For example, some students may live with family members with an elevated risk of contracting COVID-19, and efforts to keep family members safe may have been the reason for selecting a remote learning modality. When interpreting our findings, our inability to account for why adolescents participated in a particular learning modality needs to be considered and we cannot claim that student differences in engagement and connectedness are solely a function of learning modality. Relatedly, having access to a device and internet to complete the survey was necessary for a student to participate in our study. Thus, our findings can only be generalized to students who had electronic devices and internet in the fall of 2020.

Third, our study does not include measures on the classroom instructional quality or school characteristics. The lack of data on schools and classroom characteristics limits the conclusions we can make about the impact of learning modalities because the adoption or implementation of learning modalities in schools may be related to confounding predictors of engagement. There also may be considerable variation in how each learning modality is implemented, such that there may be a greater variation in student engagement and connectedness within than between each learning modality. Future studies need to assess instructional practices and school-wide supports that can influence students' engagement across COVID-adapted learning modalities. Along these lines, we assessed hybrid learning modalities at the between-student level, and understanding daily variance related to

learning modality for hybrid students would be an important future direction, namely the links between instructional strategies, learning modalities, and engagement.

Lastly, our study did not assess student engagement in specific subjects, and this limits our understanding of whether students reporting a sense of connectedness to teachers and classmates operated as mediators universally across different types of classrooms. It also limited the extent to which we can draw conclusions about the relationship between learning modalities and engagement in specific academic subjects. Understanding daily engagement by subject domains can provide a much more nuanced understanding of its potential antecedents and more specific ways to support student engagement (Patall et al., 2018; Wang et al., 2021).

4.5. Implications and conclusions

Overall, strategies that maximize connections between students and their teachers and classmates are essential for meeting students' needs for connectedness, and these connections facilitate students' active participation in the learning process. Our study provides evidence that COVID-adapted learning modalities and their implementation may play a role in students' daily sense of connection and engagement in learning, and we outline two potential implications.

First, students' academic engagement and sense of connectedness may be higher when teachers and students are in the same physical space, at least when adapting to the "new normal" of an ongoing pandemic. Given this, policymakers and administrators need to take action to make schools safer (e.g., improving ventilation systems and providing larger classrooms) to reduce the spread of airborne COVID-19 (Olsiewski et al., 2021, pp. 1–34; Trinidad, 2021). In addition, as the COVID-19 pandemic has persisted for over two years with new variants continually emerging, research and system-wide interventions need to target ways to improve connectedness in COVID-adapted hybrid and remote learning modalities. Promising prior research outlined several strategies to promote social presence and students' sense of connectedness. These strategies include systems that support flexibility in pacing to support student autonomy, ample time for teachers to provide students with one-on-one guidance, and additional resources for both synchronous (e.g., Zoom and consistent internet access) and asynchronous (e.g., Khan Academy) instruction (Baker et al., 2021; MacIntyre et al., 2020; Salmela-Aro et al., 2021; Sung & Mayer, 2012). Such efforts to promote students' connectedness in online learning may help ameliorate differences in students' academic engagement across learning modalities.

Despite most students' return to in-person learning, COVID-19 is still a public health threat. The relaxing of social distancing policies in the U. S. has also been linked to additional outbreaks and new variants (Tsai et al., 2021). For example, during the Omicron variant surge, many schools adopted remote and hybrid learning modalities again (Camera, 2022), or were likely subject to school-wide outbreaks (Belsha, 2022; Lessler et al., 2021). Moreover, even as most schools have returned to in-person classes and the Center for Disease Control has removed mask mandates (Safarpour et al., 2022), many aspects of remote and hybrid instruction are still being used, and the risk of further, more severe COVID-19 variants and spikes in cases looms (Candelli, 2022). Hence, it is critical to understand what supports adolescent students' sense of connectedness and academic engagement across learning modalities and during times of crisis.

Data availability statement

Data available on request due to privacy/ethical restrictions.

Declaration of interest statement

We have no conflicts of interest to disclose.

Funding sources

This research was supported by the National Science Foundation grant numbers 1920766 and 1561382 (PI: Dr. Ming-Te Wang). Funding sources had no such involvement in the collection, analysis and interpretation of data; in the writing of the report; and in the decision to submit the article for publication.

