Do Principal Preparation and Teacher Qualifications Influence Different Types of School Growth Trajectories in Illinois?A Growth Mixture Model Analysis[1]

Alex J. Bowers[2] & Bradford R. White
Teachers College, Columbia University & Illinois Education Research Council

ABSTRACT

Purpose – The purpose of this study was to examine the independent effects of principal background, training and experience as well as teacher academic qualifications on school proficiency growth through time.

Design - We analyzed the entire population of all elementary and middle schools in the state of Illinois, n=3,154 schools, from 2000-2001 through 2005-2006 using growth mixture modeling. We examined growth at the school level in the percentage of students meeting or exceeding standards on the Illinois Standard Achievement Test (ISAT), analyzing separate models for Chicago and non-Chicago schools.

Findings - Our results suggest that there are two statistically significantly different latent school proficiency trajectory subgroups through the six-year time period, one high and one low, for both Chicago and non-Chicago schools. In addition, our models suggest that teacher academic qualifications, principal training, principal experience as a principal and an assistant principal, and experience of the principal as a teacher previously in their schools are significantly related to school proficiency growth over time, dependent upon school context.

Implications – Recent studies on the independent effects of principal experience, training and teacher academic qualifications have shown inconsistent results on school achievement growth. We demonstrate that principal training and background may have an effect on school-level proficiency score growth.

Originality – This study is one of the first to examine statistically different proficiency growth trajectories using an entire state-wide dataset over a long-term, six-year timeframe.

Keywords: School leadership, educational administration, school administration, administrator effectiveness, administrator qualifications, principal preparation, principal experience, school proficiency, standardized test scores, growth mixture modeling, teacher qualifications, assistant principal, value added.

INTRODUCTION

The purpose of this study is to examine the extent to which principal preparation and professional experience and teacher qualifications affect different types of school growth trajectories, using a dataset containing all public elementary and middle schools in Illinois from 2000-2001 through 2005-2006. A growing body of recent research has begun to focus on the extent to which principals influence student achievement. However, much of this research domain has had to acknowledge the long history of problems with examining direct effects models of principal impact on achievement (Hallinger & Heck, 1996, 2011a, 2011b). Recent studies have shifted to examining principal effects on student growth in achievement over time, as well as principal effects on teacher professional development, job satisfaction, hiring, retention and academic climate (Beteille, Kalogrides, & Loeb, 2009; Boyd et al., 2011; Brewer, 1993; Grissom & Loeb, 2011; Horng, Klasik, & Loeb, 2010; Kenneth Leithwood & Jantzi, 2008; Kenneth Leithwood, Patten, & Jantzi, 2010; Printy, Marks, & Bowers, 2009; Shen, Leslie, Spybrook, & Ma, 2012; Urick & Bowers, 2011, 2014, 2014; White & Bowers, 2011). Nevertheless, all of the studies to date have viewed these significant variables associated with schools and student achievement gains as having consistent effects across all schools. This has resulted in statistical models that fit all schools and school gains over time to single trajectories, and subsequently examining the associated influence of variables of interest on the fitted trajectory. Fitting all schools to a single best fit line, such as through OLS or HLM regression, ignores the point that there may be different types of schools that react in different ways to the same variables, dependent upon context and the organization. Thus, there may be different types of trajectories of school growth in achievement through time that vary in significantly different ways (Hallinger & Heck, 2011b).

In the present study, we hypothesize that principal preparation, principal professional experience and teacher qualifications may influence different school growth trajectories. Recently, Growth Mixture Modeling (GMM) has emerged from the larger mixture and structural equation modeling literature as an attractive means to empirically identify statistically different subgroups of trajectories from within a broader population, controlling for known covariates, background, and context variables (Duncan, Duncan, & Strycker, 2006; Jung & Wickrama, 2008; B. O. Muthén, 2004; Petras & Masyn, 2010; Shiyko, Li, & Rindskopf, 2012). Also known as Latent Change Analysis (Hallinger & Heck, 2011b), GMM uses a structural equation modeling framework to test whether there are significantly different growth trajectory subgroups and how different variables impact the rate of growth through time. Thus, GMM provides an attractive means to examine the extent to which principal preparation, professional experiences and teacher qualifications influence different types of school achievement growth. In the present study, we identify

---

[1] This document is a pre-print of this manuscript, published in the *Journal of Educational Administration*. Recommended Citation: Bowers, A.J., White, B.R. (2014) Do Principal Preparation and Teacher Qualifications Influence Different Types of School Growth Trajectories in Illinois? A Growth Mixture Model Analysis. *Journal of Educational Administration*. 52(5) p.705-736. http://doi.org/10.1108/JEA-12-2012-0134
[2] Teachers College, Columbia University; Bowers@tc.edu; 525 W. 120th Street, New York, New York 10027.
ORCID: 0000-0002-5140-6428, ResearcherID: C-1557-2013
Note: This document was last updated on July 21, 2014

principal experience and background factors that are most associated with trajectories of school proficiency on state standardized test scores through examining six years of data, from academic years 2000-2001 through 2005-2006, for the entire population of elementary and middle schools in Illinois. We find that principal background variables (such as principal age and ethnicity) are unrelated to growth in school proficiency but that principal experience as a principal as well as experience as an assistant principal, and experience as a teacher at the same school in which they became the principal were significantly related to school achievement growth.

LITERATURE & BACKGROUND:

> *In a complex, dynamic, and internationally conscious world, a search for general patterns of change requires even more focus on temporal and spatial context* (Pettigrew, Woodman, & Cameron, 2001) (p. 697).

As the central leader of a school, the principal has long been identified as having a strong role in the effectiveness of the instruction provided within a school (Bryk, Sebring, Allensworth, Luppescu, & Easton, 2010). Evolving from conceptions of good management practices and effective schools research (Edmonds, 1979; Kenneth Leithwood, 1994), instructional leadership has emerged as the means through which principals can best lead instructional improvement throughout their schools (Hallinger, 2005; Hallinger & Murphy, 1985; Marks & Printy, 2003; Robinson, Lloyd, & Rowe, 2008; Urick & Bowers, 2014). Through instructional leadership, principals manage the organization, coordinate the core instructional program of the school through setting a vision and mission, focus on aligned and high quality teacher professional development, work to build community, and distribute leadership with teachers (Hallinger & Heck, 2002; Heck & Hallinger, 2009; Neumerski, 2013; Price, 2012). Throughout this literature, findings have consistently demonstrated that organizational management focused on curricular and instructional improvement is a central component of instructional leadership (Grissom & Loeb, 2011; Kenneth Leithwood, et al., 2010; Thoonen, Sleegers, Oort, Peetsma, & Geijsel, 2011). However, how principals gain the skills that they need to lead organizational improvement, and which principal skills and experiences are most related to student achievement has received much less attention (Rice, 2010). Acknowledging that principals themselves note that the most important aspect of their training and certification program to their school leadership practice are internships and experience in a school (Militello, Gajda, & Bowers, 2009), the question of which principal training experiences are most related to student achievement has recently come to the fore.

Estimation of Principal Factors Associated with Student Achievement

While there is a rich domain of research detailing the leadership behaviors that lead to instructional leadership, historically, estimation of principal and teacher background and training direct effects on student achievement across large-scale samples has shown weak to non-significant effects as researchers have searched to demonstrate which principals and principal factors may be the most effective in different contexts (Hallinger & Heck, 1996, 2011a; Kyriakides, Creemers, Antoniou, & Demetriou, 2009; Rice, 2010). As a point, based on these past results, some researchers such as Kyriakides et al. (2009) have made the following claim about discounting principal effects in schools:

> The results of this meta-analysis revealed that leadership has a very weak effect on student outcomes… Therefore, school factors should not be concerned with who is in charge of designing and/or implementing the school policy, but with the content of the school policy and the type of activities that take place in school. (p.820)

While school policy and the activities within the school are known to significantly impact student achievement, as opposed to statements from the past literature such as Kyriakides et al. (2009), the recent literature has shown definitively that leadership in schools does matter, not only through leading the processes that result in high quality instructional leadership (Robinson, 2010; Robinson, et al., 2008), but also through specific principal factors, such as principal training and experience.

As an example, recent non-peer reviewed online reports detailing Value Added Model (VAM) results from Florida, Pennsylvania and North Carolina have shown varying results, from small effects to non-significant effects of principal experience and training variables on student achievement (Chaing, Lipscomb, & Gill, 2012; Dhuey & Smith, 2012; Grissom, Kalogrides, & Loeb, 2012). As with all non-peer reviewed posts online, the results must be judged as suspect since the methods and reporting have not been vetted by other researchers in the domain (Bornmann, 2011), however these reports do suggest interesting paths forward for researchers and policymakers interested in principal effects. First, the effects of new principals in their first three years on value added student achievement were weak to non-significant (Chaing, et al., 2012; Dhuey & Smith, 2012). Second, principal experience as a principal and a principal's certification and training through advanced degree programs were positive and significant in North Carolina (Dhuey & Smith, 2012). And third, principal and school background and demographic variables as well as academic climate variables were included in the models, but as control variables so specific coefficients and effect sizes were not reported (Dhuey & Smith, 2012; Grissom, et al., 2012). Nevertheless, the utility of value-added models of teacher and principal effects is highly problematic given the multiple violations of the central assumptions of the statistics (Harris, 2011; Murphy, Hallinger, & Heck, 2013; Papay, 2011; Raudenbush, 2004; Reardon & Raudenbush, 2009), especially in the face of stronger modeling frameworks that attempt to model the variance and school and principal effects over time more appropriately.

Thus, in comparison to direct effects and value added models, recent work has shifted to examining the complex nature of school leadership through mediated models (Heck & Hallinger, 2009; Kenneth Leithwood & Jantzi, 2008; Kenneth Leithwood, et al., 2010) and time-nested growth models, examining the influence of principals on growth or decline in student achievement, controlling for prior school performance and exogenous variables (Coelli & Green, 2012). Unfortunately, as with the recent principal value-added models, much of this prior literature using growth modeling has been reported almost exclusively in non-peer reviewed white papers and online reports (Branch, Hanushek, & Rivkin, 2009, 2012, 2013; Clark, Martorell, & Rockoff, 2009; White & Bowers, 2011). Despite this draw-back, these reports have examined rich datasets that include multiple years of data across entire policy-domain datasets, such as all schools in the state of Texas (Branch, et al., 2009, 2012, 2013), schools across New York City (Cullen & Mazzeo, 2007), and all schools in the state of Illinois (White & Bowers, 2011). These reports come to three major conclusions. First, principal effects appear to be stronger in high poverty schools (Branch, et al., 2009, 2012, 2013). Second, principal education, experience and training appear to be weakly to unrelated to student performance growth in both NYC and Illinois (Cullen & Mazzeo, 2007; White & Bowers, 2011). However, third, principal on-the-job experiences do appear to influence student achievement, replicating across the NYC and Illinois studies (Cullen & Mazzeo, 2007; White & Bowers, 2011). Specifically, principals who were previously assistant principals are associated with increased growth in student achievement, controlling for the other variables in the models, while first year and long-term principals (six or more years as principal) experienced lower student achievement growth rates than principals on the job for two to five years. Together, these studies suggest that while principal training may be weakly related to student achievement growth, principal experiences are associated with growth in student achievement over time.

However, these growth model studies, while an improvement over past direct effects models, fail to adequately model much of the variance across schools. As has been recently argued by Hallinger and Heck (2011a, 2011b), more complex models of school leadership effects are needed to accurately model the complexities of the schooling process and the leadership effect. As an example, following this line of reasoning, recently Coelli and Green (2012) examined the principal effect over time in more detail, finding strong evidence for *time-dependent effects* of leadership on student performance. In their study, they examined ten years of data from secondary schools across British Columbia, examining the effects of individual principals on grade 12 English standardized test performance and graduation rates. They found that when they modeled principal influence over time as a "dynamic" process, in which principal influence was assumed to grow each year that the principal was in the school, rather than as a fixed constant effect per year, they found a strong association between principal tenure and grade 12 English performance, with weak to moderate effects on graduation rates. As stated by Coelli and Green (2012):

> When we allow for the possibility that it takes time for principals to have their full effect on a school, we find that individual principals can have substantial impacts on both outcomes if given enough time at a school to make their mark (p.107).

