Using Factor Analysis and Hierarchical Linear Modeling to Analyze STEM Majors' Perceptions of the Commitment to Teach in High Need Schools Survey

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Abstract

Factor analysis was applied to analyze the Noyce Scholarship Program Evaluation Scholar Survey, and then further hierarchical linear modeling (HLM) was applied to differentiate the variance due to program effects from individual scholars' effects. This survey was constructed to determine scholars' perception of their individual teacher preparation programs, their personal experience, and their decision to teach in high needs schools. Explanatory factor analysis was used to combine the many items into a few constructs. Based on theories and research, group members' professional opinions and confirmatory factor analysis, the final eight-factor model was determined. Two of the eight factors are scholars' perceptions of the influence of scholarship on becoming teachers and becoming high need teachers. While the two factors about scholars' perceptions of scholarships were entered as the outcome variables in HLM analyes, other variables were used as explanatory variables at the scholar level and the program level. The results show the program effect and some variables at the scholar level and the program level had statistically significant relationships with the outcome variables.

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Survey is one of the most common methods used for measuring perception. As such, appropriately and effectively applying measurement principles and statistical analyses to survey data is highly consequential. In addition, time and money used to create and carry out surveys is a better investment when the greatest amount of information is collected, and when researchers can build statistical models which explain respondents' perceptions. Therefore, this study intended to use the Noyce Scholarship Program Evaluation Scholar (NSPES) Survey to demonstrate factor analysis and hierarchical linear modeling (HLM), analyzing which variables explain scholars' decisions to become teachers and teach in high need schools. The motivation to use NSPES survey is that there is little information about the financial incentives at the teacher recruitment phase (Allen, 2005), and what variables might influence potential candidates, especially science, technology, engineering, and mathematics (STEM) majors, to become teachers and teach in high need setting. Therefore, in order to investigate this issue carefully, we need to use sophisticate techniques like factor analysis and HLM rather than the traditional survey data analysis.

Recruitment and retention of quality teachers in high need schools is especially needed in the subject areas of math and science. Teacher quality in mathematics and science education and student achievement has been consistently correlated in research literature (Jordan, Mendro, & Weerasinghe, 1997; National Research Council [NRC], 2000; Sanders & Rivers, 1996). Additionally, the No Child Left Behind Act of 2002 mandates that schools staff classrooms with highly qualified teachers. However, recent research indicates that students in high need areas are much more likely to be taught by a substitute teacher (National Center for Education Statistics

[NCES], 2006), or a teacher with emergency certification (Christensen & Levine, 1998) than a highly qualified teacher. To compound the issue, attrition is greatly elevated in high need areas in comparison with other types of environments (Darling-Hammond & Sykes, 2003; Ingersoll, 2002, 2003; Smith & Ingersoll, 2004).

To address the shortage of qualified teachers, Darling-Hammond (1997) recommended that states and districts “provide scholarships to recruit teachers for ‘high-need’ subjects and locations” (p. 4). Many state and federal agencies have heralded this recommendation by offering scholarships and financial incentives to address the necessities of high need schools, and science and mathematics shortages. Many of these programs are complex involving not only financial incentives, but also academic support, extensive field experiences, mentoring and employment assistance (see Clewell, Darke, Davis-Googe, Forcier & Manes, 2000) while others mainly provide scholarships. Evaluation of these programs often focuses on who the programs attract to teaching and their retention while investigations of the influence of disaggregated elements is less common (see Clewell et al.).

The outcomes of scholarship, in terms of how scholarships influence recipients and the quality of the pool of educators available for high need areas, have not been investigated frequently. However, Darling-Hammond and Sykes (2003) reported positive outcomes from scholarship/forgivable loan programs designed to increase the number and quality of teachers across subject matter areas, which both reached these goals and increased long-term retention.

Conversely, Bull, Marks, and Salyer (1994) focused specifically on the influence of scholarship programs on attracting individuals to science education and found that the scholarships used to draw individuals to teaching actually attracted those who were already committed to teaching, thereby not actually increasing the supply pool. They suggested that other factors such as a desire to teach the subject matter, work with children and a sense of social justice were greater contributors to teachers' motivation to teach and that the scholarship program simply supported those who were already committed to the profession. Therefore, the efficacy of scholarships and loan forgiveness programs on recruiting and retaining qualified teachers to high need settings may be affected by the reasons participants actually chose to accept scholarships or enroll in loan forgiveness programs. Given the mixed results of scholarship/loan forgiveness programs, Darling-Hammond and Sykes (2003) suggested that to be effective, scholarship programs should focus not only on academic merit, but also qualities such as commitment and perseverance.

In fact, commitment has been shown to have a significant relationship with teacher job satisfaction and eventual retention. Day, Elliot and Kington (2005), in an investigation of teachers who had been in the profession for 25-35 years, concluded that commitment is "a set of personal and professional values that extend well beyond the traditional ideas of caring and dedication" (p. 573) and suggested that low commitments to teaching are related to higher levels of turnover, lowered job satisfaction and motivation, while environments that support commitments to education in the form of collegial connections and administrative support are related to retention. While these studies focus on the relationship between commitment and retention, it could be extrapolated that notions of commitment are likely present during recruitment and can have implications for whom to recruit and which strategies most effectively identify those with the highest levels of commitment. However, the role of financial incentives on teachers' commitments has not been investigated in the literature, suggesting a specific area of needed research. While the studies described previously focus broadly on education, it can also be deduced that if persons enter high need education with low commitments to those specific environments, but strong commitments to teaching in general, they may be more likely to leave high need settings for other areas.