Acknowledgments

This research was supported by the National Science Foundation grant numbers 1920766 and 1561382 (PI: Dr. Ming-Te Wang) and by the Institute of Education Sciences, U.S. Department of Education, through Grant R305A220236 to the University of Pittsburgh. The opinions expressed are those of the authors and do not represent the views of the National Science Foundation, the Institute of Education Sciences, or the U.S. Department of Education. Funding sources had no such involvement in the collection, analysis, or interpretation of data; in the writing of the report; and in the decision to submit the article for publication.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.learninstruc.2022.101659.

References

Abou-Khalil, V., Helou, S., Khalifé, E., Chen, M. A., Majumdar, R., & Ogata, H. (2021). Emergency online learning in low-resource settings: Effective student engagement strategies. *Education Sciences, 11*(1), 24. https://doi.org/10.3390/educsci11010024

Allen, K.-A., Gray, D. L., Baumeister, R. F., & Leary, M. R. (2021). The need to belong: A deep dive into the origins, implications, and future of a foundational construct. *Educational Psychology Review*. https://doi.org/10.1007/s10648-021-09633-6

Ariens, S., Ceulemans, E., & Adolf, J. K. (2020). Time series analysis of intensive longitudinal data in psychosomatic research: A methodological overview. *Journal of Psychosomatic Research, 137*, Article 110191. https://doi.org/10.1016/j.jpsychores.2020.110191

Baker, C. N., Peele, H., Daniels, M., Saybe, M., Whalen, K., Overstreet, S., & The New Orleans Trauma-Informed Schools Learning Collaborative. (2021). The experience of COVID-19 and its impact on teachers' mental health, coping, and teaching. *School Psychology Review*, 1–14. https://doi.org/10.1080/2372966X.2020.1855473, 0(0).

Beal, D. J. (2015). ESM 2.0: State of the art and future potential of experience sampling methods in organizational research. *Annual Review of Organizational Psychology and Organizational Behavior, 2*(1), 383–407. https://doi.org/10.1146/annurev-orgpsych-032414-111335

Belsha, K. (2022). January 10). Schools already had a fragile grasp on stability. *Then omicron hit*. Chalkbeat https://www.chalkbeat.org/2022/1/10/22872988/omicron-covid-disruptions-stability-staff-shortages.

Bolger, N., & Laurenceau, J.-P. (2013). *Intensive longitudinal methods: An introduction to diary and experience sampling research*. The Guilford Press.

Bülow, M. W. (2022). Designing synchronous hybrid learning spaces: Challenges and opportunities. In E. Gil, Y. Mor, Y. Dimitriadis, & C. Köppe (Eds.), *Hybrid learning spaces* (pp. 135–163). Springer International Publishing. https://doi.org/10.1007/978-3-030-88520-5_9.

Camera, L. (2022). *January 10). Closures, pivots to virtual mount as Omicron overwhelms schools*. U.S. News & World Report. https://www.usnews.com/news/education-news/articles/2022-01-10/closures-pivots-to-virtual-mount-as-omicron-overwhelms-schools.

Candelli, M. (2022). COVID-19 vaccine: what are we doing and what should we do? *The Lancet Infectious Diseases, 22*(5), 569–570. https://doi.org/10.1016/S1473-3099(22)00003-2

Coker, D. (2020). The canary in the mine: Remote learning in the time of COVID-19. *Journal of Curriculum and Teaching, 9*(3), 76. https://doi.org/10.5430/jct.v9n3p76

Delahunty, J., Verenikina, I., & Jones, P. (2014). Socio-emotional connections: Identity, belonging and learning in online interactions. A literature review. *Technology, Pedagogy and Education, 23*(2), 243–265. https://doi.org/10.1080/1475939X.2013.813405

Dorn, E., Hancock, B., Sarakatsannis, J., & Viruleg, E. (2020). *COVID-19 and student learning in the United States: The hurt could last a lifetime*. McKinsey & Company (p. 9).

Duckworth, A. L., Kautz, T., Defnet, A., Satlof-Bedrick, E., Talamas, S., Lira, B., & Steinberg, L. (2021). *Students attending school remotely suffer socially, emotionally, and academically*. Educational Researcher, Article 0013189X211031551. https://doi.org/10.3102/0013189X211031551

Edmunds, W. J. (2020). Finding a path to reopen schools during the COVID-19 pandemic. *The Lancet Child & Adolescent Health, 4*(11), 796–797. https://doi.org/10.1016/S2352-4642(20)30249-2

Ellerbrock, C. R., & Kiefer, S. M. (2013). The interplay between adolescent needs and secondary school structures: Fostering developmentally responsive middle and high school environments across the transition. *High School Journal, 96*(3), 170–194.