Indeed, Coelli and Green (2012) note that when using the past traditional modeling framework in their principal model espoused by Rivkin et al. (2005) for estimating teacher effects that assumes a constant cross-sectional effect for each year in the data (Rivkin, Hanushek, & Kain, 2005), they find few specific principal effects on English scores or dropout rates in their sample. In contrast, when they allow the principal effect to vary over time in a model that includes time-nested longitudinal effects more appropriately, they find that the model explains 58.8% of the variance in grade 12 English scores for schools in which principals remained in their schools over six years (Coelli & Green, 2012), one of the strongest findings of a leadership effect in schools to date.

The Coelli and Green (2012) study was problematic however, in that they examined the limited outcome of effects only on the final year of schooling in English and graduation rates. In addition, while the dataset was large and included the entire province over an extended period of time, generalizability to other countries is an issue since the study was conducted with British Columbia data and the distribution of schools in the province includes only a single metropolitan area, Vancouver, which is highly skewed towards a very rural population of schools. Nevertheless, appropriately modeling these types of principal effects in more accurate ways that represent the context of leadership influence in schools helps to further inform what is known about principal effects on achievement which in turn informs school, district and policy decisions on principal hiring, training, and assignment to schools.

In the end, work to date on the factors most associated with school leader effects on student achievement over time can be organized into three groups: 1) principal professional experience, 2) principal preparation, and 3) teacher turnover and qualifications. First, the literature on principal professional experience suggests that the number of years of a principal's experience on the job and in the school may be strongly related to schooling outcomes (Branch, et al., 2009; Clark, et al., 2009; Coelli & Green, 2012; Dhuey & Smith, 2012; Wheeler, 2006; White & Bowers, 2011). In addition, experience in the school may play an important role in a future principal's effectiveness, especially when they have previously served as an assistant principal (Clark, et al., 2009; White & Bowers, 2011). Second, principal preparation and academic background through undergraduate and graduate programs appears to have inconsistent effects, with some studies showing a positive relationship between student achievement and principal's attending competitive post-secondary institutions or obtaining advanced degrees (Clotfelter, Ladd, Vigdor, & Wheeler, 2007; Dhuey & Smith, 2012; K. Leithwood, Day, Sammons, Hopkins, & Harris, 2006) while others demonstrate little to any relationship (Clark, et al., 2009; White & Bowers, 2011). Third, recent research has shown that the mediated effect of principal leadership on student achievement can be attributed in part through principal influence over teacher turnover, hiring practices and retention (Brewer, 1993; Fuller, Young, & Baker, 2011; Hallinger & Heck, 1998; Seashore Louis, Leithwood, Wahlstrom, & Anderson, 2010) and development of highly qualified teachers (Jacob & Lefgren, 2008; White, Presley, & DeAngelis, 2008). Indeed, a small but growing set of studies suggests that principals with strong academic qualifications hire and retain teachers with strong academic qualifications which in turn may lead to increased student performance (Baker & Cooper, 2005; Ingle, Rutledge, & Bishop, 2011; Wheeler, 2006). However, despite the growing body of evidence, the association between these principal factors and student achievement noted above remains problematic due to multiple methodological issues throughout the studies, especially in relation to appropriately modeling the complex longitudinal nature of the effect of leadership on school-wide academic achievement.

Toward Modeling the Complex Longitudinal Nature of Principal Effects

Along with arguing for increased complexity in the models at the principal level, Hallinger and Heck (2011a) also argue that leadership is enacted within the organizational settings of the schools. Consequently, the organizational level and the variance between school settings should be appropriately modeled and controlled. One way to examine this type of organizational variance is to test if there are statistically significantly different sub-groups of trajectories of school achievement growth or decline (Hallinger & Heck, 2011b). In their study, Hallinger and Heck (2011b) tested for the extent to which there were statistically significantly different trajectories in school growth in grade 5 mathematics standardized test scores over four years, using data from 193 elementary schools from a western U.S. state, and controlling for a multitude of student and school background, context and processes. They used multilevel latent change analysis, which is analogous to the growth mixture modeling (GMM) approach employed in the present study. They specified a two-level hierarchical linear growth model - in which school-level test scores at each time-point (level-1) are nested within each school (level-2) – and used the variance in different growth trajectories over time to estimate a level 2 latent variable that tested whether there were statistically significantly different subgroups of school trajectories. Hallinger and Heck (2011b) found three statistically different groups of school trajectories that varied by both the intercepts and the slopes, in which the first started high and ended high, the second started in the middle and ended high and the third started low and ended with relatively high mathematics scores. Each trajectory differed by school and student contexts, and their results suggest that the trajectories differed by the change in amount of instructional leadership and academic capacity of the teachers. Thus, in an effort to test the proposition that more complex models of principal effects are needed that include not only effects over time but that also include controls for different organizational-level contexts (Hallinger & Heck, 2011a), Hallinger and Heck (2011b) were able to demonstrate that different school performance trajectories can be identified, and that they may be linked to different leadership and organizational capacity factors. However, their study was limited in that as a demonstration of how researchers may extend current models into the “mixture” framework, through examining different groups of trajectories, they used only 193 schools and single subject test scores. In addition, they did not provide many of the specific results from their models, including intercept and slope coefficients, standard errors, and other standard fit statistics that would aid in helping to replicate and extend the findings.

Framework of the study

Therefore, there is a need to examine the multiple school and principal factors identified in the previous literature as significantly associated with school achievement growth, while acknowledging the recent advances in theory and statistical modeling when considering principal effects research, and using large policy-relevant datasets. Indeed, no studies to date have combined these issues nominated across the above reviewed literature and examined the effects of principal training and background on different trajectories of schools using population-level datasets. Thus, the research questions for this study were:

1) To what extent are there different school growth trajectories of elementary and middle school test score proficiency across multiple years of data in Illinois?
2) To what extent are principal background and experience variables related to the school proficiency growth trajectories?

METHODS

Data

This study is a secondary data analysis of all Illinois elementary and middle school standardized test proficiency over six academic years, 2000-2001 through 2005-2006. Including all of the data within a policy region over an extended period of time is recommended for this type of study (Bowers, 2010b). We obtained the data from the Illinois State Board of Education (ISBE) and the Illinois Education Research Council (IERC). The dataset includes *n*=3,154 schools. Because the Illinois school context includes Chicago as a large single school district metropolitan area with its own distinct contexts, we followed the recommendations of past Chicago school performance and leadership studies (Bryk, Bebring, Kerbow, Rollow, & Easton, 1999; Bryk, et al., 2010; White & Bowers, 2011) and separated the data into two distinct datasets for which all subsequent models were run separately, non-Chicago (*n*=2,654) and Chicago (*n*=500). As noted by Bryk et al. (2010) on the justification for examining Chicago as a separate context from the rest of Illinois, the authors note that a very high percentage of Chicago Public School (CPS) students live in poverty in comparison with the rest of the state of Illinois such that:

> …if we were to relocate one of Chicago’s “more affluent” and integrated schools in almost any other district in the state of Illinois, it would immediately rank as that district’s most disadvantaged school. When we think about Chicago’s modal school – racially isolated, with a 100-percent African-American student body and a low-income enrollment exceeding 90 percent – there is literally no relevant comparison school in most other districts in Illinois (Bryk et al. 2010, p.14).

Variables

The variables used in the subsequent analyses are detailed in Tables 1 and 2, disaggregated by non-Chicago and Chicago. We used past theory and literature on principal effects on achievement over time reviewed above to guide our selection of variables. The dependent variable in the models discussed below is the percentage of students in each school meeting or exceeding proficiency standards on the Illinois Standard Achievement Test (ISAT). The ISAT is assessed in the spring of each academic year for all public elementary and middle schools in Illinois in grades 3 through 8, assessing reading and mathematics (ISBE, 2011). For the independent variables, all of the data are specified as school-level aggregates. Our school aggregated student background and control variables include school *enrollment*, *percentage African American*, *Hispanic*, and *Asian* students, *percent LEP* students (Limited English Proficient), *percent free and reduced lunch*, and the student *mobility* rate for each school.

To examine the independent effects of teacher experience in the subsequent models, we included the variable *percentage of inexperienced teachers* with three or less years of experience as a teacher (Fuller, et al., 2011). We chose three years or less to classify inexperienced teachers given the past literature on teacher experience that has demonstrated that teacher effectiveness can grow rapidly over the first three years, and that after three years effectiveness levels off (Rice, 2003; Wayne & Youngs, 2003). We included a school-level measure of teacher academic capital, the Index of Teacher Academic Capital (ITAC) that represents overall teacher training and qualifications (DeAngelis & Presley, 2011; Smalley, Lichtenberger, & Brown, 2010; White, et al., 2008), including average teacher ACT composite and English scores, teacher basic skills test results, teacher certification status, and teacher undergraduate college competitiveness (see White et al. 2008).

Table 1: Descriptive Statistics for Non-Chicago Schools

Variable Name	Mean	SD	Min	Max	Description
ISAT	72.38	14.48	7.10	100.00	Percent met or exceed Illinois Standard Achievement Test
Student					
Enrollment	436.39	229.93	28	2384	School enrollment
% African American	0.14	0.24	0	1.00	Percent African American students
% Hispanic	0.11	0.18	0	0.97	Percent Hispanic students
% Asian	0.03	0.05	0	0.53	Percent Asian students
% LEP	0.05	0.10	0	0.87	Percent Limited English Proficiency students
% Free Reduced Lunch	0.32	0.26	0	1.00	Percent free and reduced price lunch students
Mobility	0.16	0.11	0	2.54	Student mobility rate
Teacher					
% Inexp. Teachers	0.17	0.11	0	0.90	Percent teachers with three or less years experience
ITAC	0.12	0.74	-6.39	2.90	Index of Teacher Academic Capital
Principal					
Age	47.62	7.91	22	72	Age of principal
Female	0.51	0.50	0	1	Principal is female (vs. male)
Minority	0.10	0.30	0	1	Principal is from minority ethnic group (vs. white)
Select. Undergrad	0.18	0.38	0	1	Principal undergraduate degree from selective institution
Select. Grad	0.14	0.35	0	1	Principal graduate degree from selective institution
First Year Principal	0.11	0.40	0	1	Principal is first year principal (vs. 6+ yrs)
Principal 2-5 years	0.35	0.46	0	1	Principal for 2-5 years (vs. 6+ yrs)
Asst. Principal	0.40	0.49	0	1	Principal was previously an assistant principal
Taught in same school	0.12	0.33	0	1	Principal was previously a teacher in same school
n	2,654				

Table 2: Descriptive Statistics for Chicago Schools

Variable Name	Mean	SD	Min	Max	Description
ISAT	46.00	19.47	10.00	100.00	Percent met or exceed Illinois Standard Achievement Test
Student					
Enrollment	670.55	324.45	51	2227	School enrollment
% African American	0.56	0.43	0	1.00	Percent African American students
% Hispanic	0.31	0.36	0	1.00	Percent Hispanic students
% Asian	0.03	0.08	0	0.87	Percent Asian students
% LEP	0.13	0.16	0	0.72	Percent Limited English Proficiency students
% Free Reduced Lunch	0.85	0.20	0.05	1.00	Percent free and reduced price lunch students
Mobility	0.25	0.14	0.01	2.04	Student mobility rate
Teacher					
% Inexp Teachers	0.17	0.11	0	1	Percent teachers with three or less years experience
ITAC	-1.16	0.94	-7.27	2.93	Index of Teacher Academic Capital
Principal					
Age	53.48	6.89	30	81	Age of principal
Female	0.69	0.46	0	1	Principal is female (vs. male)
Minority	0.68	0.47	0	1	Principal is from minority ethnic group (vs. white)
Sel. Undergrad	0.26	0.44	0	1	Principal undergraduate degree from selective institution
Sel. Grad	0.23	0.42	0	1	Principal graduate degree from selective institution
First Year Principal	0.09	0.29	0	1	Principal is first year principal in the school (vs. 6+ yrs)
Principal 2-5 years	0.33	0.47	0	1	Principal for 2-5 years (vs. 6+ yrs)
Asst. Principal	0.41	0.49	0	1	Principal was previously an assistant principal
Taught in same school	0.19	0.39	0	1	Principal was previously a teacher in same school
N	500				

Principal background variables included in the models were principal *age* (in years), if the principal was *female*, and if the principal was from a *minority* ethnic group (Dhuey & Smith, 2012; Fuller, et al., 2011; White & Bowers, 2011). Principal training variables included if the principal had obtained their *undergraduate degree from a selective* post-secondary institution or their *graduate degree from a selective graduate* institution (Dhuey & Smith, 2012; Fuller, et al., 2011; White & Bowers, 2011). We defined "selective" by merging the Barron's competitiveness ratings (Barron's, 2003) for post-secondary institutions to our principal data on each principal's degree awarding undergraduate and graduate institution. Our principal experience variables were of three types. First, we included if the principal was in their *first year as a principal* and if the principal had been a *principal for 2-5 years*, with principal six plus years as the reference group (Chaing, et al., 2012; Coelli & Green, 2012;

Dhuey & Smith, 2012). The second principal experience variable was if the principal had previously been an *assistant principal* (Clark, et al., 2009). The final principal experience variable was if the principal had *taught previously in the same school* that they became the principal of as a teacher.

