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A Latent Class Analysis of Student Science Attitudes, Perceived Teacher Support and STEM Career Attainment

[1]Karen Nylund-Gibson, [2]Marsha Ing, [1]Kyusang Park
[1]*Gevirtz Graduate School of Education, University of California, Santa Barbara*
[2]*Graduate School of Education, University of California, Riverside*

--ABSTRACT--
There is a global need to increase the number of students pursuing science and mathematics careers to fill 21st century occupations. The purpose of this study is to explore the role of teachers in encouraging students to pursue these types of careers. Latent class analysis is used to analyze survey responses from a nationally representative sample of seventh graders from the United States (N = 2,835). Students were surveyed about their interest in science, their perceptions of the utility of science, and their perceptions of their science teachers' support to pursue careers in science. Findings indicate that there are students who are interested in science careers but do not perceive that their science teachers encourage this interest. Interest and perceived support from teachers were related to student science career attainment approximately 20 years later. These findings have implications for preparing teachers to support student careers in science, technology, engineering, and mathematics.

Keywords *– education, science, mathematics, teachers, students, perceptions.*

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I. INTRODUCTION

Many employment opportunities in the 21st century's global economy require knowledge and skills in mathematics and science. To educate a competitive workforce, the United States invests in funding from early childhood to job training. For example, funding is allocated to recruit and prepare 100,000 science, technology, engineering, and mathematics teachers within the decade [1]. There are many questions around how to best recruit and prepare these 100,000 teachers. While there is consensus that these teachers need content knowledge (see for example, [2]), knowledge of the teaching the particular content area (see for example, [3]), and knowledge of students (see for example, [4]), there is less consensus on the other skills and knowledge that these teachers need to educate a competitive workforce. This study addresses one aspect that may be useful for these future teachers. In particular, this study focuses on mathematics and science teacher encouragement of student pursuit of mathematics and science careers. This research draws on existing literature on the influence of teachers on student attitudes, achievement, and career interests and extends this extensive body of research to explore the influence of mathematics and science teacher encouragement to pursue mathematics and science careers while considering student attitudes towards science. In doing so, this study explores one characteristic of future teachers that may increase the number and quality of students who can compete in the 21st century's global marketplace.

II. BACKGROUND

There is extensive literature on early career interests and development of attitudes toward science (for review see [5]). There are complex and interdependent factors such as families [6], peers [7], and teachers [8] that influence the ways in which individuals may develop interest in science. Social cognitive career development theory suggests that attitudes help regulate students' career behavior by influencing choices and attainment [9]. This theory places an emphasis on early attitudes and interests in activities that have potential career relevance because of the influence on future career interests and factors that help shape these early attitudes. Students with supportive experiences are more likely to develop interest in these types of activities and pursue careers that involve these types of interests. Similarly, students with less supportive experiences are less likely to develop interest in these types of activities and pursue careers with these types of activities.

This study builds on this extensive literature by using a method to classify student attitudes toward science in seventh grade. In this study, attitude is defined in terms of the perceived utility or value of science from the student's perspective. While there are numerous factors that influence student attitudes and their persistence in science, this study focuses on science teachers. In particular, this study includes student perceptions of their science teacher's encouragement to pursue science because this is one potentially malleable factor that can increase student persistence in science careers. This study explores differences in attitudes in terms of gender and ethnicity and relates these differences to whether or not these students were in a science, technology, engineering, or mathematics (STEM) occupation by their mid-30's.

III. METHOD

3.1. Sample

A nationally representative sample of seventh graders in 1987 who participated in the Longitudinal Study of American Youth (LSAY) are included in this study (N = 2,835). These seventh graders were from 52 middle schools across the United States. Approximately 60 students were randomly selected from each school. The sample was predominantly White (70%). The sample included 9% Hispanic, 11% African American, 4% Asian, 2% Native American (5% of students did not indicate any race/ethnicity), and approximately equal numbers of females (48%) and males (52%). Less than half of the students in the sample (31%) had at least one parent who completed college. In 2007, when these students were in their mid-30's, more than 95% of the original sample completed a questionnaire about their educational and occupational outcomes [10, 11].

