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Cognitive Variables, Classroom Behaviors, and a Participation Intervention on Students' Classroom Participation and Exam Performance

Daniel F. McCleary
and Brittany McCreary
Stephen F. Austin State University

Jeremy Coles
Columbus City Schools

We examined how predictive pre-course knowledge, critical thinking, attendance, course credit, and exam grades are of in-class participation. The association between exam performance and pre-course knowledge, critical thinking, participation, course credit, and attendance was also investigated. A two-level hierarchical linear model was used to examine these relationships in an undergraduate course. Students with higher critical thinking scores were more likely to participate when course credit was provided for participation than when no participation credit was available. Therefore, credit contingencies may more effectively raise participation levels of students with high critical thinking skills than students with low critical thinking skills.

Many college educators highly value student participation in class discussion (Bean & Peterson, 1998; Howard, James, & Taylor, 2002; Lai, 2012). Nonetheless, many students choose not to participate in class, even when credit is provided for participation (Aspiranti et al., 2013; Foster et al., 2009; Krohn et al., 2010; McCleary, et al., 2011; Taylor, Galyon, Forbes, Blondin, & Williams, 2014). Given the value attributed to participation, researchers have attempted to determine its importance by examining outcomes of participation (such as exam grades), quality of in-class discussion, and reasons why students choose to participate or not. In addition, some authors suggest that cognitive variables, such as pre-course knowledge and critical thinking, may play a role in the level of students' participation (Connor-Greene, 2005; Dixson, 1991; Fassinger, 1995a; Svinicki & McKeachie, 2014). Shyness, fear of social disapproval, lack of knowledge, or poorly defined ideas may be related to ongoing student reticence to participate, even when provided incentive (Connor-Greene, 2005; Fassinger, 1995b; Galyon, Blondin, Yaw, Nalls, & Williams, 2012; Mainkar, 2008; Weaver & Qi, 2005). Further, findings regarding the relationship between participation and exam performance suggest participation to be a weaker predictor of exam scores than both homework completion and critical thinking scores combined (Galyon, Blondin, Forbes, & Williams, 2013). Instead, pre-course knowledge and ACT scores were found to significantly predict exam scores in introductory psychology classes (Thompson & Zamboanga, 2004).

One persistent concern among college educators is providing incentive, such as credit, for student participation. Specifically, many college educators are reluctant to provide credit for student participation for fear that students will contribute comments that are off-topic, purposefully superficial, or a repetition of another student's previous comments. To explore this concern, Carstens, Wright, Coles, McCleary, and Williams (2013) implemented a participation evaluation system using self-monitoring feedback from college students, immediate feedback from instructors, and interrater data from external observers on the quality of student discussion comments per discussion session. In this study, students immediately recorded a brief summary of their comments in class, followed by a rating of comment quality, using daily report cards. In addition, instructors provided a summary of each student comment, as they occurred, along with feedback that indicated the quality of the contribution (using instructor feedback categories known to the students) and a written score. Data regarding the quality and frequency of comments was found to significantly predict exam performance. Furthermore, quality of comments was equivalent to the combination of both the quantity and quality of comments in predicting exam scores. These findings suggest that, when required to evaluate the quality of their own comments, students are unlikely to intentionally contribute extraneous comments merely to meet a perceived participation quota.

To increase the value of in-class participation, researchers examined various methods of reinforcement procedures. For example, Boniecki and Moore (2003) used token economies with backup rewards to heighten participation. Results showed that college students increased participation and responded more quickly under treatment conditions (1 s) than non-treatment conditions (6 s). Hodge and Nelson (1991) used differential reinforcement to balance participation across college students. Reticent students received check marks next to their name on the chalkboard when contributing or even attempting to contribute (e.g., raising hand) to class discussion, whereas dominating students received check marks next to their name when they did not participate, did not interrupt, or participated only when called upon. Although course credit was not contingent upon the check marking system, this system produced a more equitable distribution of comments among students. Aspiranti et al. (2013), Foster et al. (2009), Krohn et al. (2010), and McCleary et al. (2011) used course credit contingencies and self-monitoring to increase participation of reticent students and to reduce the frequency of comments made by dominating participants. In general, these researchers required college students to record the gist of their comment, and instructors gave either a stable or increasing number of participation points for up to two comments per 50 min class.

Many researchers have established the important roles of critical thinking, pre-course knowledge, and classroom participation in relation to exam grades. However, we could locate no study that simultaneously addressed all of these variables while also accounting for attendance and credit offered for participation. Furthermore, no identified articles examined the relationship between the presence of a participation credit contingency and pre-course knowledge or critical thinking. The relationship between these variables is an important area for investigation given the multitude of instructors who provide credit for participation. Knowing how credit contingencies affect students is important in course design and allocation of participation credit. If pre-course knowledge and pre-course critical thinking account for student's participation in a course, is it appropriate for instructors to continue to offer credit to the detriment of those with lower pre-course knowledge and critical thinking skills and does it perpetuate social injustice by awarding students with pre-existing skills and penalizing students who have not been provided the same affordances (i.e., the Matthew effect, in which the rich [high critical thinking] get richer and the poor [low critical thinking] get poorer [failure to earn participation points])?