Enders, C. K. (2001). A primer on maximum likelihood algorithms available for use with missing data. *Structural Equation Modeling, 8*(1), 128–141. https://doi.org/10.1207/S15328007SEM0801_7

Ewing, L.-A., & Cooper, H. B. (2021). Technology-enabled remote learning during COVID-19: Perspectives of Australian teachers, students and parents. *Technology, Pedagogy and Education*, 1–17. https://doi.org/10.1080/1475939X.2020.1868562, 0 (0.

Fitzpatrick, B. R., Berends, M., Ferrare, J. J., & Waddington, R. J. (2020). Virtual illusion: Comparing student achievement and teacher and classroom characteristics in online and brick-and-mortar charter schools. *Educational Researcher, 49*(3), 161–175. https://doi.org/10.3102/0013189X20909814

Fredricks, J. A., Wang, M.-T., Schall Linn, J., Hofkens, T. L., Sung, H., Parr, A., & Allerton, J. (2016). Using qualitative methods to develop a survey measure of math and science engagement. *Learning and Instruction, 43*, 5–15. https://doi.org/10.1016/j.learninstruc.2016.01.009

Gillen-O'Neel, C. (2021). Sense of belonging and student engagement: A daily study of first- and continuing-generation college students. *Research in Higher Education, 62*(1), 45–71. https://doi.org/10.1007/s11162-019-09570-y

Haig-Ferguson, A., Cooper, K., Cartwright, E., Loades, M. E., & Daniels, J. (2021). Practitioner review: Health anxiety in children and young people in the context of the COVID-19 pandemic. *Behavioural and Cognitive Psychotherapy, 49*(2), 129–143. https://doi.org/10.1017/S1352465820000636

Hanno, E. C., Fritz, L. S., Jones, S. M., & Lesaux, N. K. (2022). School learning format and children's behavioral health during the covid-19 pandemic. *JAMA Pediatrics*. https://doi.org/10.1001/jamapediatrics.2021.5698

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*, 1–43. https://doi.org/10.1080/19345747.2021.1938314, 0(0).

Lessler, J., Grabowski, M. K., Grantz, K. H., Badillo-Goicoechea, E., Metcalf, C. J. E., Lupton-Smith, C., Azman, A. S., & Stuart, E. A. (2021). Household COVID-19 risk and in-person schooling. *Science, 372*(6546), 1092–1097. https://doi.org/10.1126/science.abh2939

Lin, T.-J., Jadallah, M., Anderson, R. C., Baker, A. R., Nguyen-Jahiel, K., Kim, I.-H., Kuo, L.-J., Miller, B. W., Dong, T., & Wu, X. (2015). Less is more: Teachers' influence during peer collaboration. *Journal of Educational Psychology, 107*(2), 609–629. https://doi.org/10.1037/a0037758

Lüdtke, O., Marsh, H. W., Robitzsch, A., Trautwein, U., Asparouhov, T., & Muthén, B. (2008). The multilevel latent covariate model: A new, more reliable approach to group-level effects in contextual studies. *Psychological Methods, 13*(3), 203–229. https://doi.org/10.1037/a0012869

MacIntyre, P. D., Gregersen, T., & Mercer, S. (2020). Language teachers' coping strategies during the COVID-19 conversion to online teaching: Correlations with stress, wellbeing and negative emotions. *System, 94*, Article 102352. https://doi.org/10.1016/j.system.2020.102352

MacKinnon, D. P., Fairchild, A. J., & Fritz, M. S. (2007). Mediation analysis. *Annual Review of Psychology, 58*(1), 593–614. https://doi.org/10.1146/annurev.psych.58.110405.085542

Manwaring, K. C., Larsen, R., Graham, C. R., Henrie, C. R., & Halverson, L. R. (2017). Investigating student engagement in blended learning settings using experience sampling and structural equation modeling. *The Internet and Higher Education, 35*, 21–33. https://doi.org/10.1016/j.iheduc.2017.06.002

Mason, J. (2020). *September 24). This isn't what we meant by hybrid learning. We Are Teachers*. https://www.weareteachers.com/this-isnt-hybrid-learning/.

