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Building Links between Early Academic Skills and Later Academic Achievement: A Cross-Country Analysis

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Abstract

This study focuses on the relationship between students' early academic skills and academic achievement. In this context, it is aimed to examine the predictors of students' early literacy and numeracy skills on their later math and science achievements across countries. A quantitative research approach using a correlational survey design was performed. The sample of this study consists of 15815 fifth-grade students who participated in TIMSS-2019 from Norway, South Africa, and Türkiye. Multiple linear regression analysis was used to analyze data obtained from two different scales and students' math and science tests. The study's findings supported the essential roles that early literacy and numeracy skills play in fifth-grade students' math and science achievement in the three-country contexts. The results revealed that the more frequent involvement of parents in early literacy activities could increase children's later science achievement and that children's ability to perform early numeracy tasks better when beginning primary school could increase students' later mathematics achievement. Another result of the study is that for countries where all of the other early academic skills within the scope of this study are statistically significant, they can contribute positively to students' later mathematics and science achievement, which may be long-term. Finally, it is recommended that activities and tasks to increase parental participation can be included in preschool curricula. In addition, support that can help children develop early academic skills can be provided to children who have not yet started primary school and their parents.

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Introduction

One of the leading indicators of the outcomes of the curriculum is academic achievement. The academic achievement reflects the degree to which a student, teacher/instructor, curriculum, and educational institution have met set educational goals (Kpolovie, Joe, & Okoto, 2014). It can be said that to the extent that academic achievement is high, students acquire the curriculum objectives. One of the factors that make academic achievement necessary is that it plays a decisive role in preparing students well-equipped for professional and social life and shaping their future (Bücker, Nuraydin, Simonsmeier, Schneider, & Luhmann, 2018; Peng & Kievit, 2020; Sarıer, 2016; Yıldırım, 2000). Academic achievement, in general, refers to the thinking skills and competencies related to communication (speaking, reading, writing), mathematics, science, and social sciences that enable a student to be successful "in school and society" (Lindholm-Leary & Borsato, 2006, p. 176). Because these forms of achievement are challenging to assess, a narrower definition is made that is generally limited to the results of standardized achievement tests. Therefore, what is usually meant by academic achievement is a result that shows the quality of their academic work, such as standardized achievement tests, students' course grades, or grade point average (York, Gibson, & Rankin, 2015). However, academic achievement is a product of recent and old familial, community, and educational experiences (Rivkin, Hanushek, & Kain, 2005). One of these experiences is students' early academic skills.

Early academic skills are literacy and numeracy skills in preschool (Uyanık & Kandır, 2010). Early academic skills include basic literacy abilities such as letter recognition and phonemic awareness and numeracy abilities such as knowledge of numbers and understanding the order of numbers (Rabiner, Godwin, & Dodge, 2016). Before discussing the conceptual framework for linking early academic skills and later academic achievement, a model that can help to better establish this connection is presented in Figure 1.

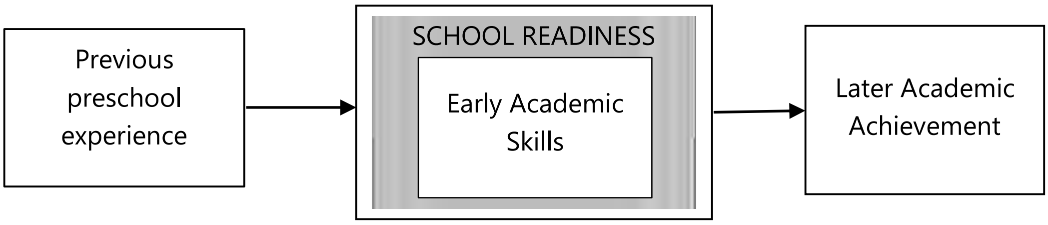

Figure 1. *Early Academic Skills Framework*. Adapted from "Ready for School? Systematic Review of School Readiness and Later Achievement," by Marília Mariano et al., 2019, *Global Journal of Human-Social Science Research, 19*(10), p. 63. Copyright 2019 by the Global Journals.