Framework of the Study

The current study seeks to determine the extent to which pre-course knowledge, critical thinking, attendance, course credit, and exam grades predict participation in class discussion and the extent to which pre-course knowledge, critical thinking, participation, course credit, and attendance, predict exam performance. Assuming that most students contribute to class discussion when they regard themselves as well-informed, critical thinkers about the discussion topic, we predict that both critical thinking skills and pre-course knowledge will increase the likelihood of students commenting in class discussion. The underlying belief is that students often do not participate in class discussion because they lack information regarding course issues or have limited skills in analyzing issues related to that information. However, the authors expect pre-course knowledge to be the stronger of the two cognitive predictors, given its direct conceptual link to issues discussed in class. Because attendance is needed to partake in class discussion, we expect attendance to be predictive of class participation. Similarly, we hypothesize that the more course credit (i.e., points toward overall final grade) accrued, the more likely students will participate in class discussion. Next, we anticipate pre-course knowledge and critical thinking to predict exam performance, as demonstrated in previous studies; however, pre-course knowledge is expected to be more strongly related to exam performance than critical thinking scores. Course credit and attendance are also predictors of exam performance, as credit indicates both level of participation and refined knowledge.

Performance on course exams provide a practical extension of the participation prediction, as we intended to identify the impact of attendance and participation as they relate to an objective measure of course knowledge. If the cognitive variables significantly predict participation, then we expect these same factors will contribute to exam performance. In addition, participation, and accompanying incentives, should also contribute to exam performance. Lastly, while a student's participation in class discussion implies an active involvement in learning, the addition of the attendance predictor can capture passive learning (i.e., not directly observed) contingent on one's presence in the classroom. Furthermore, if there are other psychological factors that may have inhibited participation, modeling attendance and passive learning can better control for and capture these factors.

Method

Participants

This study initially included 167 participants from three sections of an undergraduate educational psychology course at a major Southeastern university. Students typically enroll in this course as part of a teacher preparation program. Ten of the students either declined to participate in the research project or unenrolled from the class during the semester; these students were not included in the study. Therefore, the final sample population included 157 students (n = 50 to 55 students in each section). Females comprised 77% (n = 121) of the sample. The academic standings of the students were as follows: first year, (n = 3); second year, (n = 65); third year, (n = 56); fourth year, (n = 22); fifth year, (n = 1); and unidentified, (n = 10).

Course Structure

The course consisted of five units in which students discussed various psychoeducational issues in

Table 1
Counterbalancing across Class Units

	Unit				
	1	2	3	4	5
Section A	Baseline	Treatment	Withdrawal	Treatment	Withdrawal
Section B	Baseline	Treatment	Withdrawal	Treatment	Withdrawal
Section C	Baseline	Baseline	Treatment	Withdrawal	Treatment

human development (i.e., physical, cognitive, social, psychological, and values). Each unit consisted of 1 video day (i.e., a video depicting various concepts related to the unit), 3 to 4 days of discussion, and 1 day to take the unit test. On discussion days, students were required to complete a specified set of questions over the required articles and to review instructor-prepared notes before coming to class; thus, students had the potential to be well-informed regarding the content to be targeted in class discussion.

Second-year graduate teaching assistants (GTAs) served as lead instructors in all three sections of the course and were under the guidance of the same advisor, who trained the GTAs in methods of leading a discussion (i.e., asking conceptual questions, summarizing the students' comments, and providing affirmative feedback). In two out of five total units, students received one point for their first comment and one additional point for their second comment. The units students received credit were counterbalanced across sections and were non-consecutive within sections (see Table 1).

Critical Thinking

Students completed the *Watson-Glaser Critical Thinking Appraisal-Form S* (WGCTA) at the beginning of the semester (Watson & Glaser, 1994). Form S, a short form of the WGCTA-Form A, has 40 items and is designed to provide a general critical thinking measure for adults. The distribution of students' WGCTA scores were compared to the most recent psychometric characteristics of the norming population working in education (Watson & Glaser, 2008) and to the distribution of scores provided by independent studies of education majors in the college setting (Gadzella, Stacks, Stephens, & Masten, 2005; Zascavage, Masten, Shroeder-Steward, & Nichols, 2007). Independent T-tests indicated no significant differences in the distribution compared to the samples ($p < 0.05$); furthermore, the current sample's distribution was consistent with the sample distributions from the two studies examining college education majors. Thus, there is no evidence that participants lacked motivation to complete the measure.

Pre-course Knowledge

Students also took a 50-item multiple-choice exam that contained 10 items from each of the five course units on the first or second day in class. The purpose of this exam was to determine each student's pre-course knowledge of material that would be presented in class. Presumably, students with greater knowledge of course content could better participate in class discussion from the beginning of the course. Students received bonus credit for completing the WGCTA and the pre-course knowledge measure (approximately 4% of course credit).

Participation Procedures

The method used to measure the number of comments made by each student was previously used in the Krohn et al. (2011) study. Students could earn a small amount of credit for their contribution to class discussion during four selected days of two credit units. During each of those days, students jotted down a brief summary of each comment they made in class, along with their name and date on blank 3 by 5 index cards. A comment could consist of a student response to a question raised by the instructor, a question posed to the instructor, an opinion related to course concepts, and rationale for agreement or disagreement with the content under discussion.

