# Results from a Cross-Sectional Structural Equation Model

# Assessing the Impact of Middle Grades Structures

Matthew Hesson-McInnis, Ph.D.
Psychology Department
Illinois State University
Normal, IL 61790
(309) 439-7266
mshesso@ilstu.edu

Carianne Bishop
CPRD, University of Illinois
510 Devonshire Drive
Champaign, IL 61820
(217) 333-3231
chbishop@uiuc.edu

Steven B. Mertens, Ph.D.
CPRD, University of Illinois
510 Devonshire Drive
Champaign, IL 61820
(217) 333-3231
mertens@uiuc.edu

Nancy Flowers
CPRD, University of Illinois
510 Devonshire Drive
Champaign, IL 61820
(217) 333-3231
nflowers@uiuc.edu

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Abstract

The last paper in the symposium will address the preliminary results of our analyses utilizing structural equation modeling to examine the inter-relationships between and among the following constructs: teaming structure/organization, quality of interdisciplinary team interactions, school contextual factors, and team and classroom practices on student outcomes.

Due to the nature of our data, varying levels of analyses have been identified and include team level, grade level, and school level. As described in other papers for this symposium, due to the large sample size, we were able to randomly assign schools to either a *model testing* group or a *model development* group, thus providing us with the ability to develop and refine models with one sub-sample and test it with another independent sample.

Our preliminary modeling work has focused on identifying the types of relationships that exist between the model constructs. Exogenous variables for these models include teaming structure/organization (team size, length of time teaming, and common planning time frequency and length), in addition to enrollment, numbers of teachers and students per team, and percentage of free/reduced-price lunch students (SES proxy). Thus far, our preliminary analyses have identified relatively strong relationships between the quality of interdisciplinary team interactions and team practices, which is also influenced by levels of teaming implementation. Additionally, we have identified models indicating significant relationships between team and classroom practices, as well as those between practices and positive school climate and student outcomes.

While our preliminary analyses have focused on concurrent relationships in the 2003 cross-sectional data, it is hoped that these analyses will help inform broader future model development to include the multiple years of data we have already collected.

Results from a Cross-Sectional Structural Equation Model

Assessing the Impact of Middle Grades Structure

Assessing the impact of the structure of middle grades schools on student outcomes is a necessarily complex endeavor. There are no simple measures or definitions of the relevant constructs, which are multidimensional and complex, resisting more straight forward attempts at operational definition. As a result, research in this area must reflect this complexity, suggesting multivariate analyses such as structural equation modeling to examine and account for variance and covariance rather than mean comparisons or a more descriptive examination of correlations.

The theoretical rationale for studying the relationships among school contextual factors, interdisciplinary teaming structures, team and classroom practices, and student outcomes (including socio-emotional, behavioral, and academic achievement outcomes) was put forth in an earlier paper in this symposium (Mertens, Flowers, Hesson-McInnis, & Bishop, 2007). That paper postulated a multi-level, multivariate model of the impact of middle grade structures, organizations, and practices on student outcomes.

The nature of the data collected and methods for processing that data prior to analysis is described in the second paper of this symposium (Bishop, Mertens, Flowers, & Hesson-McInnis, 2007). It is important to reiterate, however, that the extensive nature of the data set and large sample size (including more than 6,200 teachers in 235 middle-grade schools in Arkansas, Louisiana, Michigan, and Mississippi, with student data from roughly 100,000 students) allowed us to bifurcate the data, randomly assigning schools either to a *model development* sub-sample or a *model testing* sub-sample. Our nascent research to explore the structural relationships has not yet matured to the point where we can comfortably perform cross-validation studies, but it is important to remember that we will ultimately be able to cross-validate our findings in "uncontaminated" data.

The third paper in this symposium reported our findings from an examination of the factor structure of quality of interdisciplinary team interactions, school contextual factors, and student self-reported outcomes, finding good support for a higher-order factor structure (Flowers, Hesson-McInnis, Bishop, & Mertens, 2007).

## Method

The main purpose for data analysis in this paper is to identify and develop a structural equation model that accounts for the relationships among middle-grades structures, organizations, practices, and student outcomes. This initial structural equation modeling was constrained to examine only data from 2003 and only data measured at the same level of aggregation. Because we are using data from the *model development* sub-sample only, our strategy is to work with the data to build sequentially more complex models (starting initially with data at one point in time and at one level of aggregation and ending with multi-level, longitudinal models). By reserving the *model testing* sub-sample, we freely modified our initial model and made substantial changes. Although this process might be suspect on its own in terms of the potential for these changes to reflect random error rather than meaningful relationships, we will ultimately be able to cross-validate our final model with the holdout sample.