Analysis

Recently across the social and behavioral sciences, as longitudinal data collection has become much more commonplace, and the amount of data has increased not only at each time-point but also in the number of time-points, this type of longitudinal data and its analysis has come to be known as Intensive Longitudinal Data (ILD) analysis (Collins, 2006; Shiyko, et al., 2012; Walls & Schafer, 2006). However, while ILD usually includes 20 or more time-points, we argue that as more school and education data continues to be collected in more intensive and planned ways (Mandinach, 2012; Wayman & Stringfield, 2006), and put to use for data driven decision making (Bowers, 2007, 2009, 2010a, 2011; Halverson, 2010; Halverson, Grigg, Prichett, & Thomas, 2007; Mandinach & Gummer, 2013; Wayman, 2005), that school leaders, practitioners, researchers and policymakers can benefit from the application of the techniques developed from the ILD data mining literature.

Here we apply an extension of recent innovations in longitudinal data analysis (Shiyko, et al., 2012) by extending a hierarchical growth model framework (Singer & Willett, 2003) into a growth mixture model (B. O. Muthén, 2004; Petras & Masyn, 2010). Following the recommendations of the longitudinal data analysis literature on multilevel models of change over time (Singer & Willett, 2003), our data was recorded in long-format in which each year of data for each school was represented by a row of data, such that each school could be represented six times in the dataset over the academic years 2000-2001 through 2005-2006. This allowed us to analyze a two-level hierarchical linear growth model (Hox, 2010; Raudenbush & Bryk, 2002), with time (each year) nested at level 1, and schools at level 2, embedded within the omnibus simultaneous growth mixture model. As detailed by Singer and Willett (2003), the advantage of long-format data in this context is that the effects of time varying covariates on growth over time can be estimated on both the intercept and the slope-over-time by including the covariates at level 1. Thus, in the standard Raudenbush and Bryk (2002) hierarchical linear modeling nomenclature, our growth model can be represented generally by the following equations:

Level 1: $ISAT_{ij} = \pi_{0j} + \pi_{1j}YEAR_{ij} + \pi_{2j}X_{ij} \ldots e_{ij}$

Level 2: $\pi_{0j} = \gamma_{00} + r_{oj}$

$$\pi_{1j} = \gamma_{10} + r_{1j}$$

$$\pi_{2j} = \gamma_{20}$$

:

<u>In which</u>:
$ISAT_{ij}$ = School percent met or exceed proficiency standard for time i
$YEAR_{ij}$ = Year for each school's data
X_{ij} = Time varying covariates for each school in each year
π_{0j} = The slope of the intercepts varying randomly across schools
π_{1j} = The slope of time varying randomly across schools
π_{2j} = The slope of a level 1 predictor across schools

However, as discussed above with the recent work of Hallinger and Heck (2011b) in applying latent change analysis and growth mixture models to school test proficiency change-over-time, for the present study we postulated that there may be more than one statistically significantly different trajectory of school ISAT growth over the six years for both non-Chicago and Chicago schools. Following the recommendations of recent research on applying growth mixture models to this type of long-format data (Shiyko, et al., 2012) we extended the multilevel model of change framework into a GMM by specifying a simultaneous multinomial logistic regression at level 2 to estimate the different latent trajectory classes using the embedded hierarchical growth model. For a review of GMM, especially as applied to education data see (Bowers & Sprott, 2012; B. O. Muthén, 2004; Petras & Masyn, 2010). Thus, the model is a single omnibus model, in which a simultaneous hierarchical growth model is used as the basis to identify latent trajectory classes. Following the recommendations of the mixture modeling literature (Jung & Wickrama, 2008; B. O. Muthén, 2004; Petras & Masyn, 2010), this model is represented in an SEM framework in Figure 1. Thus, in a GMM of this type, growth in school ISAT proficiency over time is modeled conditional on latent class trajectory.

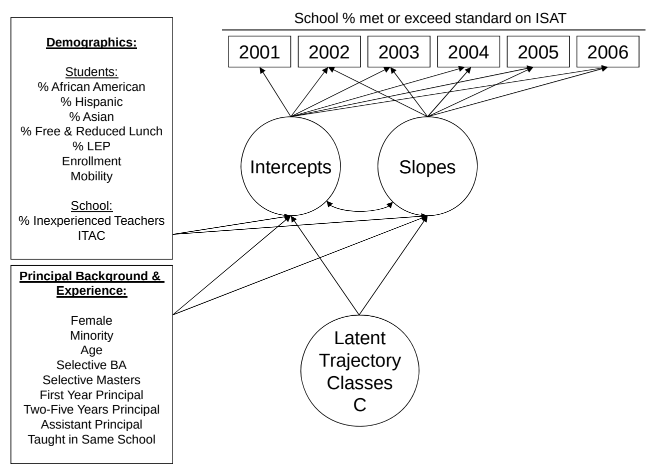

Figure 1: Growth mixture model for estimation of latent trajectory classes of school growth in ISAT from 2001-2006.

We used MPLUS 6.11 (L. K. Muthén & Muthén, 2010) to estimate two models, one for non-Chicago data and one for Chicago. We provide the Mplus code that was used to analyze both Non-Chicago and Chicago data in Appendix A. As will be discussed in the results, each model identified two trajectories, each with an intercept and slope parameter. However, due to our desire to include the effects of time-varying covariates on the slopes of the ISAT proficiency trajectories, and the requirement that time-varying covariates must be specified at level 1 (Singer & Willett, 2003) while the latent trajectory class is specified at level 2, intercept and slope coefficients cannot vary across latent trajectory groups (B. O. Muthén, 2012). Thus, while we report two significantly different trajectories for each dataset with different intercepts and slopes, we report only one set of covariate coefficients for each dataset. The GMMs were analyzed and model fit was assessed as recommended (Bowers & Sprott, 2012; Duncan, et al., 2006; Jung & Wickrama, 2008; Nylund, Asparouhov, & Muthén, 2007; Petras & Masyn, 2010; Wang & Bodner, 2007), using log-likelihood H_0 value, BIC, the Lo-

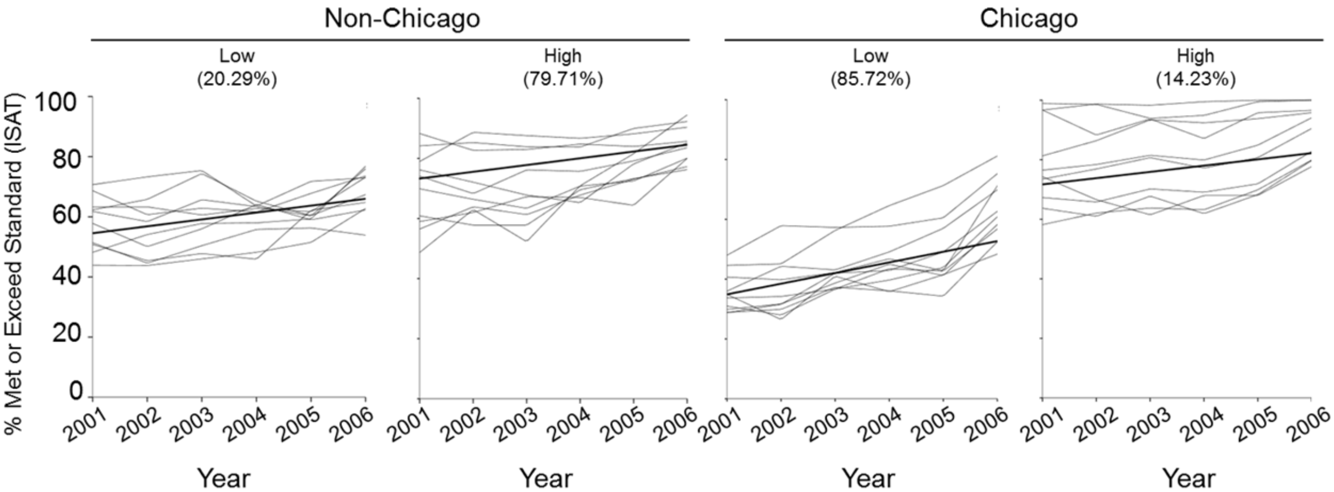

Figure 2: Growth mixture model predicted ISAT school achievement subgroups (solid dark line) for Non-Chicago and Chicago schools from school year 2000-2001 through 2005-2006 with ten randomly sampled actual trajectories (grey lines).

Mendell-Rubin (LMR) likelihood ratio test for k-1 classes (Lo, 2005; Lo, Mendell, & Rubin, 2001) and the Boostrapped Likelihood Ratio Test (BRLT) (Nylund, et al., 2007).

RESULTS

The purpose of this study was to examine the principal preparation and teacher qualification factors that are most associated with different trajectories of school state standardized proficiency growth in Illinois from 2000-2001 through 2005-2006. In this section we first present the growth mixture model fit information. We then describe each of the different significant trajectory subgroups for non-Chicago and Chicago schools and present the results of the growth model. We end this section by examining the significant coefficients in the model and how they differ across the subgroups. We then turn to a discussion of the results.

Overall Growth Mixture Model Results

We estimated two growth mixture models, one for non-Chicago schools and one for Chicago schools. Following the recommendations of the GMM literature (Jung & Wickrama, 2008; Nylund, et al., 2007; Petras & Masyn, 2010), we fit an iterative set of models for both datasets in which a single trajectory model is analyzed first and fit is assessed. If the model converges and is significant then a two trajectory model is fit and assessed, and so on. Here, for both datasets, a two latent trajectory class model fit the data well. For non-Chicago schools, the final two-class model resulted in a log-likelihood H_0 value of -46612.443, a BIC value of 93664.343, and an entropy estimate of 0.613. For GMM, higher entropy estimates, over 0.5 to 0.6, that approach 1.0 indicate good model fit (B. O. Muthén, 2004). For the Chicago schools, the final two-class model resulted in a log-likelihood H_0 value of -9580.224, a BIC value of 19525.943, and an entropy estimate of 0.830. In assessing the correct number of latent trajectory classes, for both the non-Chicago and Chicago models, the LMR and BLRT both were $p<0.001$, indicating that the two class latent trajectory model was a good fit to the data. We analyzed three class models for both datasets. For the non-Chicago school, neither LMR nor BLRT were significant, indicating that the two-class model was the better fit. For the Chicago data, the model did not converge due to instability issues with three classes, as is often the case in with these types of models (Jung & Wickrama, 2008; Shiyko, et al., 2012). Thus we considered the two latent trajectory class model to fit both datasets well.

Describing Significantly Different ISAT Proficiency Trajectory Subgroups

For both non-Chicago and Chicago, the growth mixture model identified two subgroups of school trajectories, a low and a high subgroup. To visualize the results, Figure 2 plots the trajectories of a random sample of 10 schools for the low and high subgroups for non-Chicago and Chicago for their percent met or exceeded standard on the ISAT. The bold line indicates the model predicted trajectories. Table 3 provides the model identified intercept and slope, controlling for the other variables in the model, as well as the descriptive means and standard deviations for all of the variables in each subgroup to allow comparisons between the two model identified subgroups for Non-Chicago school trajectories and the two model identified Chicago school trajectories. For the non-Chicago schools, the low subgroup represented 20.29% of the schools, which on average started at about 50% met or exceed standard in 2001 and then rose over the time period. The non-Chicago high subgroup represented the majority of the schools, 79.71%, which started on average over 70% met or exceed standard in 2001 and then rose slightly over the time period (Figure 2 and Table 3, left panels). In contrast, the Chicago low subgroup represented the majority of the schools in Chicago, 85.72%, which on average started at about 30% met or exceed standard and then rose with the highest slope over the time period to 2006. The Chicago high subgroup represented 14.23% of the schools, which started on average at about 70% met or exceeded standard and then on average rose somewhat by 2006 (Figure 2 and Table 3, right panels).