On one day in each unit, two GTAs from other sections of the course counted the number of comments that each student made. In addition to their presence on this one discussion day, the GTAs were present on the unit exam day. Consequently, they were in the classroom on 2 of 6 days in each unit, giving students sufficient opportunity to acclimate to their presence in the class. As noted in the Krohn et al. (2011) study, the agreement between the number of comments reported by students and independent raters in a similar database was .88.

Data Analysis Procedures

Hierarchical Linear Modeling (HLM) procedures were used for the analyses given that HLM allows for the variables to be nested within various structures (e.g., participants within a class section, measurements within each participant) and allows regression intercepts and slopes to randomly vary within these nested units that make up different levels of the model (Raudenbush & Bryk, 2002). Therefore, if participation and performance are impacted by the particular class section or the individuals themselves, then HLM allows for these effects to be modeled.

The research questions included in this study required two separate modeling procedures with average participation as the dependent variable of the first analysis and exam scores as the dependent variable of the second analysis. While these were two distinct analyses, the general modeling framework and procedures were similar. The procedures and notation of the models was consistent with those specified in Raudenbush and Bryk (2002) to better differentiate the variance components. The complete analyses of models used lme4 package in R.

The modeling procedures resulted in a two-level hierarchical linear model with nested and crossed modeling with both invariant and variant (by unit) variables. In particular, two of the variables (i.e., pre-course knowledge and critical thinking) were measured once at the beginning of the semester, and these were considered invariant, pre-course variables. In addition, attendance, participation, and exam scores were measured separately within each of the five units across all students. Therefore, these variables were considered variant and were nested within each student. Credit units were considered a binary treatment variable. Specifically, the three units in which credit was not given for participation were considered non-credit units (i.e., coded as a 0) while the two units in which credit was given for participation were considered credit units (i.e., coded as a 1). The units themselves were considered a random cross-effect, given that all students participated in all units and the units theoretically represent only a sample of an infinite population of possible units. This also provided a control for error across all units because each unit contains unique content and examinations.

The first model included only the within-student nested variable, which partitioned the variance between and within individuals while disregarding the impact of the unit crossed effect. The unit variable was then added next to partition the variance due to the unique content within each unit (i.e., to account for differences between unit content, interest, and difficulty level). This was considered the baseline, unconditional model, and the model fit of all subsequent models were compared to this unconditional model.

While the unconditional model includes the variance attributed to each unit, the within-student and between-student variations are the primary focus for subsequent comparisons. Specifically, the between-student variables refer to the variability that occurs across students as well as variables that are stable and invariant (e.g., pre-course knowledge). The within-student variation refers to the variability in the outcome variables that occur within each unit across the five units. This allows us to determine the impact of predictor variables that vary from unit to unit within each student (i.e., variant variables). Combined, this allows us to determine the overall effect of a predictor variable on an outcome across students, yet capture how changes in that variable can impact an individual's student outcome from unit to unit. For example, participation's impact on exam performance allows us to determine if an individual student's change in participation also corresponds to a change in exam performance.

After establishing the unconditional model with the two random effects, predictor variables were then entered sequentially, and the process was consistent across both modeling frameworks. The invariant variables were initially added to the models to establish the between-student effects. Next, the variant variables were added to establish the within-student effects; however, the variables of interest were unique to the two analyses. In particular, the credit contingency was tested in the participation modeling and the exam performance modeling, while average participation and attendance variables were exclusively tested in the exam performance modeling. Interactions with the variant and invariant variables were also tested sequentially.

Although multiple models were tested, we were primarily focused on three unique models. The first model is the unconditional model, because this serves as the baseline model of comparison. The next model includes only the invariant, pre-course variables (i.e., pre-course knowledge and critical thinking), given that this model can capture the predictive information between the students prior to class instruction. The final model is the best fitting model, after the within-student, variant predictors (i.e., attendance, participation, credit contingences), and interactions with the invariant predictors were tested. Only significant predictor variables and interactions were included in the final model.

Restricted Maximum Likelihood Estimation (RMLE) was used to determine model fit, because it provides the least biased estimation of variance components (Singer & Willet, 2003). RMLE was used for all other model comparisons and the estimation of coefficients and variance components. The denominator degrees of freedom and *t*-tests for the fixed, predictor variables were estimated using a Satterthwaite Approximation (Giesbrecht & Burns, 1985; Satterthwaite, 1941).