Furthermore, individuals have cited a myriad of intrinsic, extrinsic, and altruistic reasons for entering teaching (Brookhart & Freeman, 1992). These include viewing teaching as a vocation and as a contribution to society (Guarino et al., 2006). "Highly persistent" teachers have emphasized the intrinsic and moral rewards of teaching as factors influencing their persistence to teach (Watt & Richardson, 2008). These intrinsic factors are also coupled with extrinsic factors that influence a route to teaching. School environment also appears to be a factor influencing teachers' decision to teach. Justice, Greiner, and Andreson 2003, found that current teachers indicated their decision to teach was based on 'administrative and teacher-to-teacher support, a reduction in class size (20-23 students per class, and a district implementation of student discipline and school security guidelines.' Therefore, understanding the perceptions of individuals entering a teaching career in STEM fields is imperative for reducing attrition, especially for high needs schools and school districts where teacher attrition and turnover are quite high (Carroll & Sathya, 2008).

Except the scholars' characteristics which influence their decision to become a teacher or become a high need school teacher, the characteristics of teacher preparation programs which provide specific curricula to train these scholars also have impact on their decisions. Teacher certification programs provide scholars with initial teaching experiences and the educational knowledge base that is necessary for a successful teaching career. The diversity among teacher certification programs has been increasing with about a third of new teachers coming from alternative certification programs (Feistritzer and Chester 2002). Different methods used within the various teacher certification programs can attribute to a being a prepared teacher and having a successful teaching career (Justice, Greiner, Anderson 2003). Field-based experiences in a teacher preparation program appear to play a role in the teaching decision process. When teachers did not receive field-based experiences they felt insufficiently prepared when beginning teacher and indicated frustration in the areas of classroom management, subject matter knowledge, and effective teaching techniques (Justice et al., 2003). Therefore, the characteristics of the teacher preparation programs are also important to be considered to impact scholars' perceptions.

Research Question

As little is known about the influence of financial incentives at the recruitment phase, the purpose of this research was to investigate how these perceptions are affected by the teacher preparation programs in which these STEM majors received training. A further purpose is to examine and identify which individual (and preparation program) variables are related to scholars' perceptions of their commitment to teach and teach in high need schools because of the scholarship. By understanding the effects of variables influencing teachers' perceived commitment to become a teacher and teach in high need school, we hoped to identify variables that could be used by teacher preparation programs to design better curriculum to train STEM majors to teach in high need schools. In addition, the result might help teacher preparation programs and governments target for recruitment potential scholars with certain characteristics. In other words, the research questions being answered in this study are:

1) Which variables are related to a scholar's perceptions of their commitment to teach?
2) Which variables are related to a scholar's perceptions of their commitment to teaching at high needs schools?

Methods

Sample Description

Participants were all Noyce scholarship recipients and they were at a variety of points in their careers as educators. Of the 555 scholars responding to the survey, 30.8% were still in their teacher preparation/certification programs but not yet full-time teachers, 12.6% were still in their programs but also teaching full-time, 45.9% were teaching full-time/part-time, 0.9% taught after certification and were working in education but no longer teaching, 0.9% taught after being certified but were no longing working in education, 7.6% completed their programs but never taught, and 1.3% left their programs without completing certification. These scholars received their teacher education from 54 programs around the United States. Of the responding recipients, 34% indicated they were/are in a graduate program leading to a master's degree, 28% were/are attending an undergraduate program, 21% were/are in a post-baccalaureate program, 12% were/are attending a teaching credential program, and 5% were/are attending "other" programs.

The scholars had strong content backgrounds and reported taking several science and mathematics classes within the past few years. About 50% of all recipients indicated taking 10 to 20 STEM courses. The recipients also had strong backgrounds in teaching methods coursework, with over half (53%) reported taking four methods courses, with the majority of all participants (84%) reported taking anywhere from one to eight methods courses. About half of all scholars worked in a wide array of occupations prior to entering the teacher certification program. Average participant age was 27 with a median of 24 and a mode of 22 leading to a positively skewed distribution by a few older scholars. Fifty-three percent of the respondents decided to become STEM teachers after they were at least 23 years old, while 32% decided to become STEM teachers between 19-22 years of age.

Because of our interests in the effect of the programs on scholars' perceptions, it is important to describe the teacher preparation/certification programs in which these scholars were trained to become STEM teachers in high need settings. Teacher preparation/certification programs receiving funding through the Noyce Program exhibit a good deal of variety both within and across institutions (Author, 2008). For example, the programs represent an array of traditional and alternative certification options. Twenty-nine percent of the scholars described their teacher preparation/certification programs as undergraduate programs leading to a bachelor's degree, 12% described their programs as a teaching credential without a degree awarded, 23% described their programs as post-baccalaureate or graduate programs without a master's degree awarded, and 36% described their programs as graduate programs with a master's degree awarded.

As of 2007, 75 teacher preparation/certification institutions awarded the Noyce scholarship to prospective science and mathematics teachers, of which 66 (88%) responded to the Noyce Scholarship Program Evaluation: Principal Investigator Survey. The survey was administered to the primary investigators (PI) for the Noyce Program at each of the participating teacher education programs. Of the nine non-responding PIs, seven were in their first or second year and subsequently had no data to report in the survey. Fifty-five percent indicated that the Noyce Program paid for over 75% of recipients' tuition. In general, the PIs indicated that Noyce funding greatly increased their ability to recruit a variety of students; however, they perceived the Noyce funding as having a lesser effect on their students' perceptions about teaching careers and relationships with the surrounding community, school districts, industry and STEM faculty at their institutions.

Although the implementation of Noyce varies across programs, generally programs use some screening criteria to select scholars, such as GPA (98.5% of all programs), personal statement (97%), letters of recommendation (91%), upper level undergraduate status in science or mathematics major (82%), structured interviews (73%), bachelor's degree in the candidate's subject area (73%), and previous work experience (69%) were common areas that PIs considered when offering the Noyce Scholarship to students. The intent is to award the scholarship to the most qualified STEM candidates in terms of content knowledge and commitment to high need education.

To aid in future retention, some awarding programs also provide specific activities to best prepare scholarship and stipend recipients to become successful science and mathematics teachers in high need settings. Often this involves providing opportunities for interactions with children from different cultures such as mentoring or tutoring, coursework related to diverse cultures, and specific instruction about practicing in high need schools. Further experience is often provided with opportunities to observe/work on a limited basis through practicum, student teaching, and supervised actual classroom teaching in the form of an internship, all experienced in high need schools.