3.2. Measures

The following five items from the seventh grade LSAY survey were included in this study: Science is useful in everyday problems, I need science for a good job, I will use science often as an adult, current science teacher encourages me in science, and current science teacher encourages me to pursue a career in science and mathematics. The response options were: strongly agree, agree, not sure, disagree, and strongly disagree. These options were coded so that a higher value (5) indicated stronger agreement or more positive attitudes, and a lower value (1) indicated less agreement or less positive attitudes. In addition to responses to these survey items, this study includes student demographic characteristics (mother's education, gender, and ethnicity) and whether or not the student was employed in a science, technology, engineering, or mathematics (STEM) occupation in 2007 or not. A dichotomous variable of ethnicity was created: White and Asian (ethnicities not typically underrepresented in STEM fields), and African American, Hispanic/Latino, and Native American (ethnicities typically underrepresented in STEM fields). The student's mother's education was included as a control variable and treated as a continuous variable in the analysis. For this sample, 56% of the mothers earned a high school diploma, 12% earned a college degree, and 5% earned advanced degrees. The sample included 77% non-underrepresented students and 23% underrepresented students. A majority of the sample (85%) was not employed in a STEM occupation in 2007.

3.3. Analysis

Latent class analysis [12, 13, 14, 15] using the software package Mplus [16] was used to identify latent subgroups of students who differ in terms of their attitudes toward science careers and their perceptions of the support their teachers provide in terms of pursuing mathematics and science careers. Because LCA is an exploratory analysis, the number and type of latent classes, or latent subgroups, that exists is not known a priori. A series of models were fit, varying the number of latent classes between one and five. We used commonly accepted fit statistics to compare fit of the models to determine the best number of latent classes. Of the fit indices considered were the Bayesian Information Criterion (BIC) [17], the Lo-Mendell-Rubin likelihood ratio test (LRM), and the Bootstrapped likelihood ratio test (BLRT; for more on the LMR and BLRT, see [18]).

Once the number of classes was identified using fit indices, covariates (mother's education, ethnicity, and gender) and a distal outcome (STEM occupation in 2007) were related to the latent classes. The mean of the distal outcome was estimated for each of the latent classes using pseudoclass draws in Mplus. The p-values from a series of pairwise Wald tests were used to test for significant difference in means across the classes [19].

IV. RESULTS

The results will be presented in two sections. First, we will present the class enumeration process and the final chosen latent class model, then the relationship between the latent classes and the covariates and the distal outcome will be presented.

4.1 Class enumeration

Table 1 presents the fit indices for the one- though five-class models considered in this paper. Results indicated that a four-class solution fit best based on the lowest value of the BIC (15378.24) and the non-significant p-values for both the LMR and BLRT for the five-class solution, indicating that the four-class model fits best.

Table 1. Summary of Latent Class Analysis Fit Indices with 1-5 Latent Classes

# of classes	Log likelihood	# of parms.	BIC	LMR p-value	BLRT p-value
1	-8654.52	5	17349.22	-	-
2	-7717.07	11	15522.56	0.00	0.00
3	-7632.59	17	15401.83	0.00	0.00
4	-7596.68	23	15378.24	0.04	0.00
5	-7591.44	29	15415.98	0.06	0.12

Figure 1 presents the item probability plot with the five science attitude items along the x-axis and the probability of endorsing a given item along the y-axis. The four latent classes are differentiated by color. The blue class, labeled *Science is useful, teacher encouragement*, consists of 12% of the students and is characterized by having high probability for both the science is useful items and teach encouragement. The red class, labeled *Science is useful, no teacher encouragement*, consists of 29% of the students, is characterized by having high probability for science is useful item, but do not feel encouraged by their teachers. The green class, which is 23% of the students, is characterized by having low probability of endorsing the science is useful items and moderate probability of endorsing the teacher support items. We labeled this class the *Science is not useful, teach encouragement* class. And lastly, the purple class, labeled *Science is not useful, no teacher encouragement* is 36% of the students and is characterized by students who have low probability of endorsing the science is useful items and the teacher encouragement class.