Results

Descriptive Statistics

Table 2 provides descriptive statistics of the invariant and variant variables. As presented in Table 2, attendance was relatively consistent across units,

Table 2
Descriptive Statistics of Unit Variables

Scale	*M*	*SD*	Range
Pre-course Knowledge	22.29	4.47	11-35
Critical Thinking	26.76	5.40	16-40
Attendance			
All Units	3.59	0.71	0-4
Unit A	3.73	0.62	0-4
Unit B	3.64	0.60	0-4
Unit C	3.65	0.61	2-4
Unit D	3.39	0.82	0-4
Unit E	3.54	0.81	0-4
Average Participation			
All Units	1.13	1.11	0-6.50
Unit A	1.25	0.96	0-4.50
Unit B	1.21	1.14	0-5.75
Unit C	1.12	1.09	0-6.33
Unit D	1.23	1.24	0-6.50
Unit E	0.85	1.09	0-5.00
Exam Scores			
All Units	39.63	5.41	21-49
Unit A	39.69	4.98	23-48
Unit B	37.25	6.11	22-48
Unit C	40.85	4.45	27-49
Unit D	40.11	5.45	24-49
Unit E	40.23	5.27	21-48

Table 3
Correlations of Variables

Variable	A.	B.	C.	D.	E.	F.
A. Pre-course Knowledge	1					
B. Critical thinking	0.46*	1				
C. Attendance	-0.04	-0.10*	1			
D. Average participation	0.25*	0.21*	0.13*	1		
E. Exam performance	0.37*	0.36*	0.08^	0.28*	1	
F. Credit	0.00	0.00	0.01	0.17*	-0.06	1

Note. * *Denotes p-values significant at the 0.01 level*
Note ^ *Denotes p-values significant at the 0.05 level*

ranging from a mean of 3.39 to 3.73. Although participation was relatively consistent across all five units (ranging from 0.85 to 1.25); Unit E had a noticeable decrease in participation levels. Exam performance was relatively consistent in four of the five units; however, scores were significantly lower in Unit B compared to the other four units. Mean exam scores across units ranged from 37.25 to 40.85.

Table 3 provides the correlation coefficients between pre-course knowledge, critical thinking, attendance, average participation, exam performance, and credit. As expected, pre-course knowledge and critical thinking had a moderate relationship with one another, r (155) = 0.46, $p < .01$. Therefore, these two invariant, pre-course variables share 21% of their variability with one another.

Participation Modeling

Table 4 presents the various participation models. The unconditional model (Model B) indicates that

Table 4
Predictive Models for Participation

Parameter	Model A	Model B	Model C	Model D	Model E	Model F
Fixed Effects						
Intercept	1.31* (0.08)	1.13* (0.11)	-0.26 (0.38)	-0.62 (0.44)	-0.81 (0.44)	-0.51 (0.45)
Pre-course Knowledge			0.06* (0.02)	0.05* (0.02)	0.05* (0.02)	0.05* (0.02)
Critical Thinking				0.03 (0.02)	0.03 (0.02)	0.01 (0.02)
Credit					0.48* (0.05)	-0.27 (0.21)
Critical Thinking X Credit						0.03* (0.01)
Random Effects						
Level-2						
Intercept	0.84 (0.92)	0.84 (0.92)	0.77 (0.88)	0.76 (0.87)	0.77 (0.88)	0.77 (0.88)
Unit		0.03 (0.16)	0.03 (0.16)	0.03 (0.16)	0.04 (0.20)	0.04 (0.20)
Level-1						
Residual	0.41 (0.64)	0.39 (0.62)	0.39 (0.62)	0.39 (0.62)	0.33 (0.20)	0.33 (0.57)
-2*log-likelihood	-	-938.8	-931.8	-930.5	-927.9	-883.6
Level-2 Pseudo R^2	-	-	8.7%	9.7%	8.4%	8.0%
Level-1 Pseudo R^2	-	-	0.0%	0.0%	14.1%	15.7%
Total Pseudo R^2	-	-	6.0%	6.7%	10.2%	10.6%

Model A-Fixed Intercept with Random Intercept
Model B-Fixed Intercept with Random Intercept and Random Unit
Model C-Fixed Pre-course knowledge added to Previous Model
Model D-Critical Thinking added to Previous Model
Model E-Credit Contingency added to Previous Model
Model F-Interaction of Critical Thinking with Credit Contingency added to Previous Model
* *Denotes p-values significant at the 0.05 level*
Note. Pseudo R^2 represents the percentage of variation accounted for compared to Model B
Note. Pseudo R^2 in parentheses represents the percentage of variation accounted for compared to Model B
Note. Negative Pseudo R^2 indicates an increase in variation compared to Model B

30.8% of the variance in participation can be attributed to within-student variability (σ^2 = 0.39) and 67.2% of the variance in participation can be attributed to between-student variability (τ_{00}= 0.84). When the pre-course knowledge and critical thinking variables were added to the model (Model D), the between-student variance (τ_{00}= 0.76) decreased by 9.7% from the unconditional model, although it did not impact the within-student variance.

The best fitting model (Model F) includes the significant interactions with the invariant variables (pre-course knowledge and critical thinking) and the credit contingency. In particular, pre-course knowledge was a significant predictor of participation, β = 0.05, $t(154)$ = 2.65, p < 0.01. Also, there was a significant interaction between critical thinking and the credit contingency, β = .03, $t(622)$ = 3.61, p < 0.001; however, the main effects of critical thinking, β = 0.01, $t(167)$ = 0.87, p = 0.38, and the credit contingency, β = -0.27, $t(624)$ = -1.25, p = 0.21, were not significant. These findings indicate that higher participation is associated with higher pre-course knowledge. Furthermore, the interaction between critical thinking and the credit contingency indicates that critical thinking increased one's level of participation when the credit contingency was present more significantly than in the absence of this contingency. Overall, compared to the unconditional model, this final model decreased the between-student variance (τ_{00}= 0.77) by 8.3% and the within-student variance (σ^2 = 0.33) by 15.7%. Across these two levels, this final model decreased the variability by 10.6%.

