Science learning experiences in kindergarten and children's growth in science performance in elementary grades.

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Anaokulunda Sağlanan Bilim Öğrenme Deneyimlerinin Çocukların İlköğretim Fen Bilgisi Derslerindeki Performanslarına Etkisi

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Abstract

The present study aims to examine the influence of early science experiences in kindergarten on children's growth in science performance in elementary grades. The data for this study came from the Early Childhood Longitudinal Study – Kindergarten cohort (ECLS-K). A model illustrating the relationships between the early learning experiences and later academic performance in science was developed using the opportunity-propensity framework and the model was tested using the latent growth curve modeling technique. Results indicated that the antecedent (gender and socio economic status) and propensity (aptitude and motivation) variables predicted children's science performance. However, the science learning opportunities in kindergarten did not predict children's growth in science performance from third grade to eighth grade.

Keywords: Early childhood, science education, structural equation modeling, elementary schools, longitudinal studies

Öz

Bu çalışmanın amacı, anaokulunda verilen erken bilim eğitimi deneyimlerinin, çocukların ilköğretim yıllarında fen bilgisi alanında gösterdiği performansın gelişmesi üzerindeki etkisini incelemektir. Bu çalışmada Erken Çocukluk Boylamsal Araştırması – Anaokulu (ECLS-K) verileri kullanılmıştır. Fırsat-Eğilim Modellemesi kullanılarak araştırma değişkenleri arasındaki ilişkiler kuramsal olarak modellenmiş ve bu model Gizil Büyüme Eğrisi Analizi ile test edilmiştir. Sonuçlar, öncül değişkenlerin (cinsiyet ve SED) ve eğilim (yetenek ve motivasyon) değişkenlerinin çocukların fen bilgisi performanslarının anlamlı yordayıcıları olduğunu göstermiştir. Bununla beraber, anaokulunda sağlanan bilim öğrenme fırsatlarının, çocukların üç ile sekizinci sınıflar arasında fen bilgisi dersinde gösterdikleri performanstaki gelişmenin anlamlı yordayıcıları olmadığı bulunmuştur.

Anahtar Sözcükler: Erken çocukluk, bilim eğitimi, yapısal eşitlik modellemesi, ilköğretim, boylamsal araştırma.

Introduction

Research studies suggest that children's understanding of basic science concepts and their use of essential science process skills begin to develop during the first year of life (Carey, 2004;

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Kuhn & Pearsall, 2000; Piaget & Inhelder, 2000). Young children are competent in performing several cognitive skills including asking questions and making predictions that lay the foundation for learning of science concepts in elementary grades (Carey & Spelke, 1994; Kuhn & Pearsall, 2000; Opfer & Siegler, 2004; Zimmerman, 2000). Despite these capabilities, children's emerging skills usually are not the target of instructional practices in typical US and Turkish kindergarten classrooms (Early et al., 2010; Güler & Bıkmaz, 2002; Tu, 2006; Varol, in press).

Previous studies demonstrated that early learning experiences play a vital role in the development of cognitive capabilities in children (Brecht & Schmitz, 2008; Lawson, 2003; Lindsey, 1997; Rushton & Larkin, 2001). Nevertheless, early childhood educators do not fully agree on the types of experiences kindergartners should have during the early years. Some early childhood educators suggest that activities in kindergarten should be solely based on children's spontaneous play activities and see no room for intentional instructional activities in kindergarten classrooms (Bredekamp, 1987; Elkind, 1987; Hatch, 2002). Other educators suggest that the fundamental skills and basic concepts of mathematics, science, and literacy can be formally introduced in the early years (Gelman & Brenneman, 2004; Ginsburg & Golbeck, 2004; Greenes, Ginsburg, & Balfanz, 2004; French, 2004).

However, in recent years, there has been a growing consensus among early childhood educators on a more balanced view, which preserves play and involves the teaching of foundational academic skills and concepts in the early childhood curriculum (Bodrova, 2008; Bredekamp, 2006; Hyson, 2003; Spodek & Saracho, 2003). Nevertheless, few early childhood practitioners are equipped with the requisite content and pedagogical content knowledge for introducing science concepts and skills to young children.

Advocates for providing science learning experiences during the early years argue that children have a predisposition to enjoy studying the natural world. Therefore, learning science concepts and using inquiry skills in early years appear to be aligned well with the way young children make sense of their environments (Patrick, Mantzicopoulos, Samarapungavan, & French, 2008; Ramey-Gassert, 1997). Well implemented science learning experiences in early years can take advantage of children's disposition to learn about natural phenomena and support development of basic scientific concepts and inquiry skills (Büyüktaşkapu, Çeliköz, & Akman, 2012; French, 2004; Patrick, Mantzicopoulos, & Samarapungavan, 2009). Therefore, researchers advocate providing science learning experiences early in preschool years (Ginsburg & Golbeck, 2004; Kallery, 2004; Watters, Diezmann, Grieshaber, & Davis, 2000).