The framework in Figure 1 shows that early academic skills in the school readiness phase from previous preschool experiences are linked to later academic achievement. Some studies in the literature showed the associations between early academic skills and later academic achievement, as explained in Figure 1 (Duncan et al., 2007; La Paro & Pianta, 2000; Murrah III, 2010; Pagani, Fitzpatrick, Archambault, & Janosz, 2010; Rabiner et al., 2016; Romano, Babchishin, Pagani, & Kohen, 2010; Stevenson & Newman, 1986). In one of these studies, Stevenson and Newman's (1986) longitudinal study, a group of children was tested before starting kindergarten, and these children were monitored in the first, second, third, fifth, and tenth grades. In conclusion, these children's achievement test scores were associated with acquiring early academic skills in literacy and numeracy, such as recognizing letters and numbers. While this study provided significant findings, it had a small sample (*f*=255) and was conducted in Minneapolis, a city in the Midwest region of the United States. Therefore, since this study has a specific and limited sample in terms of cultural, geographical, and educational level, its results should be approached from this perspective.

Another study in the literature is the research of La Paro and Pianta (2000). This meta-analysis examined 70 longitudinal studies reporting the relationships between "academic/cognitive and social/behavioral measures administered in preschool or kindergarten and similar measures administered in first and second grade" (La Paro & Pianta, 2000, p. 443). As a result of this study, it was found that there was a moderate correlation (r=.48) in cognitive/academic skills from kindergarten to first or second grade. The sample sizes of the 70 studies examined ranged from 9 to 866. In this meta-analysis study, almost half of the samples were more than 50% Caucasian, and almost half involved children from primarily middle or high socioeconomic status (SES) families. The available data indicate that the use of variables such as ethnicity and development level is limited in this study.

An international consortium has investigated early academic skills that are important in predicting later academic achievement, focusing on literacy and numeracy (Duncan et al., 2007). Using six longitudinal datasets from the United States of America, Canada, and Great Britain, Duncan et al. (2007, p. 1428) examined the relationship "between three key elements of school readiness—school-entry academic, attention, and socioemotional skills—and later school reading and math achievement." All six studies concluded that the strongest predictors of later academic success were math, reading, and attention skills at the beginning of school. In a meta-analysis study, done by Duncan et al. (2007), early mathematics skills had the highest predictive power, followed by reading and attention skills. This meta analysis study focused on children from the USA, Great Britain, and Canada. Therefore, only the data of children from highly-developed countries were examined. From this point of view, although it provides crucial results for developed countries, it cannot give an idea about developing or underdeveloped countries.

Pagani et al. (2010) conducted a study similar to that of Duncan et al. (2007). The similarity between the two studies was that Pagani et al. (2010) used the data analysis strategy Duncan et al. (2007) used. What differentiated the research was that it was conducted with data from native French-speaking children in Canada. Pagani et al. (2010, p. 984) examined possible relationships "between cognitive, attention, and socio-emotional characteristics underlying kindergarten readiness and mathematics, reading, and general achievement" in second grade. At the end of the study, it was reported that cognitive and attention characteristics in kindergarten predict success at the end of the second grade. Pagani et al.'s (2010) study focused on students from the developed country, Canada, as in the studies cited earlier. Besides, student outcomes belong to the end of the second year and second grade is not that far up the academic ladder. There is a need to see results from studies that reflect longer-term outcomes.

Romano et al. (2010) conducted other research that augmented and extended the findings of Duncan et al.'s (2007) study. The study examined the effects of kindergarten literacy and math abilities, mother-reported attention, and socioemotional behaviors on third-grade math and reading outcomes using data on 1521 children from the National Longitudinal Survey of

Children and Youth (NLSCY) (Romano et al., 2010). Like Duncan et al. (2007), early literacy and numeracy skills were the strongest predictors of later achievement. Romano et al.'s study also has limitations encountered in other studies: developed country sample only and short-term (end of third grade) student outcomes. Studies using samples of countries with different cultural, geographical, and developmental levels and presenting longer-term results are needed.

Murrah III (2010) conducted a study using school readiness skills to find predictors of later academic achievement in mathematics, reading, and science. The study's data were obtained from the Early Childhood Longitudinal Study - 1998 database. The study's findings showed that early literacy and numeracy abilities predict accomplishment later in life and that school entry abilities can predict achievement in reading, math, and science later in life (Murrah III, 2010). Compared to Pagani et al.'s (2010) and Romano et al.'s (2010) studies, this study used long-term (fifth grade) student outcomes. However, a limitation encountered in other studies is also evident in this study: the sample of the USA, a developed country, was used.