Exam Performance Modeling

Table 5 presents the various exam performance models. The unconditional model (Model B) indicates that 36.4% of the variance in exam performance can be attributed to within-student variability (σ^2 = 10.82), 57.4% of the variance in exam performance can be attributed to between-student variability (τ_{00} = 17.06), and the remaining 6.3% can be attributed to between-unit variability (τ_{00} = 1.86). When the pre-course knowledge and critical thinking variables were added to the model (Model D), the between-student variance (τ_{00} = 11.75) decreased by 31.1% from the unconditional model, although it did not impact the within-student variance.

Table 5

Predictive Models for Exam Performance

Parameter	Model A	Model B	Model C	Model D	Model E	Model F	Model G
Fixed Effects							
Intercept	39.63* (0.35)	39.63* (0.70)	29.54* (1.70)	26.04* (1.86)	23.77* (2.02)	24.34* (1.99)	24.58* (1.98)
Pre-course Knowledge			0.45* (0.07)	0.32* (0.08)	0.32* (0.07)	0.29* (0.07)	0.28* (0.07)
Critical Thinking				0.25* (0.06)	0.25* (0.06)	0.24* (0.06)	0.24* (0.06)
Attendance					0.58* (0.21)	0.52* (0.21)	0.55* (0.21)
Participation						0.57* (0.18)	0.71* (0.19)
Credit							-0.72* (0.29)
Random Effects							
Level-2							
Intercept	16.68 (4.09)	17.06 (4.13)	13.05 (3.61)	11.75 (3.43)	11.40 (3.38)	10.69 (3.27)	10.56 (3.25)
Unit		1.86 (1.36)	1.86 (1.36)	1.86 (1.36)	1.91 (1.38)	2.01 (1.42)	1.89 (1.38)
Level-1							
Residual	12.68 (3.56)	10.82 (3.29)	10.82 (3.29)	10.82 (3.29)	10.78 (3.28)	10.76 (3.28)	10.70 (3.27)
-2*log-likelihood	-	-2226.9	-2208.1	-2200.7	-2196.9	-2191.8	-2188.7
Level-2 Pseudo R^2	-	-	23.5%	31.1%	33.2%	37.3%	38.0%
Level-1 Pseudo R^2	-	-	0.0%	0.0%	0.4%	0.5%	1.1%
Total Pseudo R^2	-	-	14.4%	19.0%	20.4%	23.0%	23.6%

Model A-Fixed Intercept with Random Intercept
Model B-Fixed Intercept with Random Intercept and Random Unit
Model C-Fixed Pre-course Knowledge added to Previous Model
Model D-Critical Thinking added to Previous Model
Model E-Attendance added to Previous Model
Model F-Average Participation added to Previous Model
Model G-Credit Contingency added to Previous Model
* *Denotes p-values significant at the 0.01 level*
Note. Pseudo R^2 represents the percentage of variation accounted for compared to Model B
Note. Pseudo R^2 in parentheses represents the percentage of variation accounted for compared to Model B
Note. Negative Pseudo R^2 indicates an increase in variation compared to Model B

The best fitting model (Model G; Table 5) determined that pre-course knowledge, $\beta = 0.28$, $t(156) = 3.87$, $p < 0.01$, critical thinking, $\beta = 0.24$, $t(155) = 3.93$, $p < 0.01$, attendance, $\beta = 0.55$, $t(739) = 2.63$, $p < 0.01$, average participation, $\beta = 0.71$, $t(690) = 3.84$, $p < 0.01$, and the credit contingency, $\beta = -0.72$, $t(662) = -2.50$, $p < 0.05$, were all significant predictors of exam performance. Interactions between these variables were tested, but no significant interactions were present. These findings indicate that higher scores in pre-course knowledge, critical thinking, attendance, and average participation are associated with higher exam scores. Conversely, the presence of the credit contingency is associated with a decrease in exam performance. Overall, compared to the unconditional model, this final model decreased the between-student variance ($\tau_{00} = 10.59$) by 38% and the within-student variance ($\sigma^2 = 10.70$) by 1.1%. Across these two levels, this final model decreased the variability by 23.6%. In other words, 38% of exam performance, across all students, can be explained by pre-course knowledge, critical thinking, attendance, average participation, and the credit contingency.

Discussion

This study is both a replication and extension of the existing literature. Correlations between student performance variables and participation and exam performance were reaffirmed. The sequential ordering of the modeling, with invariant, between-student predictor variables added initially, provides unique information about participation and exam performance across students that was present prior to a single day of instruction. By adding the variant, within-student variables provide unique information about the impact of variables that change across the duration of a course with changes that are unique to each student.

Examining the predictive ability of student performance variables simultaneously provides a novel approach and allows for a more comprehensive understanding of the variance associated with participation and exam performance. In addition, the examination of the effect credit contingencies and critical thinking have on participation provides new insight into how and why students may elect to participate in class discussion.