There is an increasing body of longitudinal studies that provide substantial evidence for the importance of early learning experiences for children's academic growth in the domains of literacy and mathematics (e.g. Bodovski & Farkas, 2007; Byrnes & Wasik, 2009; Connor, Jakobsons, Crowe, & Meadows, 2009). However, such studies are scarce in the domain of science education (Saçkes, Trundle, Bell, & O'Connell, 2011; Tao, Oliver, & Venville, 2012). A fairly scant number of longitudinal studies on the effect of early science learning experiences on children's science achievement in early and late elementary grades confines our capacity to make decisions about the impact of the science learning experiences provided in the early childhood classrooms. Such studies could provide valuable information for policy makers, curriculum developers, and teacher educators regarding the design and implementation of early childhood education curricula and programs for the training of the pre- and in-service early childhood teachers. Therefore, the present study uses the data set from Early Childhood Longitudinal Study – Kindergarten cohort (ECLS-K) to examine the effects of early science experiences in kindergarten on children's science achievement in the elementary grades. The present study extends a previous study, where we examined the impact of the frequency and duration of science teaching on the children's end of kindergarten and third grade science achievement (Saçkes et al., 2011). The current study elaborates our theoretical framework with new variables to examine the influence of the frequency of teaching specific science concepts on children's science achievement up to eighth grade.

Theoretical Framework

In this study we used the opportunity–propensity framework (Byrnes &Miller, 2007; Byrnes & Wasik, 2009; Jones & Byrnes, 2006) to study the influence of early science learning experiences in kindergarten on children's science growth from third to eighth grade. The opportunity–propensity framework is based on the premise that children's learning of a particular content depends on the learning opportunities provided to them and their capacity and motivation to take advantage of the learning opportunities (Byrnes & Wasik, 2009). In this framework, factors that provide a context to learn academic content, such as teachers' instructional practices, constitute the opportunity component of the framework. Variables such as aptitude and motivation that enhance the possibility of children taking advantage of learning opportunities constitute the propensity component (Byrnes & Miller, 2007; Byrnes & Wasik, 2009). Typically, gender and socio-economic status are used as antecedent factors in the opportunity-propensity framework. Antecedent factors are used to explain the differences among children in the level of propensity factors and the type of learning opportunities offered to them (Byrnes & Wasik, 2009). In the present study, we incorporated a new type of antecedent factor (teacher-level) into the propensity-opportunity framework. Hence, we differentiated the two types of antecedent factors used in our analysis: child-level antecedent factors and teacher-level antecedent factors.

Child-level antecedent factors of gender and socio-economic status were used to predict children's aptitude and motivation (propensity factors), the frequency of teaching earth and space, life, and physical science concepts (opportunity factors), and growth in science performance from third grade to eighth grade (outcome). We used two additional teacher-level antecedent factors to explain the variation in opportunity factors. We hypothesized that the frequency of providing science learning experiences in kindergarten is a function of the number of science methods courses teachers taken and years of teaching experience. The number of method courses and years of experience were only used to account for the variation in opportunity factors. Science learning experiences provided to children (opportunity factors) and children's aptitude and motivation (propensity factors) were used to predict children's growth in science performance from third to eighth grade. Figure 1 illustrates the hypothesized model tested in the study.