In general, examining the descriptive statistics in Table 3 for the two trajectory subgroups, the non-Chicago low subgroup schools in comparison to the high subgroup schools had larger enrollments, a higher percentage of African American and Hispanic students, higher percentages of students receiving free or reduced price lunches, and higher percentages of mobile students (Table 3, left). In addition, the low non-Chicago

Table 3: Variable means and standard deviations, disaggregated by latent trajectory class and Non-Chicago/Chicago.

	Non-Chicago				*Chicago*			
	Low		*High*		*Low*		*High*	
Variable Name	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
ISAT								
2000-2001	51.30	14.32	73.95	11.63	32.92	11.44	72.79	11.68
2001-2002	50.63	13.24	73.28	11.35	34.31	12.24	73.69	10.47
2002-2004	51.54	12.25	74.66	10.42	37.04	11.77	74.46	11.03
2003-2004	51.60	11.46	76.19	9.43	40.49	13.47	76.62	10.24
2004-2005	55.33	10.58	79.68	8.27	42.92	14.43	78.89	9.93
2005-2006	63.40	9.36	84.79	6.75	57.58	13.64	86.61	6.65
Model Intercept	52.26	12.53	71.06	12.53	31.36	12.44	69.62	12.44
Model Slope	2.29	1.34	2.25	1.34	3.56	1.39	2.10	1.39
Student								
Enrollment	442.98	228.37	434.71	230.31	686.43	331.00	575.15	262.84
% African American	0.40	0.33	0.07	0.14	0.61	0.43	0.29	0.32
% Hispanic	0.20	0.26	0.09	0.15	0.33	0.38	0.23	0.20
% Asian	0.01	0.03	0.04	0.06	0.02	0.05	0.10	0.14
% LEP	0.07	0.14	0.04	0.09	0.14	0.17	0.11	0.10
% Free Reduced Lunch	0.62	0.23	0.24	0.20	0.91	0.10	0.48	0.24
Mobility	0.26	0.14	0.13	0.09	0.28	0.13	0.10	0.07
Teacher								
% Inexp. Teachers	0.19	0.12	0.16	0.11	0.18	0.11	0.16	0.09
ITAC	-0.31	0.88	0.24	0.66	-1.28	0.89	-0.42	0.88
Principal								
Age	48.49	7.89	47.40	7.90	53.51	6.71	53.29	7.88
Female	0.57	0.50	0.50	0.50	0.70	0.46	0.60	0.49
Minority	0.32	0.47	0.05	0.21	0.74	0.44	0.31	0.46
Select. Undergrad	0.17	0.37	0.18	0.39	0.24	0.43	0.41	0.49
Select. Grad	0.14	0.35	0.14	0.35	0.21	0.41	0.35	0.48
First Year Principal	0.13	0.34	0.11	0.31	0.09	0.29	0.08	0.29
Principal 2-5 years	0.36	0.48	0.34	0.47	0.33	0.47	0.28	0.45
Asst. Principal	0.43	0.50	0.39	0.49	0.42	0.49	0.34	0.47
Taught in same school	0.12	0.32	0.12	0.33	0.19	0.39	0.14	0.35
n	539	(20.29%)	2,115	(79.71%)	429	(85.72%)	71	(14.23%)

subgroup in comparison to the high subgroup of schools had larger percentages of inexperienced teachers, lower teacher academic capacity as represented by a negative ITAC, and somewhat older principals, who were more likely to be female or from minority backgrounds. However, the low subgroup non-Chicago schools in comparison to the high subgroup, had about the same levels of principals who were trained in selective undergraduate and graduate programs and number of principals who had previously taught in their schools. In comparison to the high subgroup, non-Chicago low subgroup schools also had larger proportions of first year principals, and more experience as assistant principals in their schools. This suggests, that the non-Chicago low subgroups schools were serving more historically disadvantaged populations in comparison to the non-Chicago high subgroup. Similarly, the differences in the Chicago trajectories had very similar patterns to non-Chicago, with many of the student variables, as well as the teacher qualification and principal training variables, following similar patterns and in many cases exceeding the differences from non-Chicago (such as 70% of low Chicago schools had female principals versus 60% high Chicago subgroup schools; see Table 3, right). This suggests that the "low" subgroup category, for both Illinois contexts, non-Chicago and Chicago, served more heavily disadvantaged students than the "high" subgroups, with Chicago having a majority of low schools. Thus, we turn next to examining the hierarchical linear growth model portion of the growth mixture model specified in Figure 1 for first non-Chicago and then Chicago schools, to examine the independent effects of each variable in the model on the intercepts and slopes while controlling for the other variables in the model.

Principal Factors Related to Growth in School Proficiency over Time

As noted above, based on the prior theory and literature, we were most interested in examining the principal factors related to growth in longitudinal ISAT school proficiency, with a specific focus on principal professional experiences, principal preparation and teacher turnover and qualifications. Table 3 presents the results of the hierarchical linear growth model portion of the two full GMMs for non-Chicago and Chicago elementary and middle school growth in ISAT proficiency from 2000-2001 through 2005-2006. We start with describing the results for the Non-Chicago schools, which represent all elementary and middle

Table 4: Hierarchical growth model parameter estimates from the full growth mixture model on the intercepts and slopes for Illinois school ISAT proficiency from 2000-2001 through 2005-2006, Non-Chicago and Chicago.

	Non-Chicago				*Chicago*			
Parameters	*Coeff.*	*Stand. Coeff.*	*SE*	*p-Value*	*Coeff.*	*Stand. Coeff.*	*SE*	*p-Value*
Intercept								
Student-related								
Enrollment[a]	0.703		(1.093)	0.520	8.933**	0.056	(2.757)	0.001
% African American[a]	-37.670***	-0.076	(4.470)	<0.001	-24.517*	-0.034	(11.170)	0.028
% Hispanic[a]	-35.495***	-0.098	(3.177)	<0.001	-28.968**	-0.050	(10.391)	0.005
% Asian[a]	-20.910***	-0.025	(4.713)	<0.001	14.771		(16.272)	0.364
% LEP[a]	0.267		(0.206)	0.196	-0.957		(0.820)	0.243
% Free Reduced Lunch[b]	-2.012***	-0.082	(0.215)	<0.001	-2.101~	-0.025	(1.102)	0.056
Mobility[b]	-0.053		(0.143)	0.709	-0.437		(0.474)	0.357
Teacher-related								
% Inexp Teachers	1.131		(1.463)	0.439	-10.336**	-0.040	(3.188)	0.001
ITAC	0.636~	0.013	(0.331)	0.055	-1.346**	-0.032	(0.426)	0.002
Principal-related								
Age	0.012		(0.020)	0.549	0.028		(0.065)	0.664
Female	-0.550~	-0.019	(0.282)	0.051	-0.200		(0.698)	0.774
Minority	-2.228***	-0.046	(0.632)	<0.001	-0.301		(0.836)	0.719
Sel. Undergrad	0.302		(0.342)	0.377	-1.492~	-0.034	(0.766)	0.051
Sel. Grad	-0.209		(0.366)	0.568	0.908		(0.706)	0.198
First Year Principal	-0.517		(0.324)	0.111	0.368		(0.966)	0.703
Principal 2-5 years	-1.255***	-0.041	(0.267)	<0.001	-0.811		(0.661)	0.220
Asst. Principal	-0.541~	-0.018	(0.280)	0.054	-1.394~	-0.034	(0.756)	0.065
Taught in same school	-0.321		(0.409)	0.433	-2.614**	-0.052	(0.894)	0.003
Slope parameters								
Student-related								
Enrollment[a]	-1.538***	-0.030	(0.381)	<0.001	-7.128***	-0.121	(0.855)	<0.001
% African American[a]	5.983***	0.031	(1.440)	<0.001	-8.370*	-0.031	(3.824)	0.029
% Hispanic[a]	12.054***	0.081	(0.994)	<0.001	3.196		(3.051)	0.295
% Asian[a]	8.460***	0.027	(1.520)	<0.001	-5.396		(6.798)	0.427
% LEP[a]	-0.034		(0.072)	0.635	-0.185		(0.356)	0.604
% Free Reduced Lunch[b]	0.640***	0.075	(0.075)	<0.001	1.316**	0.040	(0.475)	0.006
Mobility[b]	-0.078		(0.050)	0.119	0.055		(0.166)	0.741
Teacher-related								
% Inexp Teachers	-0.222		(0.476)	0.641	5.398***	0.068	(1.103)	<0.001
ITAC	-0.134		(0.110)	0.223	0.605***	0.045	(0.173)	<0.001
Principal-related								
Age	-0.009		(0.007)	0.171	-0.019		(0.021)	0.367
Female	0.142*	0.017	(0.063)	0.025	0.021		(0.193)	0.912
Minority	-0.120		(0.151)	0.425	-0.111		(0.193)	0.565
Sel. Undergrad	0.046		(0.084)	0.588	0.636**	0.047	(0.204)	0.002
Sel. Grad	0.226*	0.017	(0.088)	0.011	0.243		(0.200)	0.225
First Year Principal	-0.025		(0.097)	0.796	-0.331		(0.343)	0.335
Principal 2-5 years	0.305***	0.034	(0.073)	<0.001	0.071		(0.213)	0.738
Asst. Principal	0.143*	0.017	(0.063)	0.024	0.335~	0.030	(0.183)	0.067
Taught in same school	0.017		(0.100)	0.868	0.680**	0.045	(0.220)	0.002

Note: [a] : Variable was natural log transformed; [b]: Variable was square root transformed; All continuous variables grand mean centered; ~ $p<0.10$; * $p<0.05$; ** $p<0.01$; *** $p<0.001$

schools in Illinois that are not affiliated with Chicago Public Schools.

The intercept coefficients represent the independent effects of each of the variables on the first year of data in the dataset, academic year 2000-2001 (see Table 4, top section). Controlling for prior performance in this way helps to isolate the associated effects of the variables on the slope parameters. Stated another way, the intercept parameter estimates represent the effect of each variable on how each school started in the model, akin to a single cross-sectional model. As opposed to value added models, or traditional regression analysis, as discussed above, in this way growth mixture models provide an additional dimension of indicators on the intercepts in addition to the slopes through time

(Bowers & Sprott, 2012; Petras & Masyn, 2010), rather than focusing only on cross-sectional regression parameters.
Starting with a focus first on the results for the Non-Chicago schools (Table 4, top section, left), the intercept results confirm much of the past literature, demonstrating that schools at the starting timepoint of the 2000-2001 school year who had higher mean enrollments of non-White students and percentage of students receiving free or reduced price lunches had lower starting mean ISAT proficiency rates. In addition, schools that had minority principals or principals in years 2-5 of being a principal also had significantly lower mean ISAT proficiency rates in 2000-2001, confirming past research that has demonstrated that outside of the urban context minority principals tend to serve in the most challenging schooling contexts (Brooks, 2012). The size of the school demographic and background coefficients and standard errors are artifacts of the data transformation to normalize the scales. Standardized coefficients are presented in addition to the non-standardized coefficients for all models as an indication of effect size and the magnitude of the contribution of the parameter to the model.

As the central focus of the present study, we turn next to describing the findings for the slope parameter estimates for Non-Chicago schools (Table 4, bottom panel, left) focusing on the associated effects on ISAT growth of principal professional experience, principal preparation, and teacher turnover and qualifications. First, for principal professional experience, principals in Non-Chicago schools who had been assistant principals experienced faster growth in ISAT scores, as did principals who had been principals for 2-5 years versus first year principals and the reference group of principals who had served for six or more years. The assistant principal finding replicates past research on assistant principal effects (Clark, et al., 2009) that has shown that assistant principal experience may help current principals understand the complexities of the day-to-day management of the school in addition to leading the curriculum and instruction (Marshall & Hooley, 2006; Sun, 2011). The principal experience finding builds upon the work discussed above that demonstrates that principal experience matters, especially Coelli and Green (2012), here demonstrating a nonlinear effect, in that in comparison to principals who had served for six or more years, principals with 2 to 5 years of experience had statistically significantly greater growth in ISAT scores (0.034 standard deviations per year), while first year principals were not significantly different from 6+ year principals. We will discuss this issue at further length in the discussion. Second, for principal preparation, growth in ISAT proficiency was statistically significantly related to Non-Chicago principals who had received a selective graduate degree which extends the previous literature on principal training that has previously shown conflicting results across state contexts (Dhuey & Smith, 2012; Fuller, et al., 2011). Third, for Non-Chicago schools, controlling for the other variables in the model, percent inexperienced teachers and teacher qualifications as represented by ITAC were unrelated to ISAT proficiency growth.