McKellar, S. E., Cortina, K. S., & Ryan, A. M. (2020). Teaching practices and student engagement in early adolescence: A longitudinal study using the Classroom Assessment Scoring System. *Teaching and Teacher Education, 89*. https://doi.org/10.1016/j.tate.2019.102936

Miller, K. E. (2021). A light in students' lives: K-12 teachers' experiences (re)building caring relationships during remote learning. *Online Learning, 25*(1), 115–134.

Miočević, M., O'Rourke, H. P., MacKinnon, D. P., & Brown, H. C. (2018). Statistical properties of four effect-size measures for mediation models. *Behavior Research Methods, 50*(1), 285–301. https://doi.org/10.3758/s13428-017-0870-1

Moore, M. G. (1993). Editorial: Is teaching like flying? A total systems view of distance education. *American Journal of Distance Education, 7*(1), 1–10. https://doi.org/10.1080/08923649309526806

Nezlek, J. B. (2001). Multilevel random coefficient analyses of event- and interval-contingent data in social and personality psychology research. *Personality and Social Psychology Bulletin, 27*(7), 771–785. https://doi.org/10.1177/0146167201277001

North, A. (2020). *October 19). Hybrid school might be the worst of both worlds. Vox*. https://www.vox.com/21515864/covid-hybrid-school-learning-remote-plan-pandemic.

Oh, C. S., Bailenson, J. N., & Welch, G. F. (2018). A systematic review of social presence: Definition, antecedents, and implications. *Frontiers in Robotics and AI, 5*, 1–35.

Olsiewski, P. J., Bruns, R., Gronvall, G. K., Bahnfleth, W. P., Mattson, G., Potter, C., & Vahey, R. A. (2021). *School ventilation: A vital tool to reduce covid-19 spread*. Johns Hopkins Center for Health Security. https://www.centerforhealthsecurity.org/our-work/publications/school-ventilation.

Parr, J. M., & Townsend, M. A. R. (2002). Environments, processes, and mechanisms in peer learning. *International Journal of Educational Research, 37*(5), 403–423. https://doi.org/10.1016/S0883-0355(03)00013-2

Patall, E. A., Steingut, R. R., Vasquez, A. C., Trimble, S. S., Pituch, K. A., & Freeman, J. L. (2018). Daily autonomy supporting or thwarting and students' motivation and engagement in the high school science classroom. *Journal of Educational Psychology, 110*(2), 269–288. https://doi.org/10.1037/edu0000214

Pituch, K. A., & Stapleton, L. M. (2008). The performance of methods to test upper-level mediation in the presence of nonnormal data. *Multivariate Behavioral Research, 43*(2), 237–267. https://doi.org/10.1080/00273170802034844

Preacher, K. J., Zyphur, M. J., & Zhang, Z. (2010). A general multilevel SEM framework for assessing multilevel mediation. *Psychological Methods, 15*(3), 209–233. https://doi.org/10.1037/a0020141

Qualtrics. (2022). Skip logic. *X.M. Support*. https://www.qualtrics.com/support/survey-platform/survey-module/question-options/skip-logic/.

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), 700–712. https://doi.org/10.1037/a0027268

Ryan, A. M., North, E. A., & Ferguson, S. (2019). Peers and engagement. In J. A. Fredricks, A. L. Reschly, & S. L. Christenson (Eds.), *Handbook of student engagement interventions* (pp. 73–85). Academic Press. https://doi.org/10.1016/B978-0-12-813413-9.00006-1.

Safarpour, A., Quintana, A., Lazer, D., Perlis, R., Baum, M., Ognyanova, K., Shere, A., Trujillo, K. L., Druckman, J., Santillana, M., Uslu, A., Green, J., Chwe, H., Pippert, C. H., Lin, J., & Qu, H. (2022). The COVID states project #78: American mask use and CDC guidance. *OSF Preprints*. https://doi.org/10.31219/osf.io/j53u2

Salmela-Aro, K., Upadyaya, K., Vinni-Laakso, J., & Hietajärvi, L. (2021). Adolescents' longitudinal school engagement and burnout before and during COVID-19—the role of socio-emotional skills. *Journal of Research on Adolescence, 31*(3), 796–807. https://doi.org/10.1111/jora.12654

Santibañez, L., & Guarino, C. M. (2021). The effects of absenteeism on academic and social-emotional outcomes: Lessons for COVID-19. *Educational Researcher, 50*(6), 392–400. https://doi.org/10.3102/0013189X21994488

Skinner, E. A. (2016). Engagement and disaffection as central to processes of motivational resilience and development. In K. R. Wentzel, & D. B. Miele (Eds.), *Handbook of motivation at school* (2nd ed.). Routledge.