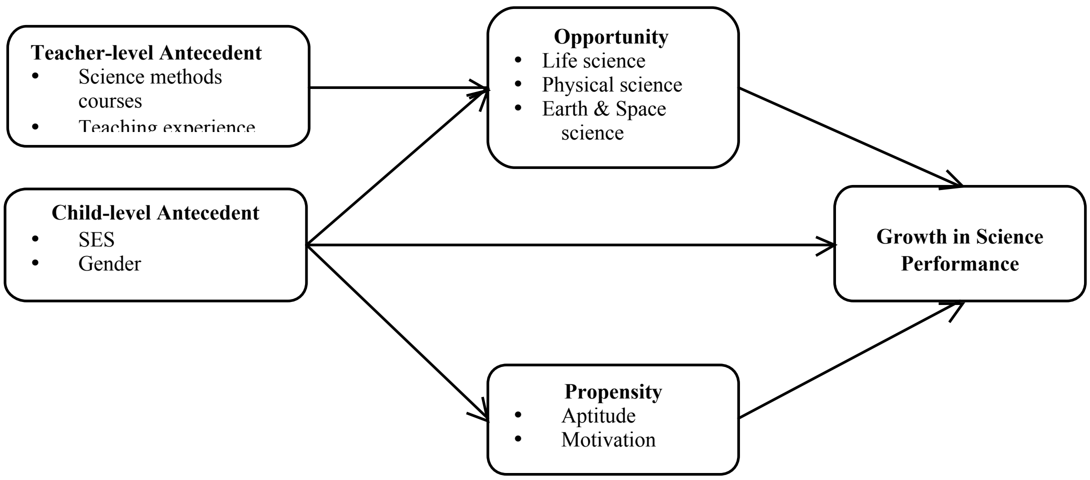

Figure 1. The Model of Early Science Learning Experiences and Growth in Science Performance.

Method

Sample

The data for this study came from the Early Childhood Longitudinal Study – Kindergarten (ECLS-K) data set, which were collected using a complex sampling design (National Center for

Educational Statistics [NCES], 2002). This sampling procedure uses stratification, clustering, and oversampling to increase sampling efficiency, so that a representative sample of a large population, such as kindergarten children in the United States, can be obtained. The base year sample (1998-1999) included 22,666 kindergarten children. From this group of students, 17,401 children were followed until the eighth grade. Children who repeated kindergarten and changed schools were not included in the study sample to evade possible confounding effects. Only the first-time kindergarten children and children who remained in the same school until the end of elementary school comprised the sample of this study. The study sample consisted of 3,501 children. The distribution of the sample is presented in Table 1.

Table 1.

Distribution of the Sample by Gender and Race

Variable	n	Unweighted %	Weighted%
Child Gender			
Boys	1735	49.6	50.7
Girls	1766	50.4	49.3
Child Composite Race			
White, non-Hispanic	2317	66.2	62.0
Black or African American, non-Hispanic	333	9.5	14.4
Hispanic, race specified	259	7.4	8.2
Hispanic, race not specified	251	7.2	8.2
Asian	169	4.8	2.7
Native Hawaiian, other Pacific Islander	32	0.9	0.7
American Indian or Alaska Native	53	1.5	1.4
More than one race, non-Hispanic	85	2.4	2.4
Not ascertained	2	0.1	0.1
Total	3501	100	100

Instruments

Data collected through the following instruments were analyzed in this study: The *Kindergarten Teacher Questionnaire* (spring kindergarten), *Approaches to Learning* (fall kindergarten), *General Knowledge Test* (fall kindergarten), *Science Achievement Test* (3rd, 5th, and 8th grades), and *Parent Questionnaire* (fall kindergarten).

Kindergarten teacher questionnaire. This tool was used to gather data about teachers' backgrounds, training, and classroom practices (NCES, 2002). The present study utilizes data collected in the spring of 1999 administration of the questionnaire. The teachers' answers to the 10 items were collected from the database (see the following link for the items, http://nces.ed.gov/ecls/pdf/kindergarten/springteachersABC.pdf) and they were used as indicators of the following three latent variables: Frequency of teaching life, earth and space, and physical science concepts (The indicators of the latent constructs were obtained from teachers' answers to the following items: "*For this school year as a whole, please indicate how each of the following SCIENCE or SOCIAL STUDIES topics or skills is taught in your class(es)?*" The response categories for this item were *not taught (taught at a higher grade level, children should already know), once a month or less, 2-3 times a month, 1-2 times a week, 3-4 times a week,* and *daily*). Of the 22 possible topics or skills included in the questionnaire, 10 were directly related to the teaching of science concepts (human body, plants and animals, dinosaurs and fossils, solar system and space, weather, temperature, water, sound, light, and magnetism and electricity). These 10 variables were used as indicators of the opportunity factors in the model. These representative concepts are among the concepts kindergarten teachers are expected to teach according to the US *National Science Education Standards* (NRC, 1996).

The content validity of the Kindergarten Teacher Questionnaire was established by the ECLS-K research team. Maximal reliability coefficients for the three opportunity factors were calculated in the present study (Hancock & Mueller, 2001). The maximal reliabilities for the teaching of life, earth and space science, and physical science were H=0.75, H=0.70, H=0.88 respectively. All three reliability coefficients were within the acceptable range (Hancock & Mueller, 2001).