For the Chicago model, the growth model results differ from Non-Chicago in interesting ways. In examining the intercepts (Table 4, top panel, right), controlling for enrollment and demographics, Chicago school 2000-2001 ISAT proficiency rates were significantly negatively related to the percent of inexperienced teachers, the academic training of the teachers in the school as represented by ITAC, and if the principal had served as a teacher in the same school. In examining the significant parameters related to growth in Chicago school ISAT proficiency (Table 3, bottom panel, right), controlling for school background and demographics, principals who had taught in the same school were significantly related to higher rates of proficiency growth. This finding perhaps indicates a context specific effect for urban school principals, extending recent research that has suggested that close knowledge of the school community may have positive implications for urban school leadership (Khalifa, 2012; Tillman, 2005), especially for Chicago in particular (Bryk, et al., 2010). In addition, principals who attended selective undergraduate institutions served in schools with significantly higher ISAT proficiency growth. And finally for Chicago, controlling for the other variables in the model, percent inexperienced teachers and ITAC both were significantly positively related to ISAT growth. For ITAC, stronger teacher academic credentials seem to matter more for Chicago schools, although this finding may be influenced by the postulated sorting effect of principals with higher academic qualifications hiring similarly qualified teachers (Clotfelter, et al., 2007). That higher levels of inexperienced teachers is positively related to ISAT proficiency growth in Chicago is an unexpected finding, although this issue may be related to previous research that has shown that inexperienced teachers in Chicago schools are much stronger academically than experienced teachers, such as with Teach for America (TFA) teachers (White, et al., 2008).

As a final note across the two models reported in Table 3, the student-related parameters demonstrate that enrollment had a strong negative effect on growth in both non-Chicago and Chicago schools, with an effect size greater than a tenth of a standard deviation for Chicago, indicating that larger schools experienced slower ISAT growth, all other variables being equal. Percent African American students was negative and significant on the slopes for Chicago. Interestingly, percent African American, Hispanic and Asian students were positive and significant for non-Chicago schools. This suggests that minority ethnic group families may have a positive influence on school-level test proficiency over time in particular contexts, as has been previously reported (Bryk, et al., 1999; Bryk, et al., 2010). Percent free or reduced price lunch students was positive and significant on the slopes in both models when controlling for the other variables. This reflects the floor and ceiling effects for the state proficiency scores, since the intercept portion of the models indicated a strong negative effect of percent free or reduced price lunch on initial status, giving schools with high percentages of free or reduced price lunch students more room to grow in ISAT proficiency.

Describing Fitted Prototypical Growth Trajectories for Significant Principal Experience Factors

As is suggested in the literature on modeling change-over-time (Singer & Willett, 2003), we plotted prototypical trajectories in Figure 3 for each latent trajectory class (low/high) for both models for the principal-related variables of if the principal had previously served as an assistant principal and if the principal had taught in the same school in which they became a principal. Plotting prototypical trajectories aids the reader in interpreting the size of the effects over time (Singer & Willett, 2003), especially here where we have modeled multiple trajectory subgroups. In the top panel of Figure 3 the trajectories for both models start at the average intercept. The slopes of each line then represent the differences experienced in a prototypical school, holding all other variables at the averages for the model and latent trajectory class, for schools that would have had only principals who had previously been assistant principals over the time period. As can

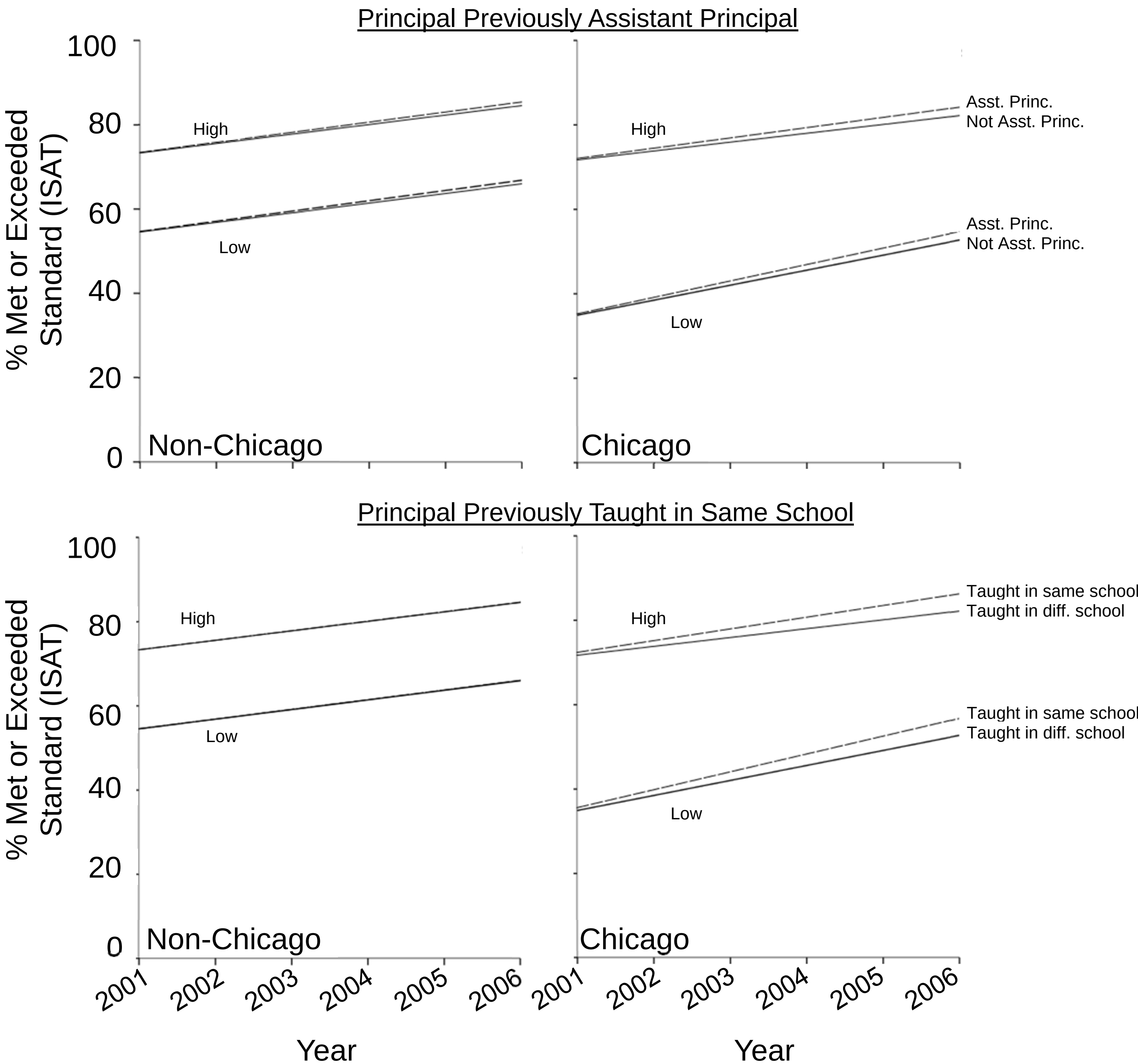

Figure 3: Prototypical ISAT proficiency trajectories for Non-Chicago and Chicago schools plotting model predicted change through time for schools in high or low trajectory groups with principals who were assistant principals prior to becoming a principal versus not an assistant principal (top panels), and if the principal had ever taught as a teacher in the same school that they became the principal of (bottom panels).

be seen in the top panels, while the differences in the low and high trajectories are slight, they are greater for the Chicago schools, as suggested by the effect sizes in the final models in Table 4. The same trends are seen in the bottom panels for the difference between the average prototypical schools which had principals who either were previously teachers in the school that they became a principal in or who did not teach in the same school. As demonstrated in the lower panels, while there was little difference for the non-Chicago schools, the model suggests that Chicago schools with principals who had taught in their schools were associated with stronger slopes over time.

DISCUSSION

The purpose of this study is to examine the principal experiences, training and teacher qualification factors most associated with different trajectories of growth in state standardized test score proficiency of elementary and middle schools in Illinois. By extending the hierarchical linear growth modeling framework into a growth mixture model, as one of the first examples in the education leadership literature, we are able to estimate and examine statistically significantly different trajectory groups of schools across a large longitudinal policy domain. Our findings suggest that while there are multiple student, teacher and principal factors that are associated with the initial proficiency levels of schools, controlling for these prior achievement factors allowed us to identify multiple principal and teacher experience variables that appear to independently influence school proficiency trajectories. In addition, our strategy to separate non-Chicago Illinois schools from Chicago schools helped to identify important differences between the two school contexts. Indeed, our results suggest that for non-Chicago schools, principal tenure, experience as an assistant principal, and attending a selective graduate degree institution are important factors that are significantly related to the rate of ISAT proficiency growth through the time period. For Chicago schools, controlling for the different context demonstrated that teacher-related variables as well as principals' previous experience as an assistant principal in their school, if the principal previously taught in their school, and the selectivity of the principal's undergraduate degree program appear to be related to ISAT proficiency growth.

While past studies have examined hierarchical growth models, especially in Illinois (White & Bowers, 2011), the inclusion of the mixture aspect of the present study to examine different growth trajectories is an important addition to the literature. When examining school achievement growth over time, it is unrealistic to require the assumption in the models that all schools fit to a single best fit trajectory (Hallinger & Heck, 2011a, 2011b). Rather, principal and school effectiveness models must begin to capture and then correctly model the significantly different variances in school achievement growth over time that can identify different latent trajectory classes. One of our goals in this study was to provide an example of how this type of modeling can be done with large comprehensive longitudinal datasets to build upon the recent work of Hallinger and Heck (2011a, 2011b), and mirroring the innovations in the recent intensive longitudinal data analysis (ILD) research (Shiyko, et al., 2012).

Our results also replicate and extend the recent research on principal effects (Chaing, et al., 2012; Clark, et al., 2009; Cullen & Mazzeo, 2007; Dhuey & Smith, 2012; White & Bowers, 2011), and indicate that assistant principal experience and principal tenure are important factors when considering school achievement growth. Research is sparse on the roles and impacts of assistant principal experience and training and how those experiences translate into principal effectiveness, or not (Clark, et al., 2009; Sun, 2011; White & Bowers, 2011). Recent research has shown that while the assistant principalship is seen as a gateway to the principalship, and thus training around the main practices of instructional leadership is central to the role, assistant principals take on a unique set of duties and responsibilities in the school (Barnett, Shoho, & Oleszewski, 2012; Kwan, 2009; Marshall & Hooley, 2006; Read, 2011). Our results indicate that these experiences may be important components of principal training, especially given that only about 40% of the principals in both samples had been assistant principals previously. Additionally, over this timespan, there is a growing trend of principals having served as assistant principals (Brown & White, 2010), an encouraging trend given our findings. Some researchers have recently argued for a change in the roles and preparation of assistant principals (Oleszewski, Shoho, & Barnett, 2012), especially for those who wish to become principals, as some school districts move away from the historic disciplinarian roles of the AP towards academic deans who help manage curriculum and instructional decisions in the school (Woods, 2012). As indicated by the results of the present study, the experiences of assistant principals as enacted in Illinois during the time period studied may provide important training and context experiences for future principals. We encourage more research in this area.

The principal tenure and experience finding that principals in years 2-5 of being a principal in Non-Chicago schools had a positive and significant association with increased growth in school ISAT proficiency is a central finding of the study. This finding replicates and extends the recent work on the positive influence of past principal experience on school performance (Clark, et al., 2009; Coelli & Green, 2012; Dhuey & Smith, 2012; White & Bowers, 2011). In addition, we also replicate and extend the findings on first year principals, in that even with large comprehensive samples such as the Illinois dataset used here, first year principal's do not appear to be significantly associated with school performance change over time. As principals gain more experience, this growing set of research shows that principal experience matters.

Conversely, our results differ from Coelli and Green (2012) for long-term principals who serve six or more years. While Coelli and Green's (2012) model did not show a decline in effect between 2-5 year principals and six or more year principals, in the present study the reference group for principal experience was six or more years of experience, and thus the interpretation of the positive effect on school ISAT growth slope in Non-Chicago schools of 2-5 year principals of 0.034 standard deviations per year can be interpreted as in comparison to six or more year principals. We interpret this difference as a difference in model effects, in that while Coelli and Green's (2012) model includes only a linear growth slope through time for experience, our present model captures the possibility of differential effects between different new principals, mid-term 2-5 year principals, and long-term six plus year principals through the inclusion of the experience variables on both the intercepts and the slopes in the GMM. Our findings indicate that for Non-Chicago schools, principals who have been principals for two to five years have the strongest association with growth in school achievement. Thus, our results, in combination with the previous studies, indicate that for some school contexts, principals in years 2-5 may have a positive effect, while new and veteran principals may have a weak to non-significant impact on achievement growth. It may be that the leader may become more complacent over time, however, given current research, it is difficult to know the processes that may be taking place in these schools. Further study is needed in this area to begin to understand the differences in leadership that may occur as a principal remains within a school.