Primary Participation Findings

One of the most interesting findings of the study, from our perspective, pertains to the credit contingency, which slightly increased between-student variance but decreased the within-student variance by 14%. On the surface, the former finding appears to contradict previous research demonstrating that credit contingencies balance classroom participation by increasing the participation of students unlikely to contribute and decreasing the participation of students who tend to dominate class discussion (Aspiranti et al., 2013; Foster et al., 2009; Krohn et al., 2010; McCleary, et al., 2011). However, it was also found that critical thinking increases participation when a credit contingency is in effect more than when no credit is offered (i.e., students high in critical thinking are more likely to participate when a credit contingency is present than students who have lower critical thinking scores). Thus, when considering both findings, it appears that the credit contingency is more effective at influencing students with higher critical thinking scores to participate more than they otherwise would and has little effect on students with low critical thinking scores. This is a variable not accounted for by previous researchers (e.g., Aspiranti et al., 2013; Foster et al., 2009; Krohn et al., 2010; McCleary, et al., 2011; Taylor et al., 2014). Therefore, while credit contingencies are effective at balancing the participation of the class, the offering of participation credit appears to only target students with higher critical thinking abilities. This interpretation is also supported by previous researchers who successfully balanced classroom participation via credit contingencies, but were still unable to effect change in the most reticent students (Aspiranti et al., 2013; Foster et al., 2009; Krohn et al., 2010; McCleary, et al., 2011). Confirmation also comes from the latter finding, which indicates that the credit contingency decreased within-student variability. The decrease in student variability suggests that the presence of the credit contingency may make students more consistent to themselves. For example, a student who does not want to talk in class will be more resolute in this position; however, a student who has something to say, but perhaps has difficulty timing the comment with the flow of the discussion, will make more of an effort to be heard when credit is offered.

As predicted, students with higher pre-course knowledge scores are more likely to participate in class discussion. A possible explanation for this relationship is that the more pre-course knowledge one has, the more likely one is able to retrieve past information and connect old information with new information (Wendling & Mather, 2009). Individuals who believe they have a strong basis for a comment may be more likely to make themselves vulnerable to a critique by participating in the class discussion.

Primary Exam Performance Findings

Pre-course knowledge and critical thinking decreased the between-student variability by 31% from the unconditional model, but they did not change the within-student variability. Both findings are expected, as both pre-course knowledge and critical thinking are unlikely to significantly change during the length of a semester (Williams, Oliver, Allin, Winn, & Booher, 2003).

Critical thinking, pre-course knowledge, attendance, average participation, and credit were all significant predictors of exam performance. Specifically, higher exam scores were associated with higher scores in critical thinking, pre-course knowledge, attendance, and average participation. Higher amounts of course participation credit received were associated with decreased exam scores, which is an unexpected finding that may be artificially induced by the design of the analysis itself. When interpreting this result, one must consider the previously discussed interaction of critical thinking, credit, and participation. As demonstrated, critical thinking was the variable influencing students to participate under the credit contingency. In this model, critical thinking is likely to have already accounted for the likelihood of the student to participate and consequently earn credit.

The final model with all significant variables decreased the variability by 24%. This is valuable information for instructors and program directors. Knowing that 24% of a students' exam grades are based on pre-course knowledge, critical thinking, attendance, average participation, and a credit contingency for participation, the instructor could more effectively design the course to target these variables and potentially raise exam grades. Although pre-course knowledge and critical thinking are unlikely to significantly change over the course of the semester, they are likely to significantly change throughout one's collegiate career. Therefore, pre-course knowledge and critical thinking are important variables to design for in one's course and the course sequence of a program. For example, ensuring a more advanced course has prerequisites that allow students to build on previously taught information while fostering in-depth student discussions can reinforce skills necessary to critically evaluate course concepts. Instructors with little control over course sequence may consider altering methods of demonstrating participation. For example, a participation grade may be based on a written reflection instead of an oral contribution during class. Additional options are to provide questions in advance of class so students can prepare responses to contribute orally in class; include more wait time for students to process questions, formulate coherent responses, and orally respond; allow participation credit to be earned during small group work; or require students to post discussion questions on the course website (e.g., Desire2Learn, Blackboard), which the instructor then addresses with the class as a whole.

Limitations and Future Directions

One of the major limitations of this study is the lack of a critical thinking post-test, which would have allowed for a more thorough understanding of the relationship among the cognitive variables, classroom behaviors, and outcome variables. Another limitation of the critical thinking test and pre-course knowledge assessment is that we were unable to monitor or determine how much effort students put into these measures. However, we were able to determine that the distribution of critical thinking scores was not significantly different from the norming population and other independent studies of students in college education courses. Therefore, we believe this provides tentative evidence that the critical thinking scores are consistent with scores that would be expected in a valid sample. Furthermore, as expected there was a moderate and significant correlation between critical thinking and pre-course knowledge. Therefore, we believe that this provides additional evidence for the validity of these estimates.