Approaches to learning. The approaches to learning subscale of the social skills rating system (Gresham & Elliot, 1990) was used to measure motivational and self-regulatory characteristics of children. Using a four-point scale teachers rated children based on several characteristics such as attentiveness, persistence and eagerness to learn. The scale reported to produce psychometrically sound scores. The high correlations between children's scores from the self-control and social interaction scales and approaches to learning scale (r=.67 and r=.71 respectivelly) provide evidence for the convergent validity for the scale scores (NCES, 2002). For the fall kindergarten assessment, the reliability coefficient was reported as .89 (NCES, 2002). Children's scores from this instrument were used as measures of their motivation to taking advantage of science learning opportunities.

General knowledge test. This instrument measures children's understandings of concepts and skills related to the natural and social world. Items that target science domain in the general knowledge test focused on two areas: science concepts (earth and space science, life science, and physical science concepts) and science process skills (asking questions, deriving conclusions, and making predictions) (NCES, 2002). The alpha coefficient for the fall assessment was α= 0.88. The children's test scores were used as a proxy for their aptitude. In other words, their ability in benefiting from science learning opportunities provided to them. The Item Response Theory was used to examine the psychometric properties of the General Knowledge Test. The instrument was individually administered during the fall of 1998. The ECLS-K psychometrics reports contain a more detailed information about the psychometric properties and instrumentation procedure for the General Knowledge Test (NCES, 2002).

Science achievement test. The achievement test contains items that targeted children's understandings of science concepts and science processing skills. While items related to science concepts assess children's knowledge for physical, life, and earth and space science phenomena, items related to the science process skills measure children's scientific investigation skills like formulating and testing questions and using tools. Items were generated by following the guidelines proposed by the National Assessment Governing Board Science Framework (NAEP, 1996), American Association for the Advancement of Science (AAAS 1995) and National Research Council (NRC 1996), and based on the review of the elementary science text series. The reliability coefficients of the observed scores were: third grade assessment, α= 0.88; fifth grade, α= 0.87; and eighth grade α= 0.84 (NCES, 2009). Item Response Theory (IRT) was used to assess the psychometric properties of the science achievement test and due to their desirable psychometric properties and appropriateness for longitudinal analysis IRT-based science achievement scores, ranging from 0 to 100, were used in this study. A detailed information about the science achievement test can be obtained from the ECLS-K psychometrics reports (NCES, 2009).

Gender and socio-economic status. Information about children's gender was gathered from the *Kindergarten Teacher Questionnaire*, while data about the socio-economic statuses of the children's families were collected from the *Parent Questionnaire* (NCES, 2002). Parents' answers to two items regarding their yearly income and the highest educational level were extracted from the ECLS-K database and used to produce a composite socio-economic status variable (SES). Gender and socio-economic status were used as child-level antecedent factors in the analysis.

Data Analysis

The primary purpose of this study was to investigate the factors that contribute to development in children's science performance from third to eighth grade. Therefore, the multilevel latent growth curve modeling approach, which takes the nested structure of the data into account, was employed to explore how children's science performance change and the variables that influence the differences in children's individual science performance growth patterns (McArdle & Epstein, 1987). The loadings of the children's *Science Achievement Test* scores observed in the third, fifth, and eighth grades on the *Initial Science Performance* factor (intercept) were fixed to 1, and the loadings on the *Science Performance Growth* factor (slope) were fixed to 0, 2 and 5 respectively to mirror the time passed between each measurement point (Hancock & Lawrence, 2006).

Usually, several goodness-of-fit indices are utilized in assessing model fit (Hu & Bentler, 1999). However, when the complex survey design analysis is used the LISREL software (version 8.80) produces only two goodness-of-fit indices: the full information maximum likelihood chi-square (FIML chi-square) and the root mean square error of approximation (RMSEA). Hence, the FIML chi-square and the RMSEA values are used in assessing model fit.

Results

Structural Equation Modeling

Typically, a two-step procedure is used to evaluate a structural equation model (Hair, Black, Babin, Anderson, & Tatham, 2006). In the first step, the reliability and the validity of the measurement model is assessed to ensure the quality of the measurement model prior to hypothesis testing. The measurement model in the present study included the following three latent variables: frequency of teaching earth and space, life, and physical science concepts. The maximal reliability for the three latent constructs ranged between 0.70 and 0.88, indicating adequate to excellent reliability. Moreover, all but one indicator variable had adequate loadings to their respective latent constructs ranging from 0.29 to 0.84. An indicator of the latent variable of the frequency of teaching earth and space science concepts had a weak loading (teaching of weather concepts). We decided to keep this indicator in the model as it was an important and widely taught earth science concept in kindergarten classes and removing it from the model would result in having a latent construct with only two indicators, which is not ideal.

