Online Supplement

**Supplement Table 1**

*Intraclass Correlations for All Study Variables*

|  |  |  |
| --- | --- | --- |
| **Variable** | **Classroom-Level ICC (percentage of variance)** | **Teacher-Level ICC**  **(percentage of variance)** |
| Outcomes |  |  |
| Participation | 0.007 (0.7%) | 0.033 (3.3%) |
| Math Self-Concept | 0.006 (0.6%) | 0.058 (5.8%) |
| Grades | 0.083 (8.3%) | 0.113 (11.3%) |
| Mediators |  |  |
| Self-efficacy | 0.017 (1.7%) | 0.062 (6.2%) |
| Belonging | 0.030 (3.0%) | 0.053 (5.3%) |
| Challenge | 0.033 (3.5%) | 0.011 (1.1%) |

*Note.* ICC = intraclass correlation. ICCs were calculated from a 3-level (students nested within classrooms nested within teachers) model. As depicted above, for all variables except challenge, teachers accounted for a greater proportion of outcome and mediator variance than did classrooms. Moreover, after accounting for nesting within teachers, classrooms accounted for a very small (~1%) and statistically non-significant amount of variance in two of our three outcome variables, and two of our three mediator variables. Therefore, we chose to fit 2-level random intercepts models with students (level 1) nested within teachers (level 2), controlling for school effects.

**Supplemental Table 2**

*Unstandardized Results of Mediation Models*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | ***A - No Lags*** | | ***B - With Lags*** | |
| **Fixed Effects** | Coefficient *(SE)* | *P* | Coefficient *(SE)* | *p* |
| *Outcomes* |  |  |  |  |
| Math grades T2*a* (intercept) | 81.773 (*0.858*) | < .001 | 81.858 (*0.871*) | < .001 |
| Math grades T1 | -- |  | 0.586 (*0.058*) | < .001 |
| Social relevance T1 (*c/c’* path) | -0.126 (*0.068*) | .064 | -0.084 (*0.041*) | .042 |
| Collab. learning envir. T1(*c/c’* path) | 0.367 (*0.129*) | .004 | 0.121 (*0.055*) | .028 |
| Belonging T2 (*b* path) | 0.044 (*0.060*) | .461 | 0.117 (*0.036*) | .001 |
| Self-efficacy T2 (*b* path) | 1.266 (*0.133*) | < .001 | 0.678 (*0.091*) | < .001 |
| Challenge T2 (*b* path) | 0.223 (*0.223*) | .316 | 0.220 (*0.168*) | .191 |
| Participation T2*a* (intercept) | 3.676 (*0.043*) | < .001 | 3.677 (*0.042*) | < .001 |
| Participation T1 | -- |  | 0.500 (*0.038*) | < .001 |
| Social relevance T1 (*c/c’* path) | 0.017 (*0.003*) | < .001 | -0.004 (*0.004*) | .323 |
| Collab. learning envir. T1 (*c/c’* path) | 0.025 (*0.006*) | < .001 | 0.004 (*0.005*) | .398 |
| Belonging T2 (*b* path) | 0.064 (*0.008*) | < .001 | 0.052 (*0.007*) | < .001 |
| Self-efficacy T2 (*b* path) | 0.057 (*0.006*) | < .001 | 0.031 (*0.005*) | < .001 |