Skinner, E. A., 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), 765–781. https://doi.org/10.1037/a0012840

Sofianidis, A., Meletiou-Mavrotheris, M., Konstantinou, P., Stylianidou, N., & Katzis, K. (2021). Let students talk about emergency remote teaching experience: Secondary students' perceptions on their experience during the COVID19 pandemic. *Education Sciences, 11*(6), 268. https://doi.org/10.3390/educsci11060268

Sonuga-Barke, E. J. S. (2021). School of hard knocks" – what can mental health researchers learn from the COVID-19 crisis? *Journal of Child Psychology and Psychiatry, 62*(1), 1–4. https://doi.org/10.1111/jcpp.13364

St-Amand, J., Smith, J., & Rasmy, A. (2021). Development and validation of a model predicting students' sense of school belonging and engagement as a function of school climate. *International Journal of Learning, Teaching and Educational Research, 20*(12). Article 12 http://www.ijlter.org/index.php/ijlter/article/view/4605.

Styck, K. M., Malecki, C. K., Ogg, J., & Demaray, M. K. (2021). Measuring COVID-19-related stress among 4th through 12th grade students. *School Psychology Review*, 1–16. https://doi.org/10.1080/2372966X.2020.1857658

Sung, E., & Mayer, R. E. (2012). Five facets of social presence in online distance education. *Computers in Human Behavior, 28*(5), 1738–1747. https://doi.org/10.1016/j.chb.2012.04.014

Trinidad, J. E. (2021). Equity, engagement, and health: School organisational issues and priorities during COVID-19. *Journal of Educational Administration & History, 53*(1), 67–80. https://doi.org/10.1080/00220620.2020.1858764

Tsai, A. C., Harling, G., Reynolds, Z., Gilbert, R. F., & Siedner, M. J. (2021). Coronavirus disease 2019 (COVID-19) transmission in the United States before versus after relaxation of statewide social distancing measures. *Clinical Infectious Diseases, 73* (Supplement_2), S120–S126. https://doi.org/10.1093/cid/ciaa1502

Tu, C.-H., & McIsaac, M. (2002). The relationship of social presence and interaction in online classes. *American Journal of Distance Education, 16*(3), 131–150. https://doi.org/10.1207/S15389286AJDE1603_2

Vidergor, H. E., & Ben-Amram, P. (2020). Khan academy effectiveness: The case of math secondary students' perceptions. *Computers & Education, 157*, Article 103985. https://doi.org/10.1016/j.compedu.2020.103985

Wang, M.-T., Fredricks, J., Ye, F., Hofkens, T., & Schall, J. L. (2017). Conceptualization and assessment of adolescents' engagement and disengagement in school: A multidimensional school engagement scale. *European Journal of Psychological Assessment, 35*(4), 592–606. https://doi.org/10.1027/1015-5759/a000431

Wang, M.-T., Binning, K. R., Toro, J. D., Qin, X., & Zepeda, C. D. (2021). Skill, thrill, and will: The role of metacognition, interest, and self-control in predicting student engagement in mathematics learning over time. *Child Development, 92*, 1369–1387. https://doi.org/10.1111/cdev.13531

Wang, M.-T., Fredricks, J. A., Ye, F., Hofkens, T. L., & Linn, J. S. (2016). The math and science engagement scales: Scale development, validation, and psychometric properties. *Learning and Instruction, 43*, 16–26. https://doi.org/10.1016/j.learninstruc.2016.01.008

Yelland, N., Tsembas, S., & Hall, L. E. (2008). E-learning: Issues of pedagogy and practice for the information age. In P. Kell, W. Vialle, D. Konza, & G. Vogl (Eds.), *Learning and the learner: Exploring learning for new times*. Wollongong, AU: University of Wollongong.