In the second step, the structural model is assessed. The magnitude and significance of the path coefficients and global goodness of fit indices (such as Chi square and RMSEA) are used to evaluate the structural model. In the present study, the path coeffiecients were evaluated with two-tailed tests. Path coefficients with z-statistics equal or larger than ± 1.96 (p=.05) were considered as significant. To facilitate the presentation of the complex model tested in this investigation, we decided to present figures of the components of the model and related results in subsections rather than presenting the entire model in a large, single figure. Also, the error terms are not illustrated in the figures for the same reasons.

The structural model examined in the present study provided a good fit to the sample data (Full Information ML Chi-Square= 215.85, df=123, p<.001). Due to large sample size Chi-square statistics was significant (Bentler & Bonett, 1980). Therefore, the model fit assessment was made using a goodness-of-fit index that is not affected by the sample size, RMSEA value. The RMSEA value was 0.015 (90% CI: 0.011-0.018) suggesting that the structural model demonstrates a very good fit to the sample data (Hu & Bentler, 1999).

Growth in Performance on Science Achievement Test

The estimates of the latent intercept (science initial) and slope (science growth) means were 51.44. and 6.60 (p<0.001) respectively. These values suggest that growth in science performance from third grade to eighth grade was in a positive direction with an average increase of 6.60 units per year. The variance of the intercept was 209.8 indicating that the observed difference in students' performance on the *Science Achievement Test* for the third grade assessment was significant (p<0.001). The variance of the slope was 2.88 (p<0.001), indicating that the rates of change in *Science Achievement Test* scores from third grade to eighth grade were different for the children. The covariance between children's initial performance on the *Science Achievement Test* and their growth was -6.08 (p<. 01), suggesting that children with low performance in the third grade assessment were more likely to grow at higher rates than children with high initial performance. While the model explained 65% of the variance in the children's initial science performance, it explained only 8% variance in the children's science performance growth

Antecedent Factors

Child-level antecedent factors and opportunity factors. Children's gender was not related to the frequency of teaching life (β=0.02, p>.05), earth and space (β=0.03, p>.05), and physical science concepts (β=0.03, p>.05). Likewise, socio-economic status did not predict the frequency of teaching life (β=-0.08, p>.05), earth and space (β=0.01, p>.05), and physical science concepts (β=-0.04, p>.05). These results suggest that the boys, girls and children with different socio-economic statuses had similar science learning opportunities in kindergarten. In other words, the frequency of teaching science concepts was comparable across all of the children in this study.

Teacher-level antecedent factors and opportunity factors. The number of science methods courses that teachers had taken predicted the frequency of teaching life science (β=0.15, p<.01) and earth and space science concepts (β=0.15, p<.01), but not physical science concepts (β=0.07, p>.05). Teachers who completed a higher number of science methods courses tended to teach life science and earth and space science concepts more frequently. The number of years of teaching experience did not predict the frequency of teaching science concepts in kindergarten (p>.05). Figure 2 illustrates the relationship between antecedent factors and opportunity factors.