Instrument

The data utilized in this study were gathered from the Noyce Scholarship Program (NSP) Evaluation: Scholar Survey administered online during the summer of 2007. Participants were asked to respond to a variety of items regarding their perceptions of and experiences with the Noyce Program. The survey consisted of six main components: (a) project overview – scholars' program status and the Noyce scholarship money they can receive, (b) program characteristics and organization – details about the experiences, opportunities, and requirements of the programs scholars participated in, (c) teaching environment and experience – for those teachers who were currently teaching; scholars' current teaching status, personal feelings, and school and district environments, (d) the decision to become a teacher – timing and factors that led scholars to pursue a career in education and indication of the role played by the scholarship, (e) background and experience – scholars' academic background and work experience, and (f) overall experience – scholars' opinion of Noyce Program's effectiveness. The survey consisted of a variety of Likert-scale, multiple choice, and open-ended items. Completion of this survey was voluntary.

However, as described in the sample description section, the 555 scholars were at different points in their careers at the time of the survey (i.e., In a teacher certification program, not yet a full-time teacher; Completed a teacher certification program, but never taught; Did not complete a teacher certification program and will not return; In a teacher certification program and teaching full-time as part of that program; Teacher full-time or part-time; Taught after being certified and now working in education but not as a teacher; Taught after being certified and now not working in education). Therefore, we provided different versions of the survey to these scholars. Items did not differ across surveys. However, some items were either included or not included in surveys depending on the scholars' career progress (scholar has not taught yet or left their teaching position).

Statistical Techniques

To produce quantitative models of the Noyce Scholarship Program (NSP) based on scholars' perceptions, many statistical analyses were performed using data from the NSPE survey. A multitude of information (with a total of 83 items) can be obtained from the survey. However, because of so many items, it is impractical to use individual items to conduct statistical analyses. As a result, factor analysis was proposed for the analysis of these items. Factor analysis has long been held as a powerful tool for developing construct validation. The coalescence of multiple indicators of a construct into a single factor provides convergent and methodological evidence (Feldt & Brennan, 1989).

Exploratory factor analysis (EFA, performed with SPSS 16.0) and confirmatory factor analysis (CFA, performed with AMOS 16) were initially used to reduce the number of items into a more manageable number of factors for analysis. The 555 cases were randomly divided into two groups, where one group would be used for an EFA and the other group would be used for CFA. Principal axis factoring, orthogonal varimax rotation, and pairwise deletion were used in the EFA analysis. After examining the scree plot and factor loadings of all items, several potential factors were considered. Later, CFA was then performed to determine the fit of the factor model to the data, and to provide additional data regarding patterns that emerged. SPSS was then used to create factor scores for each factor. Finally, based on theories and research, Noyce evaluation group members' professional opinions, and CFA, the final set of factors were agreed upon, and factor scores were estimated. A factor score is a continuous variable as opposed to original dichotomous or rating-scale variables. Continuous variables can reflect a construct more accurately than the use of a dichotomous or rating scale variable (Bode, 1995; Garmoran & Behrends, 1987). The properties of these factor scores more accurately meet the assumptions of statistical analyses than dichotomous or rating scale variables. As a result, obtaining factor scores allows for further statistical analyses.

After formation of factors from these individual items, factor scores were modeled using two-level hierarchical linear modeling (HLM, performed with HLM 6.02, Raudenbush, Bryk, Cheong, & Congdon, 2000). HLM, also known as multi-level modeling, is able to differentiate between the variance due to the program effect and the variance due to individual scholar's effect (Raudenbush & Bryk, 2002).

A key assumption in single level models such as traditional regression is that the observations are independent of one another which is often not true where a nested structure exists (e.g., scholars within programs). In these situations, units of observations within a program tend to be more similar to one another than observations from other programs. In the present study, scholars who come from the same teacher preparation programs may be more similar to one another than they are to scholars from different teacher programs. Failing to take into account this dependency can result in biased statistical results (Raudenbush & Bryk, 2002). HLM takes into the nested structure of this data and therefore reduces this potential bias.

The formulations of HLMs directly follow the derivation from Raudenbush & Bryk, (2002),

The level 1 model:

$$Y_{ij} = \beta_{0j} + \beta_{1j} X_{1ij} + \beta_{2j} X_{2ij} + ... + \beta_{Qj} X_{Qij} + r_{ij} \tag{1}$$

where:

- Y_{ij} are outcomes for person *i* in level two unit *j*. It is also a function of individual characteristics, X_{qij} .
- β_{qj} are regression coefficients. *q*=0, …, Q, indicate how the outcome is distributed in organization *j* as a function of the measured person characteristics.
- X_{qij} are the predictors at the level-1
- r_{ij} are the random effects at the level-1, and it follows $N(0, \sigma^2)$

The level 2 model:

$$\beta_{qj} = \gamma_{q0} + \gamma_{q1} W_{1j} + \gamma_{q2} W_{2j} + ... + \gamma_{qS_q} W_{qS_q} + u_{qj} \tag{2}$$

where:

- β_{qj} are level-1 coefficients
- γ_{q0} are level-2 coefficients and are also called fixed effects
- W_{ij} are predictors at the level-2
- u_{qj} are random effects.

In this study, grand-mean centering was used for adjusting predictors in equations, and maximum likelihood estimation was used to estimate parameters.