Additionally, recent research on the question of what is known about how long principals should stay as principals in specific schools has shown that high principal turnover is problematic (Branch, et al., 2009, 2012, 2013; Seashore Louis, et al., 2010). However, Seashore Louis et al. (2010) have also posed the following questions when it comes to long-term principals:

> This leaves us with questions about the upper limit of a principal's tenure in a school: is there a "best by" date for principals, beyond which they should move on, or be moved on? Does a principal become stale or stagnant if he or she remains in the position for too long? We have little hard evidence bearing on this question… (p.168)

Our results presented here speak to this issue, in that for Non-Chicago schools, principals with six or more years of experience may not have as strong of a positive association with school performance growth as principals in years 2-5. However, this effect is by no means causal, and we urge caution in interpreting these relationships.

In addition to principal experience, the Chicago model results suggest that principal experience as a teacher in the school that they become the principal in was positively related to school achievement growth, while experience as a principal was not significant. While a growing set of literature has begun to consider the pipeline of experiences and training that lead to the principalship (DeAngelis & O'Connor, 2012; Farley-Ripple, Raffel, & Welch, 2012; Fuller, et al., 2011; Myung, Loeb, & Horng, 2011), little research has explored the context effects of having been a teacher in the school that the principal then leads. For urban school leadership, context matters (Bryk, et al., 2010; Cuban, 2001; Klar & Brewer, in press), and our findings for Chicago reinforce this notion. We encourage future research in this area to further detail which teacher experiences may be most associated with future principal effects.

Along with principal on-the-job experiences, principal selective post-secondary education was significant, with selective graduate programs versus non-selective positive and significant for Non-Chicago and selective undergraduate programs versus non-selective positive and significant in Chicago. This extends previous work around principal training and certification (Clotfelter, et al., 2007; Dhuey & Smith, 2012; Fuller, et al., 2011; Orr & Orphanos, 2011; White & Bowers, 2011) that has shown that principal selective degree programs may be associated with increased school performance. The difference in our model between Non-Chicago and Chicago principal degree programs may be due to a greater availability of selective graduate programs for Non-Chicago principals, as indicated by the about 10% greater number of Non-Chicago principals that hold degrees from selective institutions.

And finally, for Chicago, our model suggests that inexperienced teachers and higher levels of teacher academic training, as represented by ITAC, are significantly positively related to school achievement growth. As discussed above in the review of the literature, one hypothesized path for principal effects to influence student achievement is through hiring and retention of highly trained teachers with strong academic credentials (Clotfelter, et al., 2007; Donaldson, 2013; Fuller, et al., 2011; Seashore Louis, et al., 2010), especially for high poverty schools such as those in Chicago. The percent inexperienced teachers finding is unexpected, however we postulate that for Chicago, as demonstrated in past research (White, et al., 2008), inexperienced teachers in Chicago have stronger academic training than veterans, especially with the influx of Teach For America (TFA) teachers.

Limitations

While we believe that our results are robust, this study is limited in the following ways. First, we did not fit curvilinear trajectories to the models, which may fit the data better than linear trends. We encourage more research in this area, as additional non-linear trajectories may significantly improve the model fit. Second, due to the specification of the GMM using long-format data to include time-varying covariates on the slopes through time at level 1, we were unable to estimate separate parameter estimates for the different low/high identified subgroup trajectories. Conceptually, one would want to allow the effects of each variable to vary randomly across latent trajectory groups, since a different trajectory may be associated in different ways with specific variables. However, this is currently not possible given that the latent trajectory subgroups must be specified at level 2, the school level, since we wished to categorize schools (level 2), not time points (level 1). However, growth mixture modeling is an active domain of research, and as efforts continue in this area we encourage more work on identifying modeling protocols that may allow for this type of estimation.

Third, the study was limited by the strong ceiling effects inherent in the school percent met or exceeded standard ISAT outcome used in the present study. As has been well documented (Andrew Dean Ho, 2008), Percentage of Proficient Students (PPS) as a mainstay of multiple accountability systems is a problematic outcome for policy and research, since, as noted by Ho (2008), the proficiency cut-scores year-to-year are not completely objective and examination of trends over time of PPS conceals actual student-level gains and classroom-level variance (Wei & Haertel, 2011). These issues are especially problematic for growth models (Andrew D. Ho, Lewis, & MacGregor Farris, 2009). This issue with the choice of school ISAT proficiency should be seen as one of the central limitations of the present study. For this type of study, student-level data is preferred. However, due to confidentiality issues, student-level data was unavailable for the study. We argue here that despite this limitation, the present study is an advance over previous research using growth models and latent change analysis, here analyzing a large and comprehensive set of all elementary and middle schools in Illinois, estimating separate models for Non-Chicago and Chicago schools, and providing preliminary evidence that multiple significantly different school growth trajectories exist and are associated with different principal experience and training variables that help to replicate and extend the past research. For future research in which student-level data is available, we recommend a three-level growth mixture model, with students nested in time nested in schools, with the latent class trajectory subgroups specified at both the student and school levels to estimate statistically different trajectories of student achievement and how those trajectory subgroups influence school-level trajectory patterns.

And fourth, our models do not include an indication of how these principal effects are enacted in the schools to influence growth in achievement. As noted above, principals influence student performance through not only hiring and training teachers, but just as importantly through instructional leadership acting through the academic climate of the school (Hoy & Miskel, 1991; Kyriakides, et al., 2009; Kenneth Leithwood & Jantzi, 2008; Urick & Bowers, 2011, 2014). Our dataset, while large and comprehensive at the descriptive level of schools and principals in Illinois, lacks information about the daily processes within schools that may be influenced by principal experience and training factors. While outside the scope of the present study, we concur with Hallinger and Heck (2011a, 2011b) that research studies on principal effectiveness must work to test and incorporate more complex models that attempt to capture the multiple different longitudinal contexts of schooling and leadership. In the present study we have focused on detailing how growth mixture modeling addresses many of these issues, using the Illinois dataset. For our future research, we look forward to delving further into the processes within the schools to help to further examine how these principal factors may influence student achievement.

Conclusions

In conclusion, our results point to three main suggestions for research, policy and practice. First, our results demonstrate how growth mixture modeling is an attractive avenue for researchers to study significantly different latent trajectory groups. Second, from a policy perspective, principal and teacher training and academic qualifications may be associated with increased school proficiency growth, however our results indicate that these effects may be context specific. And finally, for practice, our results suggest that principal undergraduate and graduate training as well as on-the-job experiences do matter for school performance, especially time as an assistant principal, principal tenure in a school, and having taught previously in the school and so we encourage continued work in this area to explore the best strategies for principal training and placement decisions.

ACKNOWLEDGEMENTS

We thank the Illinois State Board of Education (ISBE) for providing the data for this study. We thank Ronald Heck and Janet Holt for their thoughtful feedback on early versions of this manuscript. A previous version of this manuscript was presented at the 2012 annual meeting of the Association for Education Finance and Policy (AEFP), Boston MA.

RECOMMENDED CITATION FORMAT

Bowers, A.J., White, B.R. (2014). Do Principal Preparation and Teacher Qualifications Influence Different Types of School Growth Trajectories in Illinois? A Growth Mixture Model Analysis. *Journal of Educational Administration*, 52(5) p.705-736. http://doi.org/10.1108/JEA-12-2012-0134

REFERENCES

Baker, B. D., & Cooper, B. S. (2005). Do Principals With Stronger Academic Backgrounds Hire Better Teachers? Policy Implications for Improving High-Poverty Schools. *Educational Administration Quarterly, 41*(3), 449-479. doi: 10.1177/0013161x04269609

Barnett, B. G., Shoho, A. R., & Oleszewski, A. M. (2012). The Job Realities of Beginning and Experienced Assistant Principals. *Leadership and Policy in Schools, 11*(1), 92-128. doi: 10.1080/15700763.2011.611924

Barron's. (2003). *Profiles of American colleges*. Woodbury, NY: W's Educational Series, Inc.

Beteille, T., Kalogrides, D., & Loeb, S. (2009). Effective schools: Managing the recruitment, development, and retention of high-quality teachers. Washington, DC: CALDER, The Urban Institute.

Bornmann, L. (2011). Scientific peer review. *Annual Review of Information Science and Technology, 45*(1), 197-245. doi: 10.1002/aris.2011.1440450112

Bowers, A. J. (2007). *Grades and data driven decision making: Issues of variance and student patterns.* Ph.D., Michigan State University, East Lansing.

Bowers, A. J. (2009). Reconsidering grades as data for decision making: More than just academic knowledge. *Journal of Educational Administration, 47*(5), 609-629. doi: 10.1108/09578230910981080

Bowers, A. J. (2010a). Analyzing the longitudinal K-12 grading histories of entire cohorts of students: Grades, data driven decision making, dropping out and hierarchical cluster analysis. *Practical Assessment Research and Evaluation, 15*(7), 1-18.

Bowers, A. J. (2010b). Toward Addressing the Issues of Site Selection in District Effectiveness Research: A Two-Level Hierarchical Linear Growth Model. *Educational Administration Quarterly, 46*(3), 395-425. doi: 10.1177/0013161X10375271

Bowers, A. J. (2011). What's in a grade? The multidimensional nature of what teacher-assigned grades assess in high school. *Educational Research and Evaluation, 17*(3), 141-159. doi: 10.1080/13803611.2011.597112

Bowers, A. J., & Sprott, R. (2012). Examining the Multiple Trajectories Associated with Dropping Out of High School: A Growth Mixture Model Analysis. *Journal of Educational Research, 105*(3), 176-195. doi: 10.1080/00220671.2011.552075

Boyd, D., Grossman, P., Ing, M., Lankford, H., Loeb, S., & Wyckoff, J. (2011). The influence of school administrators on teacher retention decisions. *American Educational Research Journal, 48*(2), 303-333. doi: 10.3102/0002831210380788

Branch, G. F., Hanushek, E. A., & Rivkin, S. G. (2009). Estimating principal effectiveness: Working paper. Washington, DC: National Center for Analysis of Longitudinal Data in Education Research.

Branch, G. F., Hanushek, E. A., & Rivkin, S. G. (2012). Estimating the effect of leaders on public sector productivity: The case of school principals. Cambridge, MA: National Bureau of Economic Research (NBER).

Branch, G. F., Hanushek, E. A., & Rivkin, S. G. (2013). School leaders matter. Retrieved from http://educationnext.org/files/ednext_20131_branch.pdf

Brewer, D. J. (1993). Principals and student outcomes: Evidence from U.S. high schools. *Economics of Education Review, 12*(4), 281-292. doi: 10.1016/0272-7757(93)90062-L

Brooks, J. S. (2012). *Black School White School: Racism and Educational (Mis) Leadership*. New York, NY: Teachers College Press.

Brown, K. S., & White, B. R. (2010). The state of leadership: Public school principals in Illinois (IERC 2010-2). Edwardsville, IL: Illinois Education Research Council.

Bryk, A. S., Bebring, P. B., Kerbow, D., Rollow, S., & Easton, J. Q. (1999). *Charting Chicago school reform: Democratic localism as a lever for change*. Boulder, Colorado: Westview Press.

Bryk, A. S., Sebring, P. B., Allensworth, E. M., Luppescu, S., & Easton, J. Q. (2010). *Organizing schools for improvement: Lessons from Chicago*. Chicago: The University of Chicago Press.

Chaing, H., Lipscomb, S., & Gill, B. (2012). Is School Value-Added Indicative of Principal Quality? Princeton, NJ: Mathematica Policy Research.

Clark, D., Martorell, P., & Rockoff, J. (2009). School principals and school performance. Washington, DC: National Center for Analysis of Longitudinal Data in Education Research, The Urban Institute.

Clotfelter, C. T., Ladd, H. F., Vigdor, J. L., & Wheeler, J. (2007). High poverty schools and the distribution of teachers and principals. Washington, DC: National Center for Analysis of Longitudinal Data in Education Research.