One of the issues that Rabiner et al. (2016) examined in their study is the relationship between early childhood characteristics and academic outcomes in the fifth grade. One study shows that early literacy skills predict reading and math achievement after the fifth grade. Early numeracy skills predicted only mathematics achievement. Unfortunately, the small sample of this study was not nationally representative, and all participants attended schools selected because of high concentrations of students at risk for developing conduct problems. Moreover, all of these participants were from the USA. Also, there was no mention of subsequent scientific achievement in this study.

Despite extensive previous research, it can be argued that there are significant gaps in the knowledge of how early academic skills affect long-term academic achievement. One of these gaps is the limitations in revealing the relationship of early academic skills with later science achievement. In addition, studies that consider early academic skills as a predictor have been conducted in high-income and developed countries and have not exceeded this limitation. Although these studies play a pioneering role in preventive intervention, they are criticized for their polarizing nature because they do not consider different social structures in terms of cultural, geographical, and educational levels (Narayan et al., 2018). Although this aspect is open to discussion, considering the importance of early academic skills in academic achievement emphasized in these studies, conducting a similar study with different and independent populations in terms of cultural, geographical, and educational levels may help generalize the results and evaluate them from different perspectives. International examination of the relationship of early academic skills to later academic achievement requires using the same data collection tools and sampling method for each country, and such data are seldom available. In the absence or absence of such data, studies examining the relationship between early academic skills and academic achievement for a single grade level in different countries may be particularly susceptible to ignoring validity and reliability factors. When seeking to understand how early academic skills related to "later academic achievement, it is important to consider how outcomes are measured, and test performance provides an important independent assessment of academic achievement" (Duncan et al., 2007, p. 1431). One of the large-scale assessment studies in which such data can be collected is the Trends in International Mathematics and Science Study (TIMSS).

The main aim of TIMSS is to measure students' knowledge and skill levels and to assess the education system's outcomes (Oral & McGivney, 2013). In other words, TIMSS offers comparative information on student accomplishment across nations over time and in connection to significant factors in the home, school, and classroom (Mullis, Martin, Foy, Kelly, & Fishbein, 2020). While TIMSS measures the performance of fourth- and eighth-grade students in the fields of mathematics and science, data is also collected on the variables that affect student success through questionnaires applied to the students participating in the application, their teachers and parents, and school administrators (Suna, Şensoy, Parlak, & Özdemir, 2020). At TIMSS 2019, data was collected through a home questionnaire given to the parents or caregivers of fourth-grade students to understand better the effects of early academic skills on student achievement in mathematics and science (Hooper, Mullis, Martin, & Fishbein, 2017).

While data on early academic skills are collected for different countries in the TIMSS-2019, general projections on the subject are kept, and it is up to researchers interested in the issue to clarify the details. On the other hand, based on the literature review conducted between 2019-2022, there is no cross-country comparative study investigating the relationship between students' early academic skills (literacy and numeracy skills) and their later mathematics and science achievements using the extensive data set provided by TIMSS-2019. Therefore, it can be said that the role of early academic skills in students' academic achievement has not been investigated significantly using a current and large data set. The present study focuses on the relationship between students' early academic skills and academic achievement. In this context, it is aimed to examine whether students' early literacy and numeracy skills predict their later mathematics and science achievement, with a cross-country comparison involving Norway, South Africa, and Türkiye. An attempt has been made to address the current gap in the research field by investigating the two research questions:

Do the early literacy and numeracy skills of fifth-grade students in Norway, South Africa, and Türkiye predict their;

1. Later mathematics achievement?
2. Later science achievements?

Considering the educational inequality between countries, differences in academic achievement between countries are an important global problem in education today (Organisation for Economic Co-operation and Development [OECD], 2018). Determining the skills significant to academic achievement is critical in designing interventions to reduce these achievement differences. Achievement differences may result from deficiencies in early academic skills (Heckman, 2006). For this reason, its possible contribution to a better understanding of how these early skills are related to academic achievement, especially for children from different cultural, geographical, and educational levels, makes the study important. An examination of the findings of studies in the literature showed that interventions in the preschool period are more effective than later interventions (Heckman, Pinto, & Savelyev, 2013). Therefore, the results obtained from the present study may help suggest various suggestions that can be implemented in preschool curricula to improve students' academic achievement.