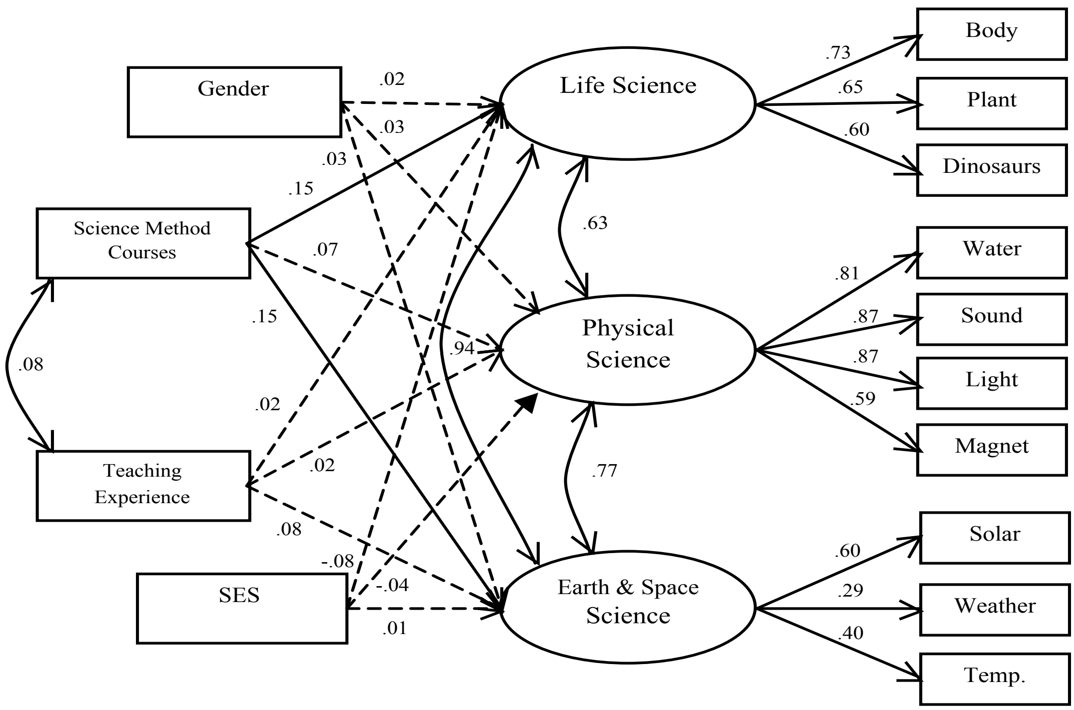

Figure 2. Child and Teacher-level Antecedent Factors and Teaching of Science Concepts in Kindergarten

Child-level antecedent factors and propensity factors. Children's gender predicted their motivation to participate in learning activities in kindergarten (β=-0.21, p<.001). Girls were more likely to be rated by their teachers as having a positive approach to learning than were boys. However, gender did not predict children's aptitude (β=0.02, p>.05). Girls and boys were comparable in their competence in taking advantage of science learning opportunities in kindergarten. Socio-economic status (SES) was a statistically significant predictor of children's motivation (β=0.18, p<.001) and their aptitude (β=0.45, p<.001). Children with a higher SES were more likely to be motivated to learn and they were more likely to have a higher aptitude than children with a lower SES. The relationship between aptitude and motivation was in a positive direction and statistically significant (r= 0.29, p<.001). Children with a high aptitude tended to be motivated to learn or vice versa. Figure 3 illustrates the relationship between child-level antecedent factors and propensity factors.

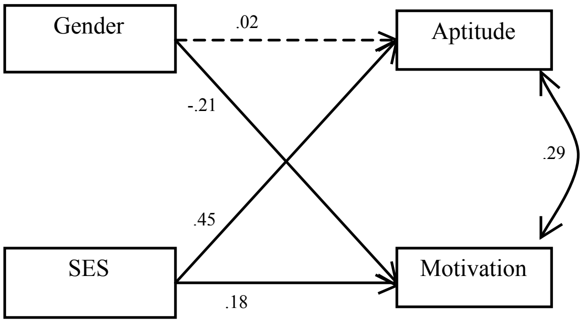

Figure 3. Child-Level Antecedent Factors and Children's Aptitude and Motivation in Kindergarten.

Child-level antecedent factors and science growth. While gender was a statistically significant predictor of children's initial performance (third grade) on the *Science Achievement Test* (β=0.15, p<.01), gender did not predict the growth in children's science performance from third grade to eighth grade (β=-0.01, p>.05). Boys were more successful on the third grade science achievement test than were girls, and the gender difference seemed to be unchanged as children moved from third grade to eighth grade. Socio-economic status predicted the growth in science performance (β=0.18, p<.01), but not the initial science performance (β=0.07, p>.05). Although, children from different socio-economic statuses tended to demonstrate similar performance on the third grade achievement test, children with a higher SES performed better on the fifth and eighth grade assessments than children with a lower SES. Figure 4 illustrates the relationship between child-level antecedent factors and science growth.

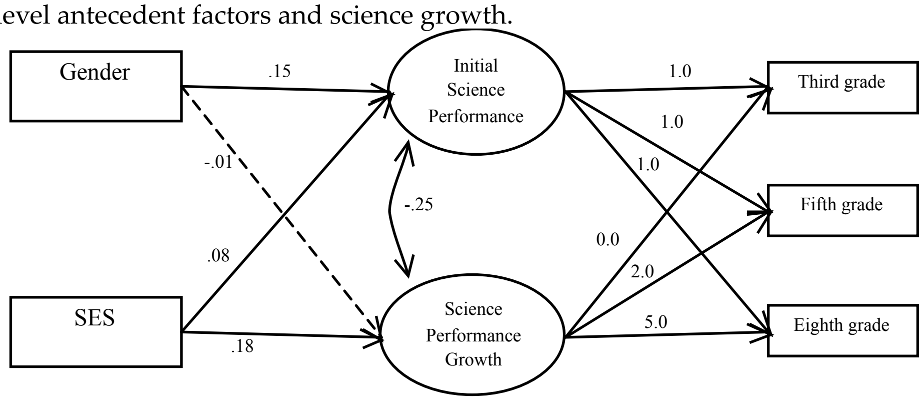

Figure 4. Child-Level Antecedent Factors and Growth in Science Performance.