| Challenge T2 (*b* path) | 0.063 (*0.015*) | < .001 | 0.059 (*0.012*) | < .001 |
| Math self-concept T2*a* (intercept) | 16.710 (*0.134*) | < .001 | 16.712 (*0.137*) | < .001 |
| Math self-concept T1 | -- |  | 0.463 (*0.025*) | < .001 |
| Social relevance T1 (*c/c’* path) | 0.051 (*0.017*) | .003 | -0.009 (*0.014*) | .535 |
| Collab. learning envir. T1 (*c/c’* path) | -0.004 (*0.016*) | .816 | -0.038 (*0.012*) | .001 |
| Belonging T2 (*b* path) | 0.057 (*0.021*) | .006 | 0.054 (*0.015*) | < .001 |
| Self-efficacy T2 (*b* path) | 0.257 *(0.017*) | < .001 | 0.190 *(0.016*) | < .001 |
| Challenge T2 (*b* path) | 0.112 (*0.049*) | .023 | 0.070 (*0.053*) | .188 |
| *Mediators* | -- |  |  |  |
| Belonging T2*a* (intercept) | -0.022 (*0.008*) | .004 | -0.025 (*0.007*) | .001 |
| Belonging T1 | -- |  | 0.393 (*0.019*) | < .001 |
| Social relevance T1 (*a* path) | 0.224 (*0.019*) | < .001 | 0.103 (*0.014*) | < .001 |
| Collab. learning envir. T1 (*a* path) | 0.112 (*0.039*) | .004 | 0.052 (*0.032*) | .105 |
| Self-efficacy T2*a* (intercept) | -0.058 (*0.018*) | .001 | -0.040 (*0.017*) | .019 |
| Self-efficacy T1 | -- |  | 0.518 (*0.024*) | < .001 |
| Social relevance T1 (*a* path) | 0.201 (*0.025*) | < .001 | 0.076 (*0.022*) | .001 |
| Collab. learning envir. T1(*a* path) | 0.001 (*0.045*) | .976 | -0.028 (*0.034*) | .403 |
| Challenge T2*a* (intercept) | -0.016 (*0.004*) | < .001 | -0.011 (*0.004*) | .002 |
| Challenge T1 | -- |  | 0.377 (*0.018*) | < .001 |
| Social relevance T1 (*a* path) | 0.066 (*0.008*) | < .001 | 0.034 (*0.008*) | < .001 |
| Collab. learning envir. T1 (*a* path) | 0.009 (*0.014*) | .503 | -0.008 (*0.010*) | .384 |
| *Note*. Column A shows coefficients from model without lagged controls, column B shows coefficients for models including lagged mediator and outcome variables *a* For the models including the lags, the meaning of T2 for each outcome is that outcome controlling for autoregressive effects of the prior timepoint’s measure. *c* path = the total effect of the relevant pedagogical characteristic on the relevant outcome; *c*’ path = the direct effect of the relevant pedagogical characteristic on the relevant outcome, controlling for the mediators; *b* path = the effect of the mediator on the relevant outcome, controlling for the other mediators and both predictor variables; *a* path = the effect of the relevant pedagogical characteristic on the relevant mediator, controlling for the effect of the other pedagogical characteristic. | | | | |