Coelli, M., & Green, D. A. (2012). Leadership effects: School principals and student outcomes. *Economics of Education Review, 31*(1), 92-109. doi: 10.1016/j.econedurev.2011.09.001

Collins, L. M. (2006). Analysis of longitudinal data: The integration of theoretical model, temporal design, and statistical model. *Annual Review of Psychology, 57*(505-528). doi: 10.1146/annurev.psych.57.102904.190146

Cuban, L. (2001). Leadership for Student Learning: Urban School Leadership--Different in Kind and Degree. Washington, DC: Institute for Educational Leadership.

Cullen, J. B., & Mazzeo, M. J. (2007). *Implicit performance awards: An empirical analysis of the labor market for public school administrators*. Unpublished Work. Kellogg School of Management - Northwestern University. Evanston, Illinois. Retrieved from http://www.kellogg.northwestern.edu/faculty/mazzeo/htm/txppals_1207.pdf

DeAngelis, K. J., & O'Connor, N. K. (2012). Examining the Pipeline Into Educational Administration: An Analysis of Applications and Job Offers. *Educational Administration Quarterly, 48*(3), 468-505. doi: 10.1177/0013161x11436269

DeAngelis, K. J., & Presley, J. B. (2011). Teacher Qualifications and School Climate: Examining Their Interrelationship for School Improvement. *Leadership and Policy in Schools, 10*(1), 84-120. doi: 10.1080/15700761003660642

Dhuey, E., & Smith, J. (2012). How School Principals Influence Student Learning. Evanston, IL: Society for Research on Educational Effectiveness.

Donaldson, M. L. (2013). Principals' Approaches to Cultivating Teacher Effectiveness: Constraints and Opportunities in Hiring, Assigning, Evaluating, and Developing Teachers. *Educational Administration Quarterly, 49*(5), 838-882. doi: 10.1177/0013161x13485961

Duncan, T. E., Duncan, S. C., & Strycker, L. A. (2006). *An introduction to latent variable growth curve modeling: Concepts, issues and applications* (2nd ed.). Mahwah, NJ: Lawrence Erlbaum Associates.

Edmonds, R. (1979). Effective schools for the urban poor. *Educational Leadership, 31*(1), 15-24.

Farley-Ripple, E. N., Raffel, J. A., & Welch, J. C. (2012). Administrator career paths and decision processes. *Journal of Educational Administration, 50*(6), 788-816. doi: 10.1108/09578231211264694

Fuller, E., Young, M., & Baker, B. D. (2011). Do Principal Preparation Programs Influence Student Achievement Through the Building of Teacher-Team Qualifications by the Principal? An Exploratory Analysis. *Educational Administration Quarterly, 47*(1), 173-216. doi: 10.1177/0011000010378613

Grissom, J. A., Kalogrides, D., & Loeb, S. (2012). Using Student Test Scores to Measure Principal Performance. Cambridge, MA: National Bureau of Economic Research (NBER).

Grissom, J. A., & Loeb, S. (2011). Triangulating principal effectiveness: How perspectives of parents, teachers, and assistant principals identify the central importance of managerial skills. *American Educational Research Journal, 48*(5), 1091-1123. doi: 10.3102/0002831211402663

Hallinger, P. (2005). Instructional leadership and the school principal: A passing fancy that refeuses to fade away. *Leadership and Policy in Schools, 4*(3), 221-239. doi: 10.1080/15700760500244793

Hallinger, P., & Heck, R. H. (1996). Reassessing the principal's role in school effectiveness: A review of empirical research, 1980-1995. *Educational Administration Quarterly, 32*(1), 5-44. doi: 10.1177/0013161X96032001002

Hallinger, P., & Heck, R. H. (1998). Exploring the Principal's Contribution to School Effectiveness: 1980-1995∗. *School Effectiveness and School Improvement, 9*(2), 157-191. doi: 10.1080/0924345980090203

Hallinger, P., & Heck, R. H. (2002). What do you call people with visions? The role of vision, mission and goals in school leadership and improvement. In K. Leithwood & P. Hallinger (Eds.), *Second International Handbook of Educational Leadership and Administration* (pp. 9-40). Dordrecht, the Netherlands: Kluwer Academic Publishers.

Hallinger, P., & Heck, R. H. (2011a). Conceptual and methodological issues in studying school leadership effects as a reciprocal process. *School Effectiveness and School Improvement, 22*(2), 149-173. doi: 10.1080/09243453.2011.565777

Hallinger, P., & Heck, R. H. (2011b). Exploring the journey of school improvement: classifying and analyzing patterns of change in school improvement processes and learning outcomes. *School Effectiveness and School Improvement, 22*(1), 1-27. doi: 10.1080/09243453.2010.536322

Hallinger, P., & Murphy, J. (1985). Assessing the Instructional Management Behavior of Principals. *The Elementary School Journal, 86*(2), 217-247. doi: 10.2307/1001205

Halverson, R. (2010). School formative feedback systems. *Peabody Journal of Education, 85*(2), 130-146. doi: 10.1080/0161956100368527

Halverson, R., Grigg, J., Prichett, R., & Thomas, C. (2007). The new instructional leadership: Creating data-driven instructional systems in school. *Journal of School Leadership, 17*(2), 159-194.

Harris, D. (2011). *Value-added measures in education: What every educator needs to know*. Cambridge, MA: Harvard Education Press.

Heck, R. H., & Hallinger, P. (2009). Assessing the contribution of distributed leadership to school improvement and growth in math achievement. *American Educational Research Journal, 46*(3), 659-689.

Ho, A. D. (2008). The problem with "proficiency": Limitations of statistics and policy under no child left behind. *Educational Researcher, 37*(6), 351-360.

Ho, A. D., Lewis, D. M., & MacGregor Farris, J. L. (2009). The Dependence of Growth-Model Results on Proficiency Cut Scores. *Educational Measurement: Issues and Practice, 28*(4), 15-26. doi: 10.1111/j.1745-3992.2009.00159.x

Horng, E. L., Klasik, D., & Loeb, S. (2010). Principal's time use and school effectiveness. *American Journal of Education, 116*(4), 491-523. doi: 10.1086/653625

Hox, J. (2010). *Multilevel analysis: Techniques and applications* (Second ed.). New York: Routledge.

Hoy, W., & Miskel, C. G. (1991). *Educational administration: Theory, research and practice*. New York, NY: McGraw-Hill.

Ingle, W. K., Rutledge, S., & Bishop, J. (2011). Context matters: principals' sensemaking of teacher hiring and on-the-job performance. *Journal of Educational Administration, 49*(5), 579-610. doi: 10.1108/09578231111159557

ISBE. (2011). Illinois standards achievement test: 2011 technical manual Retrieved Feburary 10, 2012, from http://www.isbe.net/assessment/pdfs/isat_tech_2011.pdf

Jacob, B. A., & Lefgren, L. (2008). Can Principals Identify Effective Teachers? Evidence on Subjective Performance Evaluation in Education. *Journal of Labor Economics, 26*(1), 101-136. doi: 10.1086/522974

Jung, T., & Wickrama, K. A. S. (2008). An introduction to latent class growth analysis and growth mixture modeling. *Social and Personality Psychology Compass, 2*(1), 302-317. doi: 10.1111/j.1751-9004.2007.00054.x

Khalifa, M. (2012). A Re-New-ed Paradigm in Successful Urban School Leadership: Principal as Community Leader. *Educational Administration Quarterly, 48*(3), 424-467. doi: 10.1177/0013161x11432922

Klar, H. W., & Brewer, C. A. (in press). Successful Leadership in High-Needs Schools: An Examination of Core Leadership Practices Enacted in Challenging Contexts. *Educational Administration Quarterly*. doi: 10.1177/0013161x13482577

Kwan, P. (2009). The vice-principal experience as a preparation for the principalship. *Journal of Educational Administration, 47*(2), 191-205. doi: 10.1108/09578230910941048

Kyriakides, L., Creemers, B., Antoniou, P., & Demetriou, D. (2009). A synthesis of studies searching for school factors: implications for theory and research. *British Educational Research Journal, 36*(5), 807-830. doi: 10.1080/01411920903165603

Leithwood, K. (1994). Leadership for School Restructuring. *Educational Administration Quarterly, 30*(4), 498-518.

Leithwood, K., Day, C., Sammons, P., Hopkins, D., & Harris, A. (2006). Successful school leadership: What it is and how it influences pupil learning. London, UK: UKDES.

Leithwood, K., & Jantzi, D. (2008). Linking leadership to student learning: The contributions of leader efficacy. *Educational Administration Quarterly, 44*(4), 496-528.

Leithwood, K., Patten, S., & Jantzi, D. (2010). Testing a conception of how school leadership influences student learning. *Educational Administration Quarterly, 46*(5), 671-706. doi: 10.1177/0013161X10377347

Lo, Y. (2005). Likelihood ratio tests of the number of components in a normal mixture with unequal variances. *Statistics & probability letters, 71*(3), 225-235. doi: 10.1016/j.spl.2004.11.007

Lo, Y., Mendell, N. R., & Rubin, D. B. (2001). Testing the number of components in a normal mixture. *Biometrika, 88*(3), 767-778. doi: 10.1093/biomet/88.3.767

Mandinach, E. B. (2012). A Perfect Time for Data Use: Using Data-Driven Decision Making to Inform Practice. *Educational Psychologist, 47*(2), 71-85. doi: 10.1080/00461520.2012.667064

Mandinach, E. B., & Gummer, E. S. (2013). A Systemic View of Implementing Data Literacy in Educator Preparation. *Educational Researcher, 42*(1), 30-37. doi: 10.3102/0013189x12459803

Marks, H. M., & Printy, S. M. (2003). Principal Leadership and School Performance: An Integration of Transformational and Instructional Leadership. *Educational Administration Quarterly, 39*(3), 370-397.

Marshall, C., & Hooley, R. M. (2006). *The assistant principal: Leadership choices and challenges*. Thousand Oaks, CA: Corwin Press.

Militello, M., Gajda, R., & Bowers, A. J. (2009). The Role of Accountability Policies and Alternative Certification on Principals' Perceptions of Leadership Preparation. *Journal of Research on Leadership Education, 4*(3), 30-66. doi: 10.1177/194277510900400301

Murphy, J., Hallinger, P., & Heck, R. H. (2013). Leading via Teacher Evaluation: The Case of the Missing Clothes? *Educational Researcher, 42*(6), 349-354. doi: 10.3102/0013189x13499625

Muthén, B. O. (2004). Latent variable analysis: Growth mixture modeling and related techniques for longitudinal data. In D. Kaplan (Ed.), *The Sage handbook of quantitative methodology for the social sciences* (pp. 345-370). Thousand Oaks, CA: Sage Publications.

Muthén, B. O. (2012, Feb 6, 2012). Personal communication: Growth modeling of longitudinal data, from http://www.statmodel.com/discussion/messages/14/194.html

Muthén, L. K., & Muthén, B. O. (2010). *Mplus: Statistical analysis with latent variables user's guide* (5th ed.). Los Angles, CA: Muthén & Muthén.

Myung, J., Loeb, S., & Horng, E. (2011). Tapping the Principal Pipeline: Identifying Talent for Future School Leadership in the Absence of Formal Succession Management Programs. *Educational Administration Quarterly, 47*(5), 695-727. doi: 10.1177/0013161x11406112

Neumerski, C. M. (2013). Rethinking Instructional Leadership, a Review: What Do We Know About Principal, Teacher, and Coach Instructional Leadership, and Where Should We Go From Here? *Educational Administration Quarterly, 49*(2), 310-347. doi: 10.1177/0013161x12456700

Nylund, K. L., Asparouhov, T., & Muthén, B. O. (2007). Deciding on the number of classes in latent class analysis and growth mixture modeling: A Monte Carlo simulation study. *Structural Equation Modeling: A Multidiscplinary Journal, 14*(4), 535-569. doi: 10.1080/10705510701575396

Oleszewski, A. M., Shoho, A. R., & Barnett, B. G. (2012). The development of assistant principals: a literature review. *Journal of Educational Administration, 50*(3), 264-286. doi: 10.1108/09578231211223301

Orr, M. T., & Orphanos, S. (2011). How Graduate-Level Preparation Influences the Effectiveness of School Leaders: A Comparison of the Outcomes of Exemplary and Conventional Leadership Preparation Programs for Principals. *Educational Administration Quarterly, 47*(1), 18-70. doi: 10.1177/0011000010378610

Papay, J. P. (2011). Different Tests, Different Answers: The Stability of Teacher Value-Added Estimates Across Outcome Measures. *American Educational Research Journal, 48*(1), 163-193. doi: 10.3102/0002831210362589

Petras, H., & Masyn, K. (2010). General growth mixture analysis with antecedents and consequences of change. In A. R. Piquero & D. Weisburd (Eds.), *Handbook of Quantitative Criminology*. New York, NY: Springer Science.