Opportunity Factors and Science Growth

The relationships between the frequency of teaching life, physical, and earth and space science concepts were all significant and in positive directions. The strong correlation between science concepts suggests that teachers who more frequently teach life science concepts also tended to more frequently teach earth and space science concepts in kindergarten. None of the opportunity factors were statistically significant predictors of growth in children's science performance from third grade to eighth grade (p>.05) (See Figure 5).

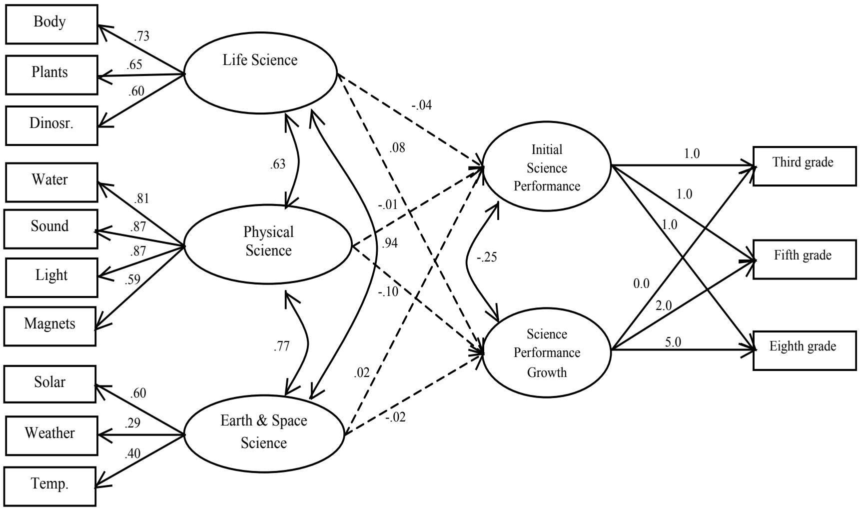

Figure 5. Opportunity Factors and Growth in Science Performance.

Propensity Factors and Science Growth

Children's aptitude was a statistically significant predictor of their initial performance at third grade (β=0.69, p<.01) and growth in science performance from third grade to eighth grade (β=-0.29, p<.01). Children with higher aptitudes tended to perform better on the third grade science achievement test than children who were identified as having lower aptitudes. However, children with higher aptitudes were more likely to have slower growth rates in their science performance than their peers with lower aptitudes. Motivation also was a statistically significant predictor of children's initial performance on the science achievement test (β=0.09, p<.01) and growth in their performance from third grade to eighth grade (β=0.11, p<.01). Children with a higher motivation to learn tended to perform better on the science achievement test at third grade, and they continued to obtain higher scores on the test than children who had lower motivation to learn (See Figure 6).

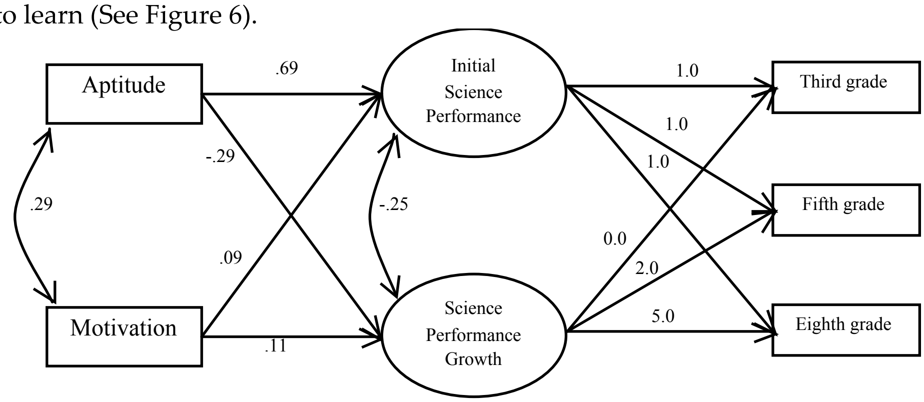

Figure 6. Propensity Factors and Growth in Science Performance.

Discussion

The results of this study demonstrate that the frequency of teaching life science, earth and space science, and physical science concepts did not predict the growth in children's performance on the *Science Achievement Test* from third grade to eighth grade. While the number of science methods courses that teachers had taken predicted the frequency of teaching life science and earth and space science concepts, years of teaching experience was not related to the frequency of teaching science concepts in kindergarten. Likewise, students'

SES level and their gender did not predict the frequency of teaching science concepts. Only the teacher-level antecedent factor of the number of science methods course taken predicted the opportunity factors.