Results

Eight Factors from EFA and CFA

After running EFA and CFA, the eight-factor solution (Table 1) was chosen as the one that appeared to best fit the data and existing theory about STEM teacher preparation after discussion within the Noyce evaluation research group. The content validity of items contained in the factors was strengthened by the elimination of few items. A total of 49 out of 71 items were used in the eight-factor model. Three items are in the "Scholars' perception of the influence of scholarship on becoming teachers" factor, three items are in the "Scholars' perception of the influence of scholarship on becoming high need teachers" factor, 13 items in the "Preparation for high needs schools" factor, seven items in the "Path to teaching" factor, five items in the "District/school high needs environment" factor, eight items in the "Personal beliefs towards teaching" factor, four items in the "School teaching environment" factor, and six items in the "Mentoring experience" factor. Detailed information about the standardized regression weights from CFA for the items in each factor is presented in Appendix A. For more detailed information about the formation of the eight-factor structure, please see Lawrenz & Liou (2008) and Liou, Kirchhoff, & Lawrenz (2008).

Table 1
The Eight Factor Structure for NSPES Survey

Factor	Factor content	Role of variable
Factor 1	Scholars' perception of the influence of scholarship on becoming teachers	Outcome variable
Factor 2	Scholars' perception of the influence of scholarship on becoming high need teachers	Outcome variable
Factor 3	Preparation for high need schools	Explanatory variable
Factor 4	Path to teaching	Explanatory variable
Factor 5	District/school high need environment	Explanatory variable
Factor 6	Personal beliefs towards teaching	Explanatory variable
Factor 7	School teaching environment	Explanatory variable
Factor 8	Mentoring experience	Explanatory variable

As for assessing the fitness of each factor, there are dozens of model fit indexes detailed in structural equation modeling (SEM) literature. Described next is a minimal set of fit indexes that should be reported and interpreted when reporting the results of SEM analyses in order to avoid biases. The fit indexes utilized to assess model fit of the eight-factor model are listed in Table 2. They include (1) the model chi-square, (2) the Bentler-Bonett normed fit index (NFI; Bentler & Bonett, 1980), (3) the Bentler comparative fit index (CFI; Bentler, 1990), and (4) the Steiger-Lind root mean square error of approximation (RMSEA; Steiger, 1990).

As a rule of thumb, the chi-square test is too sensitive to sample size, thus it is not a good index to evaluate model fitness; however, it can test the difference in fit between a given over-identified model and a just-identified version (Kline, 2005). Based on this suggestion, we do not provide an in-depth explanation of the chi-square test as an index for model fitness, however, we do elaborate on the guidelines for the other three fit indexes.

For NFI, a value between 0.90 and 0.95 is acceptable, and above 0.95 is good. For CFI, a value greater than 0.9 indicates reasonably good fit of the model (Hu & Bentler, 1999). For RMSEA, the closer the value is to 0, the better the fit. According to Browne & Cudeck (1993),

> A value of the RMSEA of about .05 or less would indicate a close fit of the model in relation to the degrees of freedom. This figure is based on subjective

> judgment. It cannot be regarded as infallible or correct, but is more reasonable than the requirement of exact fit where the RMSEA = 0.0. We are also of the opinion that a value of about 0.08 or less for the RMSEA would indicate a reasonable error of approximation and would not want to employ a model with a RMSEA greater than 0.1.

Based on the above criteria, we consider that the responses to the 13 items in the “Preparation for high need schools” factor, the five items in the “District/school high need environment” factor, the eight items in the “Personal beliefs towards teaching” factor, and the six items in the “Mentoring experience” factor do not seem to fit one dimension well because these items fail to meet standard criteria for all three tests (Table 2). On the other hand, the “Path to teaching” factor and “School teaching environment” factor do fit one dimension well as demonstrated by their model fit values. As for the “Scholars’ perception of the influence of scholarship on becoming teachers” factor and the “Scholars’ perception of the influence of scholarship on becoming high need teachers” factor, the fit index cannot be computed. Both of factors are composed of three items, so the number of parameters equal to the number of distinct sample moments. In other words, there is no degree of freedom for computing fit index.

Although not all factors have statistical evidence supporting their goodness of fit, Noyce evaluation research group members still considered these factors as having good content validity according to existing theory. Moreover, Cronbach’s alpha of the factors indicated they have median to strong internal consistency.

Table 2
Cronbach’s Alpha and Fit Indexes for Eight Factors in NSPES Survey

Factor	Cronbach’s alpha	Chi-square	D.F.	NFI	CFI	RMSEA
Factor 1: Scholars’ perception of the influence of scholarship on becoming	0.885	N/A	N/A	N/A	N/A	N/A

Factor	Cronbach's alpha	Chi-square	D.F.	NFI	CFI	RMSEA
teachers						
Factor 2: Scholars' perception of the influence of scholarship on becoming high need teachers	0.888	N/A	N/A	N/A	N/A	N/A
Factor 3: Preparation for high need schools	0.730	328.653	65	0.646	0.686	0.121
Factor 4: Path to teaching	0.722	31.047	14	0.938	0.964	0.066
Factor 5: District/school high need environment	0.716	89.400	5	0.714	0.716	0.247
Factor 6: Personal beliefs towards teaching	0.611	55.048	20	0.603	0.659	0.080
Factor 7: School teaching environment	0.775	0.769	2	0.994	1	0.000
Factor 8: Mentoring experience	0.724	106.180	9	0.723	0.732	0.198

After forming the eight factors, factor scores created by the multiple regression method were assigned for each scholar. Later, HLMs were used to differentiate the program effect from the scholars' factor score variance. HLMs were also used to identity which variables at the scholar level and the program level have influence on scholars' perceptions of their decisions to become a teacher or teach in a high needs schools. Therefore, Factor 1: Scholars' perception of the influence of scholarship on becoming teachers, and Factor 2: Scholars' perception of the influence of scholarship on becoming high need teachers were used as the two outcome variables in the analysis. Other variables were used as explanatory variables (Table 1). Factor 3 and factor 8 were mean aggregated within programs and used as level 2 (program) predictors as well as level 1 (scholar) predictors.