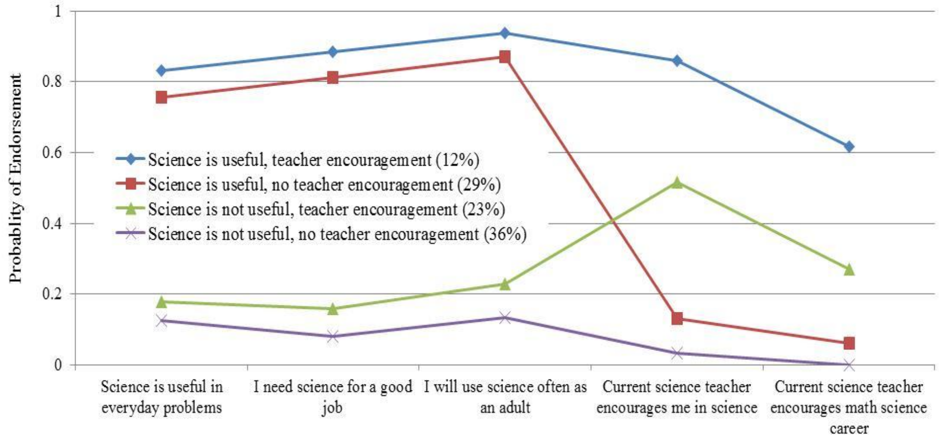

Figure 1. Four-class item probability plot.

4.2 Covariates and Distal Outcomes

Table 2 presents the covariate results of the regression of the latent classes onto the three covariates considered in this study: mother's education, ethnicity, and gender. We present the logit value, their standard errors, the corresponding t statistic, and the p-value of the logit. The reference class in the comparisons is the *Science is useful, teacher encouragement* class.

Table 2. Logit Coefficients, Standard Errors (S.E.), t values and p-values For the Four-class Solution with Mother's Education, Ethnicity, and Gender (coded 1=female, 0=male) Using the *Science is useful, teacher encouragement* Class as the Reference Class.

Covariate	*Est.*	*S.E.*	*t*	*p-value*
Science is useful, no teacher encouragement				
Mother's educ.	-0.12	0.22	-0.52	0.60
Ethnicity	0.97*	0.21	4.57	<0.01
Gender	0.25	0.19	1.29	0.20
Science is not useful, teacher encouragement				
Mother's educ.	-0.40*	0.17	-2.44	0.02
Ethnicity	0.29	0.19	1.56	0.12
Gender	0.35*	0.15	2.36	0.02
Science is not useful, no teacher encouragement				
Mother's educ.	0.51*	0.14	-3.60	<0.01
Ethnicity	-0.37	0.19	-1.93	0.05
Gender	0.81*	0.13	6.17	<0.01

Comparing the students in the *Science is useful, no teacher encouragement* class to the students in the *Science is useful, teacher encouragement* class, there are no differences with respect to mothers' education (-0.12, p >0.05) or gender (0.25, p >0.05). There were, however, significant differences in ethnicity (0.97, p <0.05). That is, underrepresented students are significantly more likely to be in the *Science is useful, no teacher encouragement* class compared to the *Science is useful, teacher encouragement* class.

Results indicate no differences in ethnicity (0.29, p >0.05) when comparing the students in the *Science is not useful, teacher encouragement* class to the *Science is useful, teacher encouragement* class. However, there were significant differences with respect to mothers' education (-0.40, p <0.05) and gender (0.35, p <0.05).

That is, students whose mothers had higher education were less likely to be in the *Science is useful, teacher encouragement* class compared to the Science *is useful, teacher encouragement* class. Further, female students were significantly more likely to be in the *Science not is useful, teacher encouragement* class compared to the *Science is useful, teacher encouragement* class.

Lastly, there were no ethnicity differences (-0.37, $p > 0.05$) when comparing the *Science is not useful, no teacher encouragement* class to the *Science is useful, teacher encouragement* class. There are differences with respect to mothers' education (0.51, $p<0.05$) and gender (0.81, $p<0.05$). That is, as a student's mother's education increases, they were more likely to be in the in *Science is not useful, no teacher encouragement* class compared to the *Science is useful, teacher encouragement* class. Further, female students were significantly more likely to be in the *Science is not useful, no teacher encouragement* class compared to the *Science is useful, teacher encouragement* class.

4.2.1 Distal Outcome

The distal outcome used in this study was whether or not the student was employed in a STEM occupation in 2007. The variable was coded 1=STEM occupation 0=no STEM occupation, so the means presented in Table 3 are the proportion of students in each of the latent classes that went into a STEM occupation in 2007.

Table 3. Proportion of Students in Each of the Latent Classes Who Went into a STEM Occupation.