Method

The present quantitative study, a relational survey design, analyzes whether the early academic skills of fifth-grade students predict their academic achievement by analyzing the secondary data obtained from TIMSS-2019. Correlational studies examine how closely differences in one variable correspond to differences in one or more other variables (Leedy, Ormrod, & Johnson, 2021). A study process known as secondary data analysis can be characterized as an empirical exercise with procedural and evaluative steps, much like gathering and analyzing primary data (Johnston, 2017). The reason for the preference of this method in this research is that studies using secondary data allow reaching new and/or additional findings that were not included in the original research (Sherif, 2018) and can "be used to provide a comparison with other contexts, over other periods, and across other social groups and cultures" (Corti, 2008, p. 801).

Population and Sample

TIMSS-2019 defines students attending the fourth and eighth grades of formal education as the international target population. As an exceptional case, England, Norway, South Africa, and Türkiye participated in the fourth-grade implementation of the TIMSS-2019 cycle at the fifth-grade level (Suna et al., 2020). In the present study, countries that participated in TIMSS-2019 at the fifth-grade level were included to understand the predictive power of early academic skills on academic achievement over a longer period. However, it was not included in the study in England because data on early academic skills were not collected. In addition to the fact that Norway, South Africa, and Türkiye participate at the fifth-grade level, their cultural, geographical, and educational differences are another factor in their preference. Norway ranks 11th, Türkiye 23rd, and South Africa 56th out of 58 countries in the TIMSS-2019 mathematics ranking. Similarly, Norway ranks eighth, Türkiye 19th, and South Africa 56th out of 58 countries in the TIMSS-2019 science rankings. In other words, it can be said that the countries that are in the upper, middle, and last places in mathematics and science achievement are within the scope of the study. From a geographical point of view, it is seen that the three countries are on different continents. Norway is in Northern Europe, South Africa is the southernmost country of the African continent, and Türkiye is a transcontinental country connecting Europe and Asia. In terms of the level of human development, Norway ranks first, Türkiye 54th, and South Africa 114th in the ranking, which includes 189 countries in the Human Development Index (United Nations Development Programme, 2020). Therefore, it can be stated that the countries within the study's scope are at different development levels.

The three countries are also culturally different from each other. Cultural difference is socially acquired values, beliefs, and rules of conduct that can be distinguished from one society to another (Jackson & Guerra, 2011). Since the first half of the 19th century, efforts have been made to establish a national culture in Norway, and the traditional cultural structure has been preserved for many years (Aşkan, 1998; Karpuz, 1999). Norway has also been included in the globalization process, which has negative effects on the national culture, and multiculturalism has been included in Norway's cultural policy (Bakke, 2001). At the beginning of 2021, immigrants and those with two immigrant parents born in Norway made up 18.5% of Norway's population (Norwegian Ministries, 2022). Norway’s national population projections imply that within a decade, the population will be made up of older people than children and teenagers, according to the national demographic forecasts for 2022, which show reduced population growth paired with stronger aging (Thomas & Tømmerås, 2022). In Norway, where religious pluralism is increasingly established, the official religion is Christianity (Önal, 2016). In Norway, equality is regarded as a key objective for society, and attempts to advance equality are seen as obligations under human rights law (Norwegian Ministry of Children, Equality and Social Inclusion, 2012).

When South Africa is examined in terms of cultural structure, it is striking that it has a very heterogeneous structure in terms of ethnic origin, official spoken language (11 official languages), and belief diversity (Özoran, 2014; Sevim, 2019). South Africa is a country where inequalities in income distribution and living standards are high and an important center of attraction for immigrants (Adepoju, 2003). Following the first democratic elections in 1994, South Africa has made remarkable progress in building a new nation in which all South Africans have equal rights (The Department of International Relations and Cooperation [DIRCO], 2022). Although South African women have fought for the nation's independence and gender equality for a long time, they finally reached the 50/50 target for women in the Cabinet in 2019 (Burger, 2020).