Gender was a statistically significant predictor of children's initial performance on the *Science Achievement Test* but not the growth in children's science performance from third grade to eighth grade. Boys performed better than the girls on the third grade science achievement test and they continued to perform better on the fifth and eighth grade assessments. Children's SES predicted the growth in their performance from third grade to eighth grade. Children with a higher SES tended to perform better than children with a lower SES on the fifth and eighth grade science assessments.

The results of this study suggest that the science learning opportunities provided in kindergarten are not effective in promoting children's science achievement in later grades. Child-level antecedent factors (i.e., gender and socio-economic status) and propensity factors (i.e., aptitude and motivation) were significant predictors of children's science achievement in later grades. In other words, early science learning experiences in kindergarten did not make a difference in the children's later science achievement. The impact of the antecedent and propensity variables were not altered by the science learning opportunities offered to children in kindergarten. These results are congruent with our previous study (Saçkes et al., 2011).

The result, that the science learning opportunities provided in kindergarten are not effective, is not surprising. A large number of teachers did not teach the targeted science concepts that they were expected to teach. In the present study, children did not learn science in kindergarten classrooms because children were provided few opportunities to learn science. Indeed, previous studies reported that children are offered fewer opportunities to engage in learning science in the early years compared to the other domains like literacy, social studies, and art (Early et al., 2010; Greenfield, Jirout, Dominguez, Greenberg, Maier, & Fuccilo, 2009). Early childhood teachers do not teach science because they feel less confident in teaching the science content and using science related teaching materials and equipments, and early childhood teachers feel pressured to teach other domains like literacy. Thus, teachers tend to allocate fewer hours to teaching science than they do for other subjects (Ekinci-Vural & Hamurcu, 2008; Greenfield et al., 2009; Varol, in press).

The findings of this research have some major implications for the education of early childhood teachers. Early childhood teachers' limited science content knowledge and pedagogical content knowledge for teaching science to preschool and kindergarten children should be promoted. Research studies suggest that when they integrate science content and pedagogical content knowledge science methods courses for preservice teachers and training programs for inservice teacher can promote teachers' and teacher candidates' knowledge and skills required for effective science teaching (e.g. Huinker & Madison, 1997; Morrell & Carroll, 2003; Palmer, 2006). More than 60% of the teachers in our study reported that they had taken two or less science methods course. Increasing the quantity and the quality of the science method courses that early childhood teachers are required to complete could address the difficulties teachers experience in teaching science with young children. Consequently, early childhood teacher education programs should develop and provide science methods courses that are designed based on the contemporary science education literature to enhance the preschool and kindergarten teachers' practices of teaching science (Saçkes, Akman, & Trundle, 2012; Saçkes et al., 2011).

Conclusion

Previous research studies demonstrated that teachers of young children are well-informed about effective pedagogical practices for teaching literacy and mathematics skills in the early childhood classrooms (e.g. Bodovski & Farkas, 2007; Byrnes & Wasik, 2009; NCES, 2006; Xue & Meisels, 2004). Using the same dataset, these studies reported a statistically significant relationship between early mathematics and literacy experience and academic achievement in early and later elementary grades. Science methods courses that are designed to utilize the documented successes of early childhood teachers in teaching mathematics and literacy could be more beneficial for teachers. More specifically, science methods courses that emphasize the integration of science with mathematics and literacy might foster early childhood teachers' science teaching skills and their confidence in teaching science (Saçkes, Flevares, Gonya & Trundle, 2012). These types of science methods courses also might facilitate the transfer of knowledge and skills teachers developed in methods courses into their classrooms.

Science method courses for early childhood teachers should emphasize using inquiry-based instructional strategies. The use of instructional strategies such as learning cycles (e.g. 3-E, 5-E) should be taught and modeled in method courses along with the strategies to promote conceptual change with young learners. Strategies to support children's motivation for learning science and children's participation in teacher-directed and child-initiated science activities should also be included in method courses. The use of various science materials to promote the development of children's process skills should be demonstrated and practical ways of assessing science learning should be modeled.

The overall findings of this study suggest that there is an urgent need to improve early childhood teachers' science content knowledge and pedagogical content knowledge for teaching science to preschool and kindergarten children. If policymakers and the educators desire for science learning experiences in early years to contribute to children's performance in upper grades, it is crucial for teachers of young children to be better armed with science content knowledge and knowledge of effective pedagogical strategies and techniques for teaching foundational science concepts and process skills in preschool and kindergarten classrooms.

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