Table 3
Items in Factor 3: Preparation for high need school

Item content	Item option
Develop specific strategies for teaching students from diverse racial and ethnic backgrounds	1: None; 2: Touched on it briefly; 3: Spent time discussing or doing; 4: Explored in some depth; 5: Extensive opportunity
Consider the relationship between education and social justice and/or democracy	1: None; 2: Touched on it briefly; 3: Spent time discussing or doing; 4: Explored in some

Item content	Item option
	depth; 5: Extensive opportunity
Education about how to work in high need schools specifically	1: No; 2: Yes
Develop specific strategies for teaching English language learners (those with limited English proficiency)	1: None; 2: Touched on it briefly; 3: Spent time discussing or doing; 4: Explored in some depth; 5: Extensive opportunity
Develop specific strategies for teaching students identified with learning disabilities	1: None; 2: Touched on it briefly; 3: Spent time discussing or doing; 4: Explored in some depth; 5: Extensive opportunity
Student teaching experience in a high need school	1: No; 2: Yes
Supervised actual classroom teaching in high need schools (this may be called student teaching, internship, etc. in your state)	1: No; 2: Yes
Opportunities to observe/work at high need schools (not student teaching)	1: No; 2: Yes
Education about different cultures	1: No; 2: Yes
Student teaching experience	1: No; 2: Yes
Opportunities to interact with children from different cultures	1: No; 2: Yes
Education field experience (e.g. tutoring, teacher aide) working in schools with young people like those who attend high need schools	1: No; 2: Yes
Opportunities to interact with adults from different cultures	1: No; 2: Yes

Table 4

Items in Factor 8: Mentoring experience

Item content	Item option
Mentoring experiences provided by your certification program during your second year of teaching	1: No; 2: Yes
Mentoring experiences provided by your district during your second year of teaching	1: No; 2: Yes
Mentoring experiences provided by your certification program during your first year of teaching	1: No; 2: Yes
Mentoring experiences provided by your district during your first year of teaching	1: No; 2: Yes
A guaranteed job (assuming successful completion of program) at a participating school district	1: No; 2: Yes
Continuing contact with participants in your teacher education program	1: No; 2: Yes

As mentioned in the instrument section, not all of the scholars answered all survey items, so not all six explanatory variables can be used in HLMs for all scholars. More detailed information about items which were responded to by scholars from certain groups is listed in Appendix A. Only Factor 3: Preparation for high need schools, Factor 4: Path to teaching, and Factor 8: Mentoring experience can be analyzed in HLMs for the whole scholars. Scholars who were currently teaching full- or part-time are the majority in the dataset, and responded to all items in the survey. Therefore, these current STEM teachers' data, a subset of the whole data, can be analyzed using all six factors in HLMs. However, because of a concern that small numbers of scholars within a program may yield inaccurate estimates, if the number of a group of scholars who come from the same program is less than five, these scholars' data would be not used in HLM. Therefore, in the end, 527 scholars from 43 programs were used for analysis. As for the current STEM teachers group data, 312 scholars from 42 programs were used for analysis. The results of HLMs for the two outcome variables for the two groups (whole scholars group and current STEM teachers group) are presented in the following section, respectively.

HLM Results for Factor 1: Scholars' perception of the influence of the scholarship on becoming teachers

Two-level hierarchical linear modeling was used to examine the effect of the different variables at the scholar level and the variables of the program level on Factor 1: Scholars' perception of the influence of scholarship on becoming teachers.

A fully unconditional random intercept model was first fit to Factor 1 scores to determine how much variation in the outcome variable lies within and between programs.

For the outcome variable (Factor 1: scholars' perception of the influence of scholarship on becoming teachers) HLM analysis for the whole scholars group, $\hat{\sigma}^2 = 0.788$ is a variance component that provides information about variability within programs, and $\hat{\tau}_{00} = 0.080$ is a variance component that provides information about variability between programs factor scores means. Therefore, the intraclass correlation, $\hat{\rho}_I$, is 0.092. It means that 9.2% of Factor 1 variation is between programs. The chi-square of 97.789 is significant at $\alpha = 0.05$ and tells us that there is significant variation among the program factor score means. Moreover, the average reliability, λ, of the program factor score means is 0.515. For the current STEM teachers group, $\hat{\sigma}^2 = 0.745$ and $\hat{\tau}_{00} = 0.087$, so $\hat{\rho}_I$ is 0.105. Therefore, 10.5% of Factor 1 variation is between programs. The chi-square of 78.382 is also significant. The average reliability is 0.414. The results from both unconditional models suggest that two-level HLMs are needed for both analyses of the Factor 1 score.

We then proceeded to fit conditional models because conditional models adding other potential explanatory variables can explain more variability. The two conditional models (1-all scholars in equation 3, 2-current STEM teacher group in equation 4) as follows:

Model 1: HLM for the whole scholar groups **(3)**

Level 1: Whole scholars

$$Y_{ij} = \beta_{0j} + \beta_{1j}(Factor3) + \beta_{2j}(Factor4) + \beta_{3j}(Factor8) + r_{ij}$$

Level 2: Program

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(aggregatedFactor3) + \gamma_{02}(aggregatedFactor8) + u_{0j}$$
$$\beta_{1j} = \gamma_{10}$$
$$\beta_{2j} = \gamma_{20}$$
$$\beta_{3j} = \gamma_{30}$$

Model 2: HLM for the current STEM teacher groups **(4)**

Level 1: Current STEM teachers

$$Y_{ij} = \beta_{0j} + \beta_{1j}(Factor3) + \beta_{2j}(Factor4) + \beta_{3j}(Factor5) + \beta_{4j}(Factor6) + \beta_{5j}(Factor7) + \beta_{6j}(Factor8) + r_{ij}$$

Level 2: Program

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(aggregatedFactor3) + \gamma_{02}(aggregatedFactor8) + u_{0j}$$

$\beta_{1j} = \gamma_{10}$
$\beta_{2j} = \gamma_{20}$
$\beta_{3j} = \gamma_{30}$
$\beta_{4j} = \gamma_{40}$
$\beta_{5j} = \gamma_{50}$
$\beta_{6j} = \gamma_{60}$

The results of the two conditional HLMs (for the whole scholar and the current STEM teacher group), are presented below in Table 5.