Türkiye also has its cultural characteristics. Anatolia, in which Türkiye was founded, is one of the oldest civilization centers in the world, and in this respect, it has thousands of years of experience besides the dominant Turkish culture (Sancak, 2016). However, Turkish society has been experiencing an international cultural interaction and change process with Western culture for various reasons since the 18th century (Türkkahraman, 2009). Türkiye has been greatly affected by the cultural dimension of globalization, and as a result, a considerable change and transformation process has begun in the tastes and interests of Turkish society (Bayar, 2008). Despite this, global culture has not displaced local culture in Türkiye, and the trend towards Western culture has not excluded local culture (Rankin, Ergin, & Gökşen, 2014). Similarly, it is stated that although the social structure in Türkiye has changed, some cultural patterns have been preserved (Kasapoğlu & Ecevit, 2004).

The TIMSS implementations employ a two-stage random sample design, with a first stage of selecting a sample of schools and a second stage of choosing one or more entire classes of students from each of the sampled schools (LaRoche, Joncas, & Foy, 2020). The population and sample of the three countries within the scope of the study are given in Table 1.

Table 1. *Population and Sample Sizes*

Country	*Population*		*Sample (Number of Students Assessed)*		*Participation Rates*		*Analyzed Sample* (N)*
	Schools (N)	*Students (N)*	*Schools (N)*	*Students (N)*	*Class Participation (%)*	*Student Participation (%)*	
Norway	1945	62012	150	3951	99	89	2327
South Africa	16254	943115	297	11891	100	96	9794
Türkiye	16205	1239900	180	4028	100	99	3694
Total	34404	2245027	627	19870	99.67	94.67	15815

Note. Population, sample, and participation rates were adapted from *Methods and Procedures: TIMSS 2019 Technical Report* by Michael O. Martin, Matthias von Davier, and Ina V.S. Mullis, 2020, p. 9.24-261. Copyright 2020 by the International Association for the Evaluation of Educational Achievement (IEA).

* The researcher calculated the analyzed sample.

The sample size given in Table 1 is the number of students participating in the assessment. The sample size calculated before the TIMSS-2019 assessment may be higher for schools or students. TIMSS guidelines emphasize that the minimum acceptable participation rate for sample participation is 85 percent for both schools and students. The participation rates given in Table 1 show that all three countries fulfill the 85% criterion. However, the number of students analyzed for mathematics and science is less than the number of participants due to missing information. In exclusion of observations with lacking or missing data from the data set, it can be assumed that these data are entirely randomly distributed (Çüm, Demir, Gelbal, & Kışla, 2018). The idea behind the utterly random distribution of data is that the likelihood of missing data for a given variable is independent of the value of either that variable or any other variable in the data set (Demir & Parlak, 2012). The remaining data can be viewed as a simple random sampling from some vast population if this assumption holds valid for all variables in the data set (Allison, 2002). Since the deleted data is student data, it can be accepted that the remaining data represent the original data set since it does not affect its value or any other variable in the data set. However, due to the large size of samples and the small number of excluded students, the missing data were not completed with statistical techniques.

Data Collection Instruments

The study's data were obtained from two different scales developed by the collaboration of "the questionnaire development team at the TIMSS & PIRLS International Study Center and the TIMSS Questionnaire Item Review Committee" and students' mathematics and science tests (Hooper et al., 2017, p. 59). The "Early Literacy and Numeracy Activities Scale" and the "Early Literacy and Numeracy Tasks Scale."

The Early Literacy and Numeracy Activities Scale

One of the scales used was the Early Literacy and Numeracy Activities scale. This scale, which consists of 18 items, was answered by the parents. The question "before your child began primary/elementary school, how often did you or someone else in your home do the following activities with him/her?" was asked to parents via the survey (Yin & Fishbein, 2020, p. 16.25). Parents answered the questions as "often," "sometimes," or "never or rarely" (Yin & Fishbein, 2020, p. 16.25). Some of the statements were "read books," "play word games," "count different things," and "write numbers" (Yin & Fishbein, 2020, p. 16.25).