**Supplement Table 3**

*Unstandardized Results of the Race/Ethnicity Moderated Mediation Model*

|  |  |  |
| --- | --- | --- |
|  | ***A - No Lags*** | ***B - With Lags*** |
| **Fixed Effects** | **Coefficient (*SE*)** | **Coefficient (*SE*)** |
| Participation (intercept) | **3.72 (*0.03*)** | **3.72 (*0.04*)** |
| Social relevance (c’ path) | **0.02 (*0.007*)** | -0.003 (*0.004*) |
| Collaborative learning environment (c’ path) | **0.03 (*0.01*)** | 0.005 (*0.006*) |
| Belonging (b path) | **0.07 (*0.006*)** | **0.052 (*0.005*)** |
| Self-efficacy (b path) | **0.05 (*0.006*)** | **0.027 (*0.005*)** |
| Challenge (b path) | **0.07 (*0.02*)** | **0.066 (*0.014*)** |
| Race/ethnicity | -0.09 (*0.05*) | -0.065 (*0.050*) |
| Belonging by race/ethnicity | -0.003 (*0.018*) | 0.005 (*0.015*) |
| Self-efficacy by race/ethnicity | -0.003 (*0.011*) | 0.004 (*0.011*) |
| Challenge by race/ethnicity | -0.035 (*0.030*) | -0.032 (*0.032*) |
| Explicit math identification (intercept) | **16.61(*0.13*)** | **16.64(*0.14*)** |
| Social relevance (c/c’ path) | **0.045 (*0.015*)** | -0.017 (*0.013*) |
| Collaborative learning environment (c’ path) | 0.007 (*0.022*) | -0.033 (*0.019*) |
| Belonging (b path) | **0.050 (*0.025*)** | **0.046 (*0.018*)** |
| Self-efficacy (b path) | **0.279 (*0.019*)** | **0.210 (*0.018*)** |
| Challenge (b path) | **0.112 (*0.055*)** | 0.062 (*0.061*) |
| Race/ethnicity | 0.196 (*0.116*) | 0.061 (*0.095*) |
| Belonging by race/ethnicity | **0.108 (*0.025*)** | **0.103 (*0.019*)** |
| Self-efficacy by race/ethnicity | **-0.105 (*0.031*)** | **-0.097 (*0.020*)** |
| Challenge by race/ethnicity | -0.073 (*0.141*) | -0.039 (*0.112*) |
| Grades (intercept) | **81.72 (*1.02*)** | **81.38 (*0.99*)** |
| Social relevance (c’ path) | -0.108 (*0.071*) | -0.079 (*0.042*) |
| Collaborative learning environment (c’ path) | **0.373 (*0.148*)** | **0.150 (*0.052*)** |
| Belonging (b path) | -0.072 (*0.091*) | 0.034 (*0.051*) |
| Self-efficacy (b path) | **1.32 (*0.14*)** | **0.716 (*0.096*)** |
| Challenge (b path) | 0.31 (*0.25*) | 0.300 (*0.227*) |
| Race/ethnicity | **-2.92 (*0.70*)** | **-1.16 (*0.43*)** |
| Belonging by race/ethnicity | **0.496 (*0.165*)** | **0.319 (*0.165*)** |
| Self-efficacy by race/ethnicity | -0.184 (*0.180*) | -0.159 (*0.112*) |
| Challenge by race/ethnicity | -0.470 (*0.424*) | -0.242 (*0.359*) |
| Belonging (intercept) | 0.074 (*0.042*) | **0.063 (*0.028*)** |
| Social relevance (a path) | **0.205 (*0.029*)** | **0.087 (*0.024*)** |
| Collaborative learning environment (a path) | **0.129 (*0.045*)** | 0.069 (*0.040*) |
| Race/ethnicity | **-0.515 (*0.192*)** | **-0.459 (*0.142*)** |
| Social relevance by race ethnicity | 0.105 (*0.061*) | 0.098 (*0.056*) |
| Collaborative learning environment by race/ethnicity | -0.075 (*0.067*) | -0.062 (*0.054*) |
| Self-efficacy (intercept) | 0.072 (*0.059*) | 0.001 (*0.035*) |
| Social relevance (a path) | **0.184 (*0.034*)** | **0.063 (*0.026*)** |
| Collaborative learning environment (a path) | 0.022 (*0.056*) | -0.017 (*0.041*) |
| Race/ethnicity | **-0.692 (*0.257*)** | -0.234 (*0.149*) |
| Social relevance by race/ethnicity | 0.072 (*0.040*) | **0.057 (*0.028*)** |
| Collaborative learning environment by race/ethnicity | 0.003 (*0.140*) | <0.001 (*0.014*) |
| Challenge (intercept) | 0.004 (*0.014*) | 0.004 (*0.014*) |
| Social relevance (a path) | **0.064 (*0.010*)** | **0.032 (*0.009*)** |
| Collaborative learning environment (a path) | 0.016 (*0.019*) | -0.003 (*0.016*) |
| Race/ethnicity | -0.110 (*0.068*) | -0.061 (*0.068*) |
| Social relevance by race/ethnicity | **0.037 (*0.016*)** | **0.037 (*0.016*)** |
| Collaborative learning environment by race/ethnicity | -0.027 (*0.044*) | -0.020 (*0.047*) |

*Note.* Bold coefficients were statistically significant. Column A shows coefficients from model without lagged controls, column B shows coefficients for models including lagged mediator and outcome variables (lagged association values omitted from table due to lack of space - all were positive and statistically significant, see primary mediation model results in table above for lagged association magnitudes). Race/ethnicity coded such that URM = 1 and White = 0; *c* path = the total effect of the relevant pedagogical characteristic on the relevant outcome for White students; *c*’ path = the direct effect of the relevant pedagogical characteristic on the relevant outcome, controlling for the mediators, for White students; *b* path = the effect of the mediator on the relevant outcome, controlling for the other mediators and both predictor variables, for White students; *a* path = the effect of the relevant pedagogical characteristic on the relevant mediator, controlling for the effect of the other pedagogical characteristic, for White students.