### *Data Analysis*

Structural equation modeling was selected as the primary method of data analysis for the ability to examine the simultaneous relationships operating between a number of latent constructs, each of which is measured with multiple measures (Bollen, 1989).  By using multiple measures of each construct, the effects of measurement error within any given, single measure can be mitigated. Further, the relationships emerging between the constructs in these analyses are describing the relationships between latent constructs independent of the measurement error (Bollen, 1989). The structural equation modeling is a natural extension of the factor analysis work we reported previously (Mertens, Flowers, Hesson-McInnis, & Bishop, 2006). In this paper, we established the ability of numerous manifest variables to serve as indicators of latent constructs, finding that the postulated constructs explain the common variance of the multiple observed measures. The next step, therefore, is to examine the directed relationships of the latent variables (i.e., factors) consistent with the theoretical model using structural equation modeling techniques.

Given the multi-level nature of our data, hierarchical linear modeling would seem a natural choice for an alternative to structural equation modeling, and these techniques may eventually be employed. An important hurdle to the implementation of hierarchical linear modeling, however, is the lack of a single hierarchy for the data: Students can be nested within schools and schools within states; teachers can be nested within schools and schools within states; but students cannot be nested within teachers within schools within states. After we come to an understanding of the relationships of middle grades structures to aggregated outcomes at a single level of analysis, we will endeavor to extend our understanding by the use of multi-level structural equation models or hierarchical linear modeling techniques.

*Model Modification*

Given that our data were extensive enough to warrant reserving a hold-out sample for eventual cross validation, we have the ability to evaluate the generalizability of our findings. Without such a hold-out sample, researchers would be prudent to avoid major modification of an initial model or need to restrict themselves to examining a finite number of models specified in advance of any analyses. With the hold-out sample, however, we can take a far more exploratory approach to modeling and make far more modifications to our initial model, having the ability to evaluate the degree to which a final model can be cross validated with independent data that were not examined previously.

The initial model, therefore, was modified in several ways. First, we considered relaxing the parameter constraints initially imposed (i.e., parameters initially constrained to be equal to zero), which amounts to adding parameters to the model. We also considered constraining freely estimated parameters (i.e., constraining them to be equal to zero, thus removing these parameters from the model). Several variables were sufficiently problematic and were removed from the model (i.e., literacy achievement was measured in radically different ways and at different grades across the schools, so much so that a consistent measure could not be constructed). In addition, the variables that measured student-to-staff ratios and that served as a proxy for socio-economic status (SES) were so consistently related to nearly all variables in the model. Rather than retain these atheoretical effects in the model, we residualized the data prior to analysis: Specifically, we used the student-staff-ratio and the SES proxy variables as predictors of all remaining manifest variables and then retained the residuals from this multiple regression as the new manifest variables. Thus, our final model describes the relationship of the study variables after the effects of student-staff ratios and SES have been removed.

## Results

The initial model was specified to mirror the conceptual model presented in Mertens et al. (2007). This model has four indicators for teaming structure, six indicators for school contextual factors, two indicators for the quality of team interactions, five indicators for team practices, nine indicators for classroom practices, six indicators for student social and emotional outcomes, and two indicators for student achievement (literacy and math). Teaming structure was modeled to effect school contextual factors, quality of team interactions, team practices, and classroom practices. School contextual factors and quality of team interactions each exhibited effects on team and classroom practices. Finally, team and classroom practices each affected the socio-emotional outcomes, which in turn were modeled to effect achievement. This model, however, exhibited very poor model fit (NNFI = .84; CFI = .85; RMSEA = .10; standardized RMR = .16, and $\chi^2$ [513, N = 124] = 1302.46). (Bentler, 1990; Bentler & Chou, 1987).

Modifications to this model were extensive and lengthy; as such, we cannot enumerate or detail each change. Figure 1 provides the final model for this stage of analysis, and this model represents several notable departures from the original model. First, the indicators for the teaming structure construct did not exhibit enough consistency in their covariance with other manifest variables for a single latent construct to explain these associations. Similarly, the indicators for the school contextual factors also failed to hold together as indicators for their respective latent factors. Thus, despite having some degree of association, these groups of manifest variables do not have enough consistency in their relationships to be explained by their corresponding latent variables. It would seem, then, that the teaming structure and school context constructs are multidimensional and complex constructs and that the corresponding indicators have unique explanatory effects that cannot be collected into the effects of a single latent variable.

Once the teaming structure construct was split into single-indicator constructs, the effects of SES (as measured by the proxy variable representing the proportion of students receiving a free or reduced price lunch) and the effects of the student-staff ratio were seen to be widespread. Rather than include a multitude of direct effects throughout the model for these two variables, we used multiple regression to remove the effects of these two variables on the remaining manifest variables. It is unsurprising that SES and student-staff ratios would have a direct impact to varying degrees on nearly all of the manifest variables, and including these specific effects does not advance our understanding of the theoretical issues. Additionally, only a small number of schools did not implement a team approach, so we eliminated those schools from the sample. Thus, the only remaining teaming structure indicator is the common planning time.