Other potential limitations to the generalizability of the results relate to the course size and design. Courses with a different focus and design should also be studied. Most of the research on critical thinking, participation, and exam performance has been conducted in discussion-based classes in which most of the discussion questions posed in class are provided prior to class. It would be interesting to identify how these results may change in a lecture-based course and in a discussion-based course that does not provide discussion questions before class. Similarly, future studies should examine potential differences between these variables in relation to the size of the class. The current study used classes which contained approximately 52 students. However, classes can range from less than ten students to several hundred. It is possible that a student who may be a dominant participant in a small class may be disinclined to participate in a larger class.

The design of the credit contingencies by unit with only three sections also provides a limitation. Specifically, with the limited number of sections, we were unable to test credit units in alternative sequences (i.e., successive units) to better determine the effects of the credit contingency and better account for error that was unique to the units in which they were offered. Although we controlled for a portion of the error by treating the units as a random crossed effect, we cannot completely ascertain the effects of uncontrolled error. This limitation may be most evident in the exam performance modeling, in that considerably more error was attributed to the unit effects. An auxiliary analysis of exam performance with score standardized by unit indicated that the coefficient remained negative but became non-significant.

Finally, the degree to which the credit contingency encourages students with high critical thinking to participate more frequently should be researched in regard to the amount of credit offered. It may be that a course offering more than approximately 4% of the total course grade for participation would be more enticing for students with lower critical thinking scores who seldom, or never, participate in discussion. Relatedly, more research is needed to ascertain the impact of personality factors that may contribute to one's willingness to participate, such as introversion, fear of negative feedback, low self-esteem, etc.

Conclusion

Students with higher critical thinking and pre-course knowledge are more likely to participate in class discussions. Furthermore, when an incentive to participate is offered, higher critical thinking is associated with higher participation than when no incentive is offered. In other words, the higher a student's critical thinking, the more likely that student is to respond to the incentive. How instructors or institutions choose to use this correlational information may vary. For example, some may view awarding of participation credit as a reprehensible social justice issue (i.e., the Matthew effect), whereas others may use this information as one method to identify students who may benefit from additional assistance. The other primary finding is that critical thinking, pre-course knowledge, participation, and attendance all contribute to exam performance, suggesting students may increase their attainment of knowledge through active (i.e., participation) and passive (i.e., attendance) learning. In sum, this study indicates the importance of examining participation both as an outcome and predictor of learning.

References

Aspiranti, K. B., McCleary, D. F., McCleary, L. N., Galyon, C. E., Blondin, C. A., Yaw, J. S., & Williams, R. L.

(2013). Student participation under random and delayed credit contingencies. *Journal on Excellence in College Teaching, 24*(2), 101-127.

Bean, J. C., & Peterson, D. (1998). Grading classroom participation. *New Directions for Teaching and Learning, 74,* 33-40. doi:10.1002/tl.7403

Boniecki, K. A., & Moore, S. (2003). Breaking the silence: Using a token economy to reinforce classroom participation. *Teaching of Psychology, 30,* 224-227. doi:10.1207/S15328023TOP3003_05

Carstens, B. A., Wright, J. M., Coles, J. T., McCleary, L. N., & Williams, R. L. (2013). The role of self-monitoring in assessing individual students' quantity and quality of comments in large-class discussion. *Journal on Excellence in College Teaching, 24,* 123-146

Connor-Greene, P. A. (2005). Fostering meaningful classroom discussion: Student-generated questions, quotations, and talking points. *Teaching of Psychology, 32,* 173-174.

Dixson, M. (1991, April). *Group discussion and individual critical thinking processes: An interactive perspective.* Paper presented at the annual meeting of the Central States Communication Association, Chicago, IL.

Fassinger, P. A. (1995a). Understanding classroom interaction: Students' and professors' contributions to students' silence. *Journal of Higher Education, 66,* 82-96. doi:10.2307/2943952

Fassinger, P. A. (1995b). Professors' and students' perception of why students participate in class. *Teaching Sociology, 24,* 25-33. doi:10.2307/1318895

Foster, L. N., Krohn, K. R., McCleary, D. F., Miller, K. B., Nalls, M. L., Quillivan, C. C., Williams, R. L. (2009). Increasing low-responding students' participation in class discussion. *Journal of Behavioral Education, 18,* 173-188. doi: 10.1007/s10864-009-9083-8

Galyon, C. E., Blondin, C. A., Forbes, B. A., & Williams, R. L. (2013). Does homework matter? A comparison of homework with established predictors of exam performance in large college classes. *Journal on Excellence in College Teaching, 24*, 77-105.