Table 5
Impact of Factors on Scholars' Perception of the Influence of the Scholarship on Becoming Teachers for "Whole Scholars" Group and "Current STEM Teachers" Group

	Whole scholars		Current STEM teachers	
	Coef.	*SE*	Coef.	*SE*
Level 2				
Intercept, γ_{00}	0.014	0.057	0.015	0.066
Aggregated Factor3, γ_{01}	-0.213**	0.102	-0.270**	0.124
Aggregated Factor8, γ_{02}	0.232	0.151	0.256	0.200
Level 1				
Factor3, β_{10}	0.054	0.052	0.094	0.055
Factor4, β_{20}	0.052	0.049	0.009	0.066
Factor5, β_{30}	N/A		0.125	0.076
Factor6, β_{40}	N/A		-0.117	0.063
Factor7, β_{50}	N/A		-0.025	0.055
Factor8, β_{60}	0.115**	0.052	0.067	0.075

Note. There were 527 scholars in 43 programs in the “whole scholars” group. There were 312 scholars in 42 programs in the “current STEM teachers” group. Coef. = coefficient.
**p<.05. *** p<.01.

Data were analyzed to address what kinds of program and scholar variables are associated with Factor 1 scores: Scholars’ perception of the influence of the scholarship on becoming teachers”. For the whole scholars group, the statistical results show that aggregated “Factor 3: Preparation for high need schools” at the level two had a significant impact on Factor 1 ($\beta = -0.213$; $SE = 0.102$; p-value<0.05). It shows that when the average Factor 3 increased one unit above the grand mean Factor 3 scores, the intercept scores decrease 0.213 units after controlling for other predictors. Moreover, “Factor 8: Scholar’s mentoring experience” was a significant predictor of factor 1 scores ($\beta = 0.115$; $SE = 0.052$; p-value<0.05). This conditional model has $\hat{\sigma}^2 = 0.772$ and $\hat{\tau}_{00} = 0.067$, so the intraclass correlation, $\hat{\rho}_I$, is 0.080. It means that this conditional model can explain more variability then the unconditional model by 0.8%. In addition, the deviance test for the unconditional and the conditional model is significant (χ^2_5 <14.398).

On the other hand, for the current STEM teachers group, the statistical results also show that the average program factor 3 score was a significant predictor of Factor 1 score intercept ($\beta = -0.270$; $SE = 0.124$; p-value<0.05). However, for the STEM teachers group, there were no variable at the scholar level related to factor 1 scores. This conditional model has $\hat{\sigma}^2 = 0.716$ and $\hat{\tau}_{00} = 0.072$, so the intraclass correlation, $\hat{\rho}_I$, is 0.091. It means that this conditional model also can explain more variability then the unconditional model by 1.4%. However, the deviance test for the unconditional and the conditional model is not significant (χ^2_8 >15.090). Due to the parsimony, the conditional model may not be used.

HLM Results for Factor 2: Scholars' perception of the influence of the scholarship on becoming high need teachers

A fully unconditional random intercept model was first fit to the factor score of "Factor 2: Scholars' perception of the influence of the scholarship on becoming high need teachers" to estimate variation between programs.

For the outcome variable (Factor 2: Scholars' perception of the influence of scholarship on becoming high need teachers) HLM analysis for the whole scholars group, $\hat{\sigma}^2 = 0.832$ is a variance component that provides information about variability within programs, and $\hat{\tau}_{00} = 0.042$ is a variance component that provides information about variability between programs factor scores means. Therefore, the intraclass correlation, $\hat{\rho}_I$, is 0.048. It means that 4.8% of Factor 2 variation is between programs. The chi-square of 66.966 is significant at $\alpha = 0.05$ and tells us that there is significant variation among the program factor score means. Moreover, the average reliability, λ, of the program factor score means is 0.356. For the current STEM teachers group, $\hat{\sigma}^2 = 0.862$ and $\hat{\tau}_{00} = 0.056$, so $\hat{\rho}_I$ is 0.061. Therefore, 6.1% of Factor 2 variation is between programs. The chi-square of 78.382 is also significant. The average reliability is 0.295. The results from both unconditional models suggest that two-level HLMs are needed for both analyses of the Factor 2 score.

The results of the conditional HLMs for the two groups (for the whole scholar and the current STEM teacher group), are presented in Table 6 below.

Table 6

Impact of Factors on Scholars' Perception of the Influence of Scholarship on Becoming High need Teachers for "Whole Scholars" Group and "Current STEM Teachers" Group

	Whole scholars	Current STEM teachers

	Coef.	*SE*	Coef.	*SE*
Level 2				
Intercept, γ_{00}	0.025	0.051	-0.039	0.066
Aggregated Factor3, γ_{01}	-0.006	0.118	-0.004	0.160
Aggregated Factor8, γ_{02}	-0.078	0.132	-0.114	0.203
Level 1				
Factor3, β_{10}	0.135***	0.046	0.129**	0.061
Factor4, β_{20}	-0.005	0.050	0.031	0.063
Factor5, β_{30}	N/A		0.078	0.079
Factor6, β_{40}	N/A		-0.040	0.081
Factor7, β_{50}	N/A		-0.098	0.078
Factor8, β_{60}	-0.024	0.055	0.056	0.072

Note. There were 527 scholars in 43 programs in the "whole scholars" group. There were 312 scholars in 42 programs in the "current STEM teachers" group. Coef. = coefficient.
***p*<.05. *** *p*<.01.