Similar to the dissolution of the teaming structure construct, the socio-emotional and achievement outcome constructs also devolved. Rather than a single, coherent socio-emotional construct, the individual indicators each had unique antecedents and consequences. It is interesting that the indicators for several constructs in our model did not hold up as coherent constructs in this model, given that previous research (Flowers, et al., 2007) found support for the constructs using confirmatory factor analyses. In those analyses, however, only a subset of variables were examined in any one model; when considering only the indicators for the construct, the indicators' relationships with each other were consistent enough for the factor models to fit; once additional variables were introduced, however, the relationships with these additional variables were inconsistent with the latent variable model previously supported.

The achievement data, however, were much more problematic. These data were enormously complex, with each state using different achievement measures and assessing achievement of different types in different grades, making comparisons quite difficult. The level of measurement also created a different type of problem:  Achievement is measured at the student level, but most of the other manifest variables in the model are measured at the teacher level. We can associate students with schools and with teams but not with individual teachers; the teachers can be associated with schools and teams but not with their students. Thus, to include the student achievement data, without progressing to multi-level modeling, would require us to aggregate all variables to the grade or school level. Doing so, however, removes important individual variation. We decided, therefore, to remove the achievement data for the time being, until our models are mature enough for multi-level modeling.

In one final set of changes, the team practices and classroom practices were combined into a single construct because the two constructs exhibited high correlations and because the indicators frequently yielded modification indices suggesting that they load on both factors. This modification to a single construct, however, is supported by the higher order confirmatory factor analyses of these items, specifically the high correlation (0.64) estimated between the higher-order team practices factor and the higher-order classroom practices factor (Mertens, Flowers, Hesson-McInnis, & Bishop, 2006).

The final model (Figure 1) demonstrated acceptable fit to the data: NNFI = .91; CFI = .92; RMSEA = .086; standardized RMR = .096, and $\chi^2$ (317, N = 222) = 826.98 (Bentler, 1990; Bentler & Chou, 1987). In this model, common planning time effects both team decision making and team and classroom practices. Team decision making, in turn, effects the quality of interdisciplinary team interactions, the work climate (which in turn also effects the quality of interdisciplinary team interactions), and teacher efficacy. Teacher efficacy has a negative effect on disruptive classroom climate but a strong, positive effect on positive classroom climate. Because the disruptive classroom climate also has a negative effect on the positive classroom climate, teacher efficacy also has an indirect, positive effect on positive classroom climate as mediated by the reduction in disruptive classroom climate. Teacher efficacy also has a direct effect on the team and classroom practices. With the exception of the effect of positive classroom climate on the students' sense of belonging, the effects of the teaming and contextual variables on the socio-emotional outcomes are indirect and transmitted by the effects of team and classroom practices, which have a direct effect on positive school climate in the model. Positive school climate, in turn, has strong, positive effects on the student sense of belonging and on student academic efficacy. Belonging, in turn, had a positive effect on academic efficacy but a strong, negative effect on the student ratings of negative school climate. Negative school climate ratings had a strong, positive effect on delinquency behaviors, but academic efficacy had a strong, negative effect on delinquency.

## Discussion

The structural equation modeling resulted in an interpretable model with team and classroom practices representing the central construct; the various team structure and context variables serve as antecedents predicting these practices, and the practices in turn explain the student socio-emotional outcomes. Common planning time and team decision making emerge as important variables in that they result in productive work climates, higher teacher efficacy and in better team and classroom practices. When these practices are in evidence, students report more positive school climates and a stronger sense of belonging, supporting their academic efficacy, protecting against negative school climate, and reducing delinquency. It was interesting that manifest variables that were highly correlated enough to support the adoption of confirmatory factor analysis models when only those variables were considered, did not have consistent correlations with the measures of other constructs for these factors to persist in the current structural equation modeling analyses. It would seem that although the latent factors for teaming structure and organization can explain the associations of their indicators in isolation, these factors were complex and multidimensional: the effects of individual measures were too unique to be summarized by directed effects of the factors.

*Limitations*

These findings must be viewed as preliminary because there were so many departures from the initial theoretical model. Further, we have not cross-validated the findings to eliminate the possibility that these changes reflect random error only, but we have not finished exploring the data in the *model development* sub-sample yet, and cross-validation at this stage would be premature. Essentially, we need to wait until there are no further contingent decisions to be made prior to cross-validation so that the degree of cross-validation support of this model does not influence model modification decisions as we extend this model longitudinally and to multiple levels of measurement.