Galyon, C. E., Blondin, C. A., Yaw, J. S., Nalls, M. L., & Williams, R. L. (2012). The relationship of academic self-efficacy to class participation and exam performance. *Social Psychology of Education, 15,* 233-249. doi:10.1007/s11218-011-9175-x

Gadzella, B. M., Stacks, J., Stephens, R. C., & Masten, W. G. (2005). Watson-Glaser Critical Thinking Appraisal, Form-S for education majors. *Journal of Instructional Psychology, 32*(1), 9-12. doi:10.2466/pr0.92.3.1249-1254

Giesbrecht, F. G., & Burns, J. C. (1985). Two-stage analysis based on a mixed model: Large sample asymptotic theory and small-sample simulation results. *Biometrics, 41,* 853-862. doi:10.2307/2530872

Hodge, G. K., & Nelson, N. H. (1991). Demonstrating differential reinforcement by shaping classroom participation. *Teaching of Psychology, 18,* 239-241. doi:10.1207/s15328023top1804_13

Howard, J. R., James, G. H., III, & Taylor, D. R. (2002). The consolidation of responsibility in the mixed-aged college classroom. *Teaching Sociology, 30,* 214-234. doi:10.2307/3211384

Krohn, K. R., Aspiranti, K. B., Foster, L. N., McCleary, D. F., Taylor, C. M., Nalls, M. L., . . . & Williams, R. L. (2010). Effects of self-recording and contingent credit on balancing participation across students. *Journal of Behavioral Education, 19,* 134-155. doi:10.1007/s10864-010-9105-6

Krohn, K. R., Foster, L. N., McCleary, D. F., Aspiranti, K. B., Nalls, M. L., Quillivan, C. C., . . . & Williams, R. L. (2011). Reliability of students' self-recorded participation in class discussion. *Teaching of Psychology, 38,* 43-45. doi:10.1177/0098628310390846

Lai, K. (2012). Assessing participation skills: Online discussions with peers. *Assessment & Evaluation in Higher Education, 37,* 933-947. doi:10.1080/02602938.2011.590878

Mainkar, A. V. (2008). A student-empowered system for measuring and weighing participation in class discussion. *Journal of Management Education, 32,* 23-37. doi:10.1177/1052562906286912

McCleary, D. F., Aspiranti, K. B., Foster, L. N., Blondin, C. A., Galyon, C. E., Yaw, J. S., . . . & Williams, R. L. (2011). Balancing participation across students in large college classes via randomized participation credit. *Journal of General Education, 60*(3)*,* 194-214. doi:10.5325/jgeneeduc.60.3.0194

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods* (2nd ed.). Newbury Park, CA: Sage.

Satterthwaite, F. E. (1941). Synthesis of variance. *Psychometrika, 6,* 309-316. doi:10.1007/BF02288586

Singer, J. D., & Willet, J. B. (2003). *Applied longitudinal data analysis: Modeling change and event occurrence.* New York, NY: Oxford University Press.

Svinicki, M. D., & McKeachie, W. J. (2014). McKeachie's teaching tips: Strategies, research, and theory for college and university teachers (14th ed.). Belmont, CA: Wadsworth.

Taylor, C. M., Galyon, C. E., Forbes, B. E., Blondin, C. A., & Williams, R. L. (2014). Individual and group credit for class participation. *Teaching of Psychology, 41,* 148-154. doi:10.1177/0098628314530348

Thompson, R. A., & Zamboanga, B. L. (2004). Academic aptitude and prior knowledge as predictors of student achievement in introduction to psychology. *Journal of Educational Psychology, 96*, 778-784. doi:10.1037/0022-0663.96.4.778

Watson, G. B., & Glaser, E. M. (1994). *Watson-Glaser Critical Thinking Appraisal Form S manual.* San Antonio, TX: Harcourt Brace.

Watson, G., & Glaser, E. M. (2008) *Watson-Glaser Critical Thinking Appraisal Form Short, Manual.* Upper Saddle River, NJ: Psychological Corporation.

Wendling, B. J., & Mather, N. (2009). *Essentials of evidence-based academic interventions*. Hoboken, NJ: John Wiley & Sons, Inc.

Weaver, R. R., & Qi, J. (2005). Classroom organization and participation: College students' perceptions. *The Journal of Higher Education, 76,* 570-601. doi:10.1353/jhe.2005.0038

Williams, R. L., Oliver, R., Allin, J. L., Winn, B., & Booher, C. S. (2003). Knowledge and critical thinking as course predictors and outcomes. *Inquiry: Critical Thinking Across the Disciplines, 22,* 57-63. doi:10.5840/inquiryctnews200322422

Zascavage, V., Masten, W. G., Schroeder-Steward, J., & Nichols, C. (2007). Comparison of critical thinking in undergraduates and graduates in special education. *International Journal of Special Education, 22*(1), 25-31. Retrieved from https://files.eric.ed.gov/fulltext/EJ814465.pdf

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DANIEL F. MCCLEARY earned his PhD in school psychology from the University of Tennessee. He is an assistant professor at Stephen F. Austin State University (SFA). Dr. McCleary works in the M.A. and PhD school psychology programs within the Department of Human Services and co-directs the SFA Charter School Doctoral School Psychology Internship. His research interests are in the areas of the scholarship of teaching and learning and math fluency.

JEREMY T. COLES received his PhD in school psychology from the University of Tennessee. He is a school psychologist for the Columbus City Schools. In addition, Dr. Coles words for Executive Selection, which provides behavioral and personality evaluations. His research interests are in the areas of the scholarship of teaching and learning and assessment and measurement.

BRITTANY MCCREARY successfully defended her M.A. thesis in 2017 and is now pursuing a PhD in School Psychology at Stephen F. Austin State University. Her research interests include metaphor comprehension and generation, autism, emotional intelligence, verbal ability, and critical thinking.