Data were analyzed to address what kinds of program and scholar variables are associated with Factor 2 scores: Scholars' perception of the influence of scholarship on becoming high need teachers. For the whole scholars group, the statistical results show that no aggregated variable at the level 2 had a significant impact on Factor 2, but "Factor 3: Preparation for high need schools" at the level 1 had a significant impact on Factor 2 ($\beta = 0.135$; $SE = 0.046$; *p*-value<0.01). It shows that when a scholar's Factor 3 score increased one unit above the grand mean, the Factor 1 scores of would increase 0.135 units above the mean. Further, this conditional model has $\hat{\sigma}^2 = 0.823$ and $\hat{\tau}_{00} = 0.038$, so the intraclass correlation, $\hat{\rho}_I$, is 0.044. It means that this conditional model can explain more variability then the unconditional model by 0.4%. However, the deviance test for the unconditional and the conditional model is significant (χ_5^2 >7.412). The conditional model may not be considered to be used.

On the other hand, for the current STEM teachers group, the statistical results also show no aggregated variables at the program level has a significant impact on Factor 1, but Factor 3 at the scholar level also had a significant relationship with Factor 2 ($\beta = 0.129$; $SE = 0.061$; *p*-value<0.05). This conditional model has $\hat{\sigma}^2 = 0.834$ and $\hat{\tau}_{00} = 0.061$, so the intraclass correlation, $\hat{\rho}_I$, is 0.068. It means that this conditional model explain less variability then the unconditional model. The conditional model would not be considered to be used.

Discussion

This study showed an example of using EFA, CFA and HLMs to analyze survey data. As mentioned in the introduction section, survey is one most commonly used tools for measuring peoples' perceptions. When this larger amount of quantitative information is collected, researchers may build statistical models which explain respondents' perceptions.

In this study, we used the NSPES Survey as the demonstration how these statistical methods can be appropriately used in similar situations. NSPES is composed of 71 items. A multitude of information can be obtained from the survey, but it is undesirable to use individual items to do further analysis. First, too many items can be put in analyses. Second, all items from the NSPES Survey are either dichotomous or rating-scale, but continuous items can reflect a construct more precisely. Therefore, the EFA was utilized to analyze the survey, and further CFA was used to confirm the structures. After finalizing the eight-factor structure, factor scores were created for the following HLMs analyses.

555 scholars from 43 programs responded the NESPES Survey. It is assumed that not only scholars' individual characteristics, but also programs' characteristics would influence their perception about the influence of the scholarship to become teachers and to become high need teachers. Especially, scholars coming from the same program tend to have similar characteristics because of similar program training and curriculum. Therefore, HLMs were utilized to differentiate programs' effect on scholars' perceptions and to identity which variables in the scholar level and in the program level had influence on scholars' perceptions.

The results from HLMs show that program effects can account for some variability of scholars' for outcome variables (Factor 1: Scholars' perception of the influence of scholarship on becoming teachers and Factor 2: Scholars' perception of the influence of scholarship on becoming high need teachers) in both groups (whole scholars group and current STEM teachers group).

For Factor 1 outcome variable, Factor 3: Preparation for high need schools at the program level has statistically significant impact on both the whole scholars group and the current STEM teachers group. The results show that there was a negative relationship between the aggregated factor scores of Factor 3 at the program level and the factor scores of Factor 1. For Factor 2 outcome variable, Factor 3 at the scholar level has statistically significant positive impact on both groups. However, these explanatory variables are not major influential variables to impact the outcome variables, since they cannot explain much variability.

There were several limitations of this study that require discussion. First, the sample size in this study is 555 which is comparatively small for using EFA for exploring the 71 items and CFA for validating 49 items. The recommended minimum for a valid factor analysis is 300. Moreover, some CFA fit statistics for several factors are not quite satisfactory. We do think the larger sample size would improve this study. However, due to the limited resources, we still had to use EFA and CFA on the 555 scholars' perceptions.

Second, we analyzed the same data twice for each outcome variables (Factor 1: Scholars' perception of the influence of scholarship on becoming teachers and Factor 2: Scholars' perception of the influence of scholarship on becoming high need teachers), so the issues of compounding Type I error have to be considered.

Third, the data were from a cross-sectional evaluation survey and it did not employ an experimental or quasi-experimental design. Therefore, there is no evidence or basis to say causal relationships exist among the scholars' and programs' characteristics and ultimately their perceptions of the commitment to teach and teach in high needs school. The only credible statements that can be made from the data are statements regarding correlations. We were also unable to track the scholarship recipients and see how their perceptions evolved over time. A longitudinal study would have allowed a more thorough understanding of how these perceptions evolved into tangible decisions that teachers make when deciding to remain in teaching.

Another limitation of this study was that this research project was a subset of a program evaluation. Because of this, we were limited by the instrument and could not examine variables that might have proven to be more relevant to examining the relationship between scholarship and perceptions about teaching and recipients' demographics. As mentioned above, the chosen explanatory variables in this study did not have strong impact on reducing variability. Future research might use other items that more appropriately measure these constructs and ask about decision to teach as well as examining other potentially useful demographic characteristics that were unavailable in this study.

In summary, the importance of this study lies in the demonstration of how EFA, CFA, and HLMs can be used in analyzing survey data. The broader context for the application can be applied in similar survey data analyses.

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Appendix A.

Eight Factors for the NSPES Survey/Groups of Scholars within the Eight Factors

Factor 1: Scholars' perception of the influence of scholarship on becoming teachers (the total number of items=3)			
Item	Standardized regression weights from CFA	Squared multiple correlations	Groups
IV.8.a Become a teacher	0.88	0.78	All groups
IV.8.b Complete the certification program	0.86	0.74	All groups
IV.8.c Take a teaching job	0.80	0.64	All groups

Factor 2: Scholars' perception of the influence of scholarship on becoming high need teachers (the total number of items=3)			
Item	Standardized regression weights from CFA	Squared multiple correlations	Groups
IV.8.d Teach in a high need school	0.87	0.75	All groups
IV.8.e Remain teaching in a high need school for the full term of your commitment	0.91	0.83	All groups
IV.8.f Remain teaching in a high need school beyond the full term of your commitment	0.77	0.60	All groups