Latent class	Mean	S.E.
Science is useful, teacher encouragement	0.082_a	0.03
Science is useful, teacher encouragement	0.117_a	0.02
Science is not useful, teacher encouragement	0.063_b	0.02
Science is not useful, no teacher encouragement	0.061_b	0.01

Note. Mean values that do not share a subscript are significantly different from each other.

Results indicate that students in the top two classes, *Science is useful, teacher encouragement* and *Science is useful, teacher encouragement,* have the same probability of being in a STEM career in 2007. These two classes have significantly higher chances, nearly twice as many, of going into a STEM occupation compared to the bottom two classes, *Science is not useful, teacher encouragement* and *Science is not useful, no teacher encouragement.*

V. CONCLUSION

Findings from the latent class analysis of a nationally representative sample of seventh graders in the United States suggests that there are students who express early interest in science but do not perceive support from their science teachers to pursue careers in science. This study focused on early support from teachers and student interest in science in seventh grade, given that this is a time when many students are making decisions about what careers to pursue and what courses to take that directly impact their STEM opportunities [20, 21]. Students who do not take the required mathematics and science courses in high school will not be prepared to take college-level STEM courses in college [22]. Thus, without early support and encouragement, the pipeline to STEM occupations lose students who may have been interested in STEM careers early on but dropped out at various points in their schooling. Teachers can nurture students who have an early interest in science, but teachers are just one component in creating this STEM pipeline. In this sample, students who perceived support from their teacher but did not find science to be useful were not likely to attain STEM careers. Underrepresented students in particular were more likely to think science is useful but did not perceive their teachers to encourage their interest in science.

This is an important finding as the United States seeks to prepare large numbers of teachers who will directly influence student interest and persistence in STEM careers. These findings suggest that it is not only important to recruit and prepare teachers who have knowledge and skills, but it is also important to consider ways in which teachers can specifically encourage or support students to pursue STEM careers and help students see the utility or value in science. One example of how teachers can encourage or support students is to have an increased awareness of how student interest in science can be translated to the wide array of STEM careers. Students who are interested in helping others through science might be encouraged to explore careers in science and engineering that focus on designing devices that provide new treatment options for brain cancer or traumatic brain injuries, or creating new materials to increase access to clean water. Many teachers may not be fully aware of the range of possible STEM careers and the ways in which student interests can be matched to these diverse careers.

One limitation of this study is that we define early interest in science based on seventh grade student responses. This focus on early interest in seventh grade is consistent with other research that found that no students who began tenth grade with moderate or lower interest in science ever developed a stronger interest later in high school [23]. However, there is also research suggesting that interest in science develops much sooner than seventh grade [5]. With increased attention to introduce science at earlier ages through formal and informal education opportunities, there are numerous ways in which students may develop their attitudes toward science before they reach seventh grade. Future research in this area should consider experiences and attitudes prior to seventh grade. In addition, this research focused on teachers but acknowledges that this is just one factor that influences students' career pursuits. Despite this limited focus, these findings highlight the importance of considering teacher encouragement of student pursuit of careers in science as one way to increase the number of students who are interested and prepared to pursue STEM careers.

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BIOGRAPHIES

Dr. Karen Nylund-Gibson is an assistant professor in the Gevirtz Graduate School of Education at the University of California, Santa Barbara. She earned her B.S. in Mathematics from Sonoma State University, her M.A. from the University of Nebraska, Lincoln, and her Ph.D. from the University of California, Los Angeles. She is a quantitative methodologist and her research focuses on latent variable and mixture models, such as latent class analysis. She is particularly interested in developing best practices for the application of mixture models including class enumeration and how to include covariate and distal outcome in mixture models.

Dr. Marsha Ing is an assistant professor of Educational Psychology in the Graduate School of Education at the University of California, Riverside. She earned her B.A. from the University of Hawaii at Manoa, and her M.A. and Ph.D. from the University of California, Los Angeles. Her research focuses on measuring teaching and learning in K-12 settings. She is particularly interested in applying quantitative methods to understand the mechanisms that influence STEM (science, technology, engineering, and mathematics) student outcomes.

Kyusang Park is a graduate student in the Gevirtz Graduate School of Education at the University of California, Santa Barbara, pursuing his Ph.D. in Education with emphasis on Quantitative Research Methodology. His research interests center around mixture models such as unrestricted and restricted latent class models, and their application to issues of educational measurement.