**Supplemental Table 4**

*Unstandardized Results of the Gender Moderated Mediation Model*

|  |  |  |
| --- | --- | --- |
| **Fixed Effects** | **Coefficient (*SE*)** | ***p*** |
| Participation (intercept) | 3.76 (*0.08*) | < .001 |
| Social relevance (c’ path) | 0.016 (*0.003*) | < .001 |
| Collaborative learning environment (c’ path) | 0.024 (*0.006*) | < .001 |
| Belonging (b path) | 0.062 (*0.010*) | < .001 |
| Self-efficacy (b path) | 0.055 (*0.004*) | < .001 |
| Challenge (b path) | 0.089 (*0.017*) | < .001 |
| Gender | -0.104 (*0.067*) | .120 |
| Belonging by gender | 0.003 (*0.014*) | .807 |
| Self-efficacy by gender | 0.004 (*0.008*) | .638 |
| Challenge by gender | -0.034 (*0.030*) | .252 |
| Explicit math identification (intercept) | 16.13(*0.16*) | < .001 |
| Social relevance (c’ path) | 0.053 (*0.017*) | .002 |
| Collaborative learning environment (c’ path) | -0.009 (*0.014*) | .547 |
| Belonging (b path) | 0.078 (*0.037*) | .036 |
| Self-efficacy (b path) | 0.273 (*0.025*) | < .001 |
| Challenge (b path) | 0.229 (*0.139*) | .100 |
| Gender | 0.753 (*0.105*) | < .001 |
| Belonging by gender | -0.025 (*0.042*) | .542 |
| Self-efficacy by gender | -0.025 (*0.041*) | .545 |
| Challenge by gender | -0.131 (*0.160*) | .412 |
| Grades (intercept) | 79.20 (*0.97*) | < .001 |
| Social relevance (c’ path) | -0.112 (*0.071*) | .115 |
| Collaborative learning environment (c’ path) | 0.353 (*0.120*) | .003 |
| Belonging (b path) | 0.051 (*0.118*) | .667 |
| Self-efficacy (b path) | 1.322 (*0.246*) | < .001 |
| Challenge (b path) | 0.536 (*0.620*) | .387 |
| Gender | 3.430 (*0.120*) | < .001 |
| Belonging by gender | -0.003 (*0.176*) | .985 |
| Self-efficacy by gender | -0.068 (*0.268*) | .800 |
| Challenge by gender | -0.353 (*0.662*) | .594 |
| Belonging (intercept) | 0.364 (*0.164*) | .027 |
| Social relevance (a path) | 0.210 (*0.034*) | < .001 |
| Collaborative learning environment (a path) | 0.105 (*0.018*) | < .001 |
| Gender | -0.515 (*0.221*) | .019 |
| Social relevance by gender | 0.010 (*0.040*) | .813 |
| Collaborative learning environment by gender | 0.007 (*0.061*) | .909 |
| Self-efficacy (intercept) | 0.343 (*0.075*) | <.001 |
| Social relevance (a path) | 0.136 (*0.083*) | .102 |
| Collaborative learning environment (a path) | 0.030 (*0.073*) | .680 |
| Gender | -0.524 (*0.113*) | < .001 |
| Social relevance by gender | 0.073 (*0.092*) | .430 |
| Collaborative learning environment by gender | -0.049 (*0.113*) | .666 |
| Challenge (intercept) | 0.120 (*0.030*) | < .001 |
| Social relevance (a path) | 0.067 (*0.035*) | .055 |
| Collaborative learning environment (a path) | 0.010 (*0.018*) | .572 |
| Gender | -0.183 (*0.046*) | < .001 |
| Social relevance by gender | -0.005 (*0.041*) | .907 |
| Collaborative learning environment by gender | -0.001 (*0.025*) | .979 |

*Supplemental Table 4 Note.* Gender coded such that girls = 1 and boys = 0; *c*’ path = the direct effect of the relevant pedagogical characteristic on the relevant outcome, controlling for the mediators, for boys; *b* path = the effect of the mediator on the relevant outcome, controlling for the other mediators and both predictor variables, for boys; *a* path = the effect of the relevant pedagogical characteristic on the relevant mediator, controlling for the effect of the other pedagogical characteristic, for boys. Nonbinary gender individuals were excluded from analyses due to low sample size *n* = 31. Descriptive statistics for all study variables are available in the table below by gender identification.

**Supplemental Table 5**

*Descriptive Statistics of All Study Variables for Nonbinary and Cisgender Students*

|  |  |  |  |
| --- | --- | --- | --- |
|  | Non-Binary | Female | Male |
| Grades | 76.17 (11.05) | 80.95 (11.01) | 78.33 (11.71) |
| Participation | 3.10 (1.06) | 3.63 (1.04) | 3.69 (0.98) |
| Explicit Math Identification | 15.37 (4.24) | 16.84 (2.76) | 16.44 (3.08) |
| Belonging | 20.26 (5.64) | 23.39 (4.38) | 24.02 (4.23) |
| Self-Efficacy | 16.33 (6.06) | 18.64 (4.36) | 19.22 (4.04) |
| Challenge | 7.55 (2.01) | 12.25 (2.55) | 11.76 (2.83) |
| Social Relevance of Math | 10.29 (4.37) | 11.85 (4.04) | 12.08 (4.00) |
| Collaborative Learning Environment |  |  |  |
| *Note.* All variables reported as *M (SD)* | |  |  |