One of the major limitations of these analyses was the inability to link the quantitative survey data to the student achievement data. We encountered several problems in attempting to utilize the student achievement data in our multivariate modeling. These included the inability to directly link the student survey data to their achievement data. First, the achievement data we obtained from the various state departments of education had no individual student identifiers, making it impossible to link the data. Second, our study sample included four states, each of which administered a different state assessment. Third, the various state assessments tested students in different subjects across varying grade levels, so it was virtually impossible to garner a large enough sample within a state to conduct the analyses. These limitations were critical in our ability to link the survey data to the achievement data. In the future, these limitations should be acknowledged and considered more fully in the methodological design.

*Future Directions*

As mentioned above, our next steps are to develop multi-level models in which the various levels of measurement of the students within teams within schools within states hierarchy are modeled explicitly and to develop longitudinal models that account for changes in the data over time. Once these models have been developed and then integrated into a single longitudinal, multi-level model, we will then cross-validate this model with the *model testing* sub-sample.

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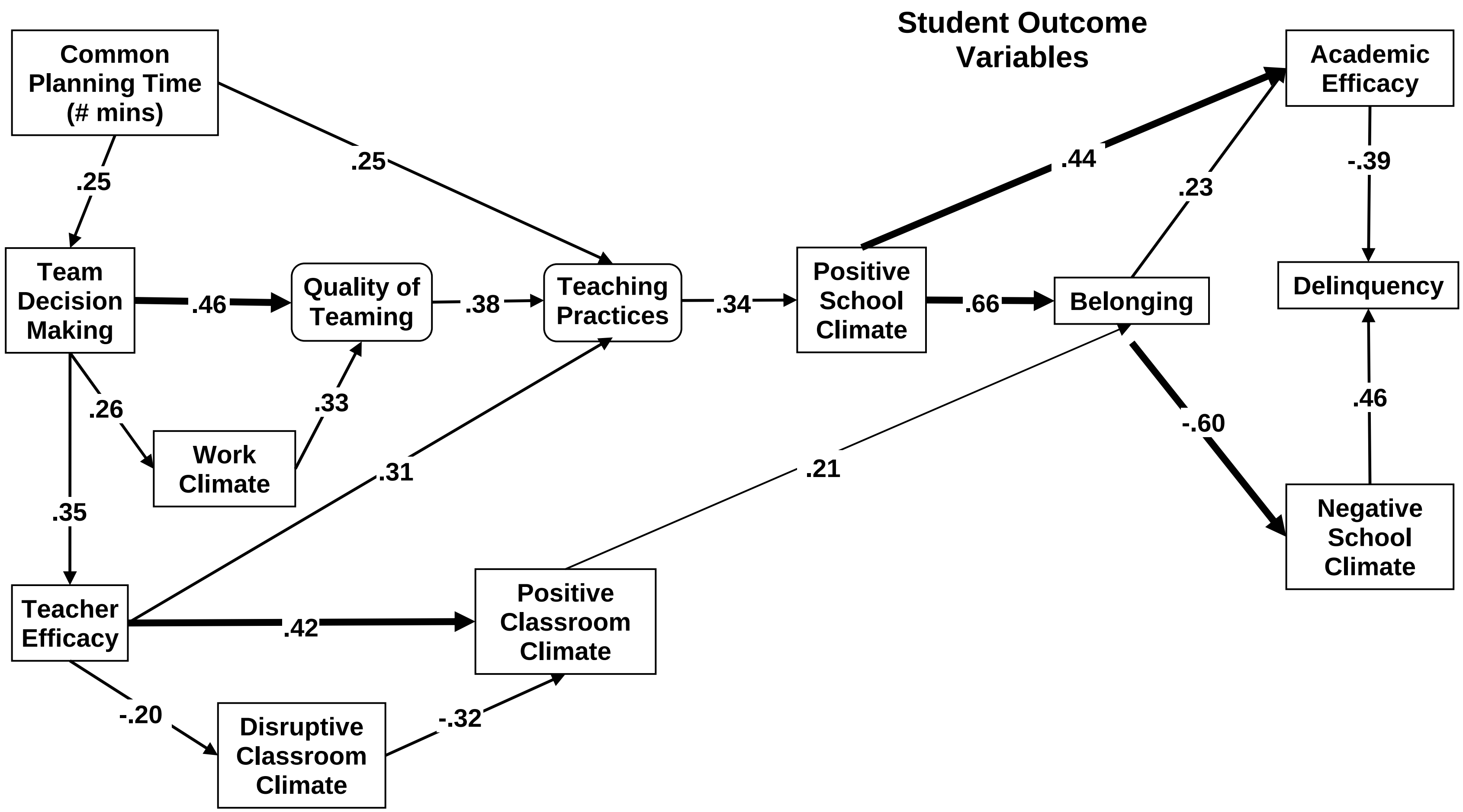
Figure 1. Structural equation model depicting relationships between common planning time, school contextual factors, teaching practices, and student socio-emotional outcomes




All variables based on residuals of SESPROXY and SSRATIO