Pettigrew, A. M., Woodman, R. W., & Cameron, K. S. (2001). Studying organizational change and development: Challenges for future research. *Academy of Management Journal, 44*(4), 697-713.

Price, H. E. (2012). Principal–Teacher Interactions: How Affective Relationships Shape Principal and Teacher Attitudes. *Educational Administration Quarterly, 48*(1), 39-85. doi: 10.1177/0013161x11417126

Printy, S. M., Marks, H. M., & Bowers, A. J. (2009). Integrated Leadership: How Principals and Teachers Share Transformational and Instructional Influence. *Journal of School Leadership, 19*(5), 504-532.

Raudenbush, S. W. (2004). What Are Value-Added Models Estimating and What Does This Imply for Statistical Practice? *Journal of Educational and Behavioral Statistics, 29*(1), 121-129. doi: 10.2307/3701310

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

Read, S. P. (2011). Factors that influence the preparedness of teachers for the vice-principal role. In A. R. Shoho, B. G. Barnett & A. K. Tooms (Eds.), *Examining the assistant principalship: New puzzles and perennial challenges for the 21st century* (pp. 11-34). Charlotte, NC: Information Age Publishing.

Reardon, S. F., & Raudenbush, S. W. (2009). Assumptions of value-added models for estimating school effects. *Education Finance and Policy, 4*(4), 492-519. doi: 10.1162/edfp.2009.4.4.492

Rice, J. K. (2003). *Teacher quality: Understanding the effectiveness of teacher attributes*. Washington, DC: Economy Policy Institute.

Rice, J. K. (2010). Principal effectiveness and leadership in an era of accountability: What the research says. Washington, DC: CALDER, The Urban Institute.

Rivkin, S. G., Hanushek, E. A., & Kain, J. F. (2005). Teachers, schools and academic achievement. *Econometrica, 73*(2), 417-458.

Robinson, V. M. (2010). From instructional leadership to leadership capabilities: Empirical findings and methodological challenges. *Leadership and Policy in Schools, 9*(1), 1-26. doi: 10.1080/15700760903026748

Robinson, V. M., Lloyd, C. A., & Rowe, K. J. (2008). The impact of leadership on student outcomes: An analysis of the differential effects of leadership types. *Educational Administration Quarterly, 44*(5), 635-674.

Seashore Louis, K., Leithwood, K., Wahlstrom, K., & Anderson, S. E. (2010). Learning from leadership: Investigating the links to improved student learning. St. Paul, MN: The Center for Applied Research and Educational Improvement, University of Minnisota.

Shen, J., Leslie, J. M., Spybrook, J. K., & Ma, X. (2012). Are principal background and school process related to teacher job satisfaction? A multilevel study using schools and staffing survey 2003-04. *American Educational Research Journal, 49*(2), 200-230. doi: 10.3102/0002831211419949

Shiyko, M. P., Li, Y., & Rindskopf, D. (2012). Poisson growth mixture modeling of intensive longitudinal data: An application to smoking cessation behavior. *Structural Equation Modeling, 19*(1), 65-85. doi: 10.1080/10705511.2012.634722

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

Smalley, D. J., Lichtenberger, E. J., & Brown, K. S. (2010). A longitudinal study of the Illinois high school class of 2002: A six-year analysis of postsecondary enrollment and completion. Edwardsville, IL: Illinois Education Research Council (IERC).

Sun, A. (2011). Sharing instructional leadership as assistant principals in an accountability-oriented environment. In A. R. Shoho, B. G. Barnett & A. K. Tooms (Eds.), *Examining the assistant principalship: New puzzles and perennial challenges for the 21st century* (pp. 153-180). Charlotte, NC: Information Age Publishing.

Thoonen, E. E. J., Sleegers, P. J. C., Oort, F. J., Peetsma, T. T. D., & Geijsel, F. P. (2011). How to Improve Teaching Practices: The Role of Teacher Motivation, Organizational Factors, and Leadership Practices. *Educational Administration Quarterly, 47*(3), 496-536. doi: 10.1177/0013161x11400185

Tillman, L. C. (2005). Mentoring New Teachers: Implications for Leadership Practice in an Urban School. *Educational Administration Quarterly, 41*(4), 609-629. doi: 10.1177/0013161x04274272

Urick, A., & Bowers, A. J. (2011). What influences principals' perceptions of academic climate? A nationally represenative study of the direct effects of perception on climate. *Leadership and Policy in Schools, 10*(3), 322-348. doi: 10.1080/15700763.2011.57792

Urick, A., & Bowers, A. J. (2014). How does Principal Perception of Academic Climate Measure Up? The Impact of Principal Perceptions on Student Academic Climate and Achievement in High School. *Journal of School Leadership, 24*(2), 386-414.

Urick, A., & Bowers, A. J. (2014). What Are the Different Types of Principals Across the United States? A Latent Class Analysis of Principal Perception of Leadership. *Educational Administration Quarterly, 50*(1), 96-134. doi: 10.1177/0013161x13489019

Walls, T. A., & Schafer, J. L. (Eds.). (2006). *Models for intensive longitudinal data*. New York, NY: Oxford University Press.

Wang, M., & Bodner, T. E. (2007). Growth mixture modeling: Identifying and predicting unobserved subpopulations with longitudinal data. *Organizational Research Methods, 10*(4), 635-656.

Wayman, J. C. (2005). Involving teachers in data-driven decision making: Using computer data systems to support teacher inquiry and reflection. *Journal of Education for Students Placed at Risk, 10*(3), 295-308.

Wayman, J. C., & Stringfield, S. (2006). Data use for school improvement: School practices and research perspectives. *American Journal of Education, 112*(4), 463-468.

Wayne, A. J., & Youngs, P. (2003). Teacher characteristics and student achievement gains: A review. *Review of Educational Research, 73*(1), 89-122. doi: 10.3102/00346543073001089

Wei, X., & Haertel, E. (2011). The Effect of Ignoring Classroom-Level Variance in Estimating the Generalizability of School Mean Scores. *Educational Measurement: Issues and Practice, 30*(1), 13-22. doi: 10.1111/j.1745-3992.2010.00196.x

Wheeler, J. (2006). *An analysis of principal turnover, distribution, and ef ectiveness in the state of North Carolina.* Masters Thesis, Duke University, Durham, NC.

White, B. R., & Bowers, A. J. (2011). Principal effects in Illinois: A research brief (IERC 2011-3). Edwardsville, IL: The Illinois Education Research Council (IERC), Southern Illinois University Edwardsville.

White, B. R., Presley, J. B., & DeAngelis, K. J. (2008). Leveling Up: Narrowing the teacher academic capital gap in Illinois. Edwardsville, IL: Illinois Education Research Council.

Woods, B. T. (2012). *Competency gaps among assistant principals: Impacts on satisfaction and job role differentiation.* Ed.D., The University of Texas at San Antonio, San Antonio, TX. Retrieved from http://ezproxy.cul.columbia.edu/login?url=http://search.proquest.com/docview/1082023733?accountid=10226 (9781267614520)

Appendix A: Mplus syntax for the final two-class growth mixture models

```
TITLE:      Illinois GMM
DATA:       FILE = C:\Data.dat;
DEFINE:
ENRLbyYR    = ENROLL * YEAR;
SBLKbyYR    = SBLACK * YEAR;
SHISbyYR    = SHIS * YEAR;
SASIbyYR    = SASIAN * YEAR;
LEPbyYR     = LEP * YEAR;
FRPLbyYR    = FRPL * YEAR;
MOBIbyYR    = MOBILITY * YEAR;
INEXbyYR    = INEXP * YEAR;
ITACbyYR    = ITAC * YEAR;
PAGEbyYR    = PAGE * YEAR;
PFEMbyYR    = PFEM * YEAR;
PMINbyYR    = PMIN * YEAR;
PMSBbyYR    = PMSELBA * YEAR;
PMSAbyYR    = PMSELADV * YEAR;
AP01byYR    = PAPYRS01 * YEAR;
PY1byYR     = PYR1ST * YEAR;
PY25byYR    = PYR25 * YEAR;
PTCSbyYR    = PTCYRS01 * YEAR;
VARIABLE:
NAMES = STATICID SCHOOLID YEAR ENROLL SBLACK SHIS SASIAN LEP FRPL ISAT
        MOBILITY INEXP ITAC PAGE PFEM PMIN PMSELBA PMSELADV PYR1ST PYR25
        PAPYR01 PTCYRS01 ENRLbyYR SBLKbyYR SHISbyYR SASIbyYR LEPbyYR
        FRPLbyYR MOBIbyYR INEXbyYR ITACbyYR PAGEbyYR PFEMbyYR PMINbyYR
        PMSBbyYR PMSAbyYR AP01byYR PY1byYR PY25byYR PTCbyYR;
IDVARIABLE  = STATICID;
USEVARIABLES=  YEAR
               ENROLL         !School enrollment
               SBLACK         !School % African American students
               SHIS           !School % Hispanic students
               SASIAN         !School % Asian students
               LEP            !School % LEP students
               FRPL           !School % free and reduced price lunch students
               MOBILITY       !School % high mobility students
               ISAT           !School % met or exceeded proficiency standards
               INEXP          !School % inexperienced teachers
               ITAC           !School ITAC score
               PAGE           !Principal age
               PFEM           !Principal is female
               PMIN           !Principal is from minority ethnic group
               PMSELBA        !Principal attended selective BA institution
               PMSELADV       !Principal attended selective grad institution
               PYR1ST         !Principal first year principal
               PYR25          !Principal 2-5 years principal
               PAPYR01        !Principal was an assistant principal
               PTCYRS01       !Principal was teacher in same school
               ENRLbyYR SBLKbyYR SHISbyYR SASIbyYR LEPbyYR
               FRPLbyYR MOBIbyYR INEXbyYR ITACbyYR PAGEbyYR PFEMbyYR PMINbyYR
               PMSBbyYR PMSAbyYR AP01byYR PY1byYR PY25byYR PTCbyYR;
CLASSES     = c(2);
CLUSTER     = SCHOOLID;
WITHIN      =  YEAR ENROLL SBLACK SHIS SASIAN LEP FRPL ISAT
               MOBILITY INEXP ITAC PAGE PFEM PMIN PMSELBA PMSELADV PYR1ST PYR25
               PAPYR01 PTCYRS01 ENRLbyYR SBLKbyYR SHISbyYR SASIbyYR LEPbyYR
               FRPLbyYR MOBIbyYR INEXbyYR ITACbyYR PAGEbyYR PFEMbyYR PMINbyYR
               PMSBbyYR PMSAbyYR AP01byYR PY1byYR PY25byYR PTCbyYR;
BETWEEN     = c;
ANALYSIS:
TYPE        = MIXTURE TWOLEVEL RANDOM;
PROCESSORS  = 32 (STARTS);
MITERATION = 5000;
STARTS = 8000 1600;
STITERATIONS = 500;
LRTBOOTSTRAP = 100;
MODEL:
%WITHIN%
%OVERALL%
```

```
s | ISAT ON YEAR;
ISAT ON ENROLL SBLACK SHIS SASIAN LEP FRPL ISAT
       MOBILITY INEXP ITAC PAGE PFEM PMIN PMSELBA PMSELADV PYR1ST PYR25
       PAPYR01 PTCYRS01 ENRLbyYR SBLKbyYR SHISbyYR SASIbyYR LEPbyYR
       FRPLbyYR MOBIbyYR INEXbyYR ITACbyYR PAGEbyYR PFEMbyYR PMINbyYR
       PMSBbyYR PMSAbyYR AP01byYR PY1byYR PY25byYR PTCbyYR;
%BETWEEN%
%OVERALL%
ISAT WITH s;
%c#1%
ISAT WITH s;
%c#2%
ISAT WITH s;
OUTPUT:     SAMPSTAT TECH1 TECH4 TECH7 TECH11 TECH12 TECH14;
SAVEDATA:   SAVE=CPROBABILITIES;
            FILE IS CPROBSAV01.DAT;
            FORMAT IS FREE;
            ESTIMATES=MIXESTIMATES01_01.DAT;
```