Factor 3: Preparation for high need schools (the total number of items=13)			
Item	Standardized regression weights from CFA	Squared multiple correlations	Groups
II.4.c Develop specific strategies for teaching students from diverse racial and ethnic backgrounds	0.82	0.68	All groups
II.4.d Consider the relationship between education and social justice and/or democracy	0.67	0.45	All groups
II.1.e Education about how to work in high need schools specifically	0.48	0.23	All groups
II.4.a Develop specific strategies for teaching English language learners (those with limited English proficiency)	0.66	0.44	All groups
II.4.b Develop specific strategies for teaching students identified with learning disabilities	0.76	0.57	All groups
II.1.h Student teaching experience in a high need school	0.28	0.08	All

			groups
II.2.d Supervised actual classroom teaching in high need schools (this may be called student teaching, internship, etc. in your state)	0.27	0.08	All groups
II.1.f Opportunities to observe/work at high need schools (not student teaching)	0.31	0.10	All groups
II.1.c Education about different cultures	0.32	0.10	All groups
II.1.g Student teaching experience	0.18	0.03	All groups
II.1.b Opportunities to interact with children from different cultures	0.41	0.17	All groups
II.2.a Education field experience (e.g. tutoring, teacher aide) working in schools with young people like those who attend high need schools	0.24	0.06	All groups
II.1.a Opportunities to interact with adults from different cultures	0.31	0.10	All groups

Factor 4: Path to teaching (the total number of items=7)

Item	Standardized regression weights from CFA	Squared multiple correlations	Groups
IV.2 What age were you when you began the teacher certification program?__years	0.81	0.65	All groups
V.3 Did you work full time before becoming a teacher? If yes, in what field was the majority of your work? If yes, in what field was the majority of your work?	0.74	0.54	All groups
IV.1 At what point in your life did you decide to become a STEM teacher?	0.74	0.55	All groups
V.4 In becoming a teacher, do you consider yourself to have made a “career changer”?	0.72	0.52	All groups
V.1.a How many STEM classes were taken?	0.43	0.19	All groups
V.2.a In what year did you last take a formal course for college credit in: Mathematics	0.30	0.09	All groups
V.2.b In what year did you last take a formal course for college credit in: Science	0.38	0.14	All groups

Factor 5: District/school high need environment (the total number of items=5)

Item	Standardized regression weights from CFA	Squared multiple correlations	Groups
III.4.b Over 33% of teachers lack sufficient training in their academic area.(district)	0.40	0.16	4, 5, 6, 7

III.3.b Over 33% of teachers lack sufficient training in their academic area.(school)	0.27	0.07	4, 5, 6, 7
III.3.a Over 50% of students receive free or reduced lunch.(school)	0.90	0.82	4, 5, 6, 7
III.4.a Over 50% of students receive free or reduced lunch.(district)	0.84	0.71	4, 5, 6, 7
III.1 Which of the following describes your current teaching status?	0.62	0.38	4, 5

Factor 6: Personal beliefs towards teaching (the total number of items=8)

Item	Standardized regression weights from CFA	Squared multiple correlations	Groups
III.2.a I am satisfied with my current teaching job	0.52	0.27	4, 5, 6, 7
III.2.c If I had to do it all over again, in view of my present knowledge, I would become a teacher	0.58	0.33	4, 5, 6, 7
III.2.d If I had it to do all over again, I would choose the same teacher preparation program and/or route into teaching	0.44	0.19	4, 5, 6, 7
III.2.e In the next three years, I am likely to assume a leadership position (e.g., lead teacher, department chair, official or unofficial mentor)	0.52	0.27	4, 5
IV.3.f I feel that I have a talent for teaching STEM	0.26	0.07	All groups
III.5 Within the last three years have you held any professional educational leadership positions, e.g., lead mathematics teacher, science committee chair, etc.	0.32	0.10	4, 5
IV.3.d I like the flexibility and/or autonomy of STEM teaching	0.27	0.07	All groups
IV.3.b I like working with young people	0.23	0.06	All groups

Factor 7: School teaching environment (the total number of items=4)

Item	Standardized regression weights from CFA	Squared multiple correlations	Groups
III.6.b Strong collaborative leadership (e.g., principals and other leaders provide teachers with opportunities to do well; principals and other leaders can be trusted; principals and other leaders share your vision of successful classroom practice)	0.82	0.67	4, 5, 6, 7
III.6.a Collegial relationships (e.g., teachers consult on the quality of student work and make joint decisions based on assessment, collaborate to solve classroom	0.56	0.32	4, 5, 6, 7

challenges, observe and discuss each others			
III.6.d Mentoring and/or induction support (e.g., organized, supported contact with a more experienced teacher, help with issues particular to early career teaching)	0.63	0.40	4, 5, 6, 7
III.6.c Availability of supplies or material (e.g., textbooks, print resources, instructional materials such as lab supplies or math manipulatives, and classroom supplies such as paper, pencils, or tape)	0.57	0.32	4, 5, 6, 7

Factor 8: Mentoring experience (the total number of items=6)

Item	Standardized regression weights from CFA	Squared multiple correlations	Groups
II.1.l Mentoring experiences provided by your certification program during your second year of teaching	0.83	0.69	All groups
II.1.m Mentoring experiences provided by your district during your second year of teaching	0.45	0.20	All groups
II.1.j Mentoring experiences provided by your certification program during your first year of teaching	0.75	0.57	All groups
II.1.k Mentoring experiences provided by your district during your first year of teaching	0.38	0.15	All groups
II.1.i A guaranteed job (assuming successful completion of program) at a participating school district	0.42	0.18	All groups
II.1.n Continuing contact with participants in your teacher education program	0.38	0.14	All groups

Groups

1. In a teacher certification program, not yet a full-time teacher
2. Completed a teacher certification program, but never taught
3. Did not complete a teacher certification program and will not return
4. In a teacher certification program and teaching full-time as part of that program
5. Teacher full-time or part-time
6. Taught after being certified and now working in education but not as a teacher
7. Taught after being certified and now not working in education