The Early Literacy and Numeracy Tasks Scale

Another scale from which data was obtained is the Early Literacy and Numeracy Tasks scale. Parents responded to twelve items under three questions through the Early Literacy and Numeracy Tasks scale. The first question was "How well could your child do the following when he/she began the first grade of primary/elementary school?" (Yin & Fishbein, 2020, p. 16.32). There were seven statements associated with the question, such as "read some words", "write letters of the alphabet", and "write his / her name" (Yin & Fishbein, 2020, p. 16.32). Parents matched them with the appropriate one of "very well", "moderately well", "not very well", and "not at all" (Yin & Fishbein, 2020, p. 16.32). The second question was "Could your child do the following when he/she began the first grade of primary/elementary school?" (Yin & Fishbein, 2020, p. 16.32). The tasks associated with the question were "count by himself/herself", "recognize written numbers", and "write numbers" (Yin & Fishbein, 2020, p. 16.32). Parents marked one of "up to 100 or higher", "up to 20", "up to 10", and "not at all" for the tasks (Yin

& Fishbein, 2020, p. 16.32). Finally, the question "Could your child do the following when he/she began the first grade of primary/elementary school" was asked again to the parents (Yin & Fishbein, 2020, p. 16.32). The parents answered as "yes" or "no" to the expressions given for the question as "do simple addition" and "do simple subtraction" (Yin & Fishbein, 2020, p. 16.32).

The Cronbach's Alpha reliability coefficient and percent of variance explained by the Early Literacy and Numeracy Activities scale, and the Early Literacy and Numeracy Tasks scale are given in Table 2.

Table 2. *Cronbach's Alpha Reliability Coefficient and Percent of Variance Explained of the Scales*

Country	*Early Literacy and Numeracy Activities Scale*		*Early Literacy and Numeracy Tasks Scale*	
	Cronbach's α Reliability Coefficient	*Variance Explained, %*	*Cronbach's α Reliability Coefficient*	*Variance Explained, %*
Norway	.87	31	.90	48
South Africa	.88	32	.85	39
Türkiye	.94	50	.95	64

Note. From *Methods and Procedures: TIMSS 2019 Technical Report* by Michael O. Martin, Matthias von Davier, and Ina V.S. Mullis, 2020, p. 16.29-36. Copyright 2020 by the International Association for the Evaluation of Educational Achievement (IEA).

Cronbach's alpha coefficients given in Table 2 are .70 and above, so the scales can be considered reliable with countries' samples (Pallant, 2005). In addition, it is deemed sufficient for single-factor designs to explain 30% or more of the variance (Büyüköztürk, 2003). The variance explained values in Table 2 are greater than 30%, indicating that the relevant structures are well measured in all three countries.

Mathematics and science scores of students were used as an indicator of academic achievement, which is the dependent variable of the current study. Five plausible values were calculated for math and science tests in TIMSS-2019. OECD (2017, p. 145) stated that "the plausible value methodology uses proficiency distributions and accounts for error (or uncertainty) at the individual level by using multiple imputed proficiency values (plausible values) rather than assuming that this type of uncertainty is zero." In simpler terms, plausible values represent the range of plausible proficiency a student may have based on students' responses to items (Wu, 2005). Plausible values are random scores derived "from the distribution of scores that can be reasonably assigned to each" student (Monseur & Adams, 2009, p. 6), and "plausible values are generated using students' responses to the items and conditioning them according to all available background data" (Laukaityte & Wiberg, 2017, p. 11344). Therefore, five different plausible values are calculated for students. Using only one of the five plausible values or the mean may cause the standard error values to be miscalculated (Rutkowski, Gonzalez, Joncas, & von Davier, 2010). It is recommended that all five reasonable values be included in the calculations for the analyses (OECD, 2009). In the current study, all five plausible values were included in the analysis as dependent variables at the same time to obtain unbiased and stable estimates, and suggestions were made on using probable values in large-scale international evaluations (OECD, 2009; Rutkowski et al., 2010) were taken into account.

Data Analysis

Multiple linear regression (MLR) analysis was used in the data analysis. In social science research, MLR is a potent approach for spotting intricate relationships between data (Nimon, 2010). MLR makes it possible to investigate the relationships between more than one continuous or categorical independent variable and one continuous dependent variable (Coxe, West, & Aiken, 2013). The bilateral correlations between dependent and independent variables in this study are presented in Table 3.

Table 3. *The Bilateral Correlations (r) between Dependent and Independent Variables*

Country	*Variables*	*Correlations (r)*					
		(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Norway	Early literacy activities before school (1)	1.00					
	Early numeracy activities before school (2)	.74	1.00				
	Early literacy tasks beginning school (3)	.37	.33	1.00			
	Early numeracy tasks beginning school (4)	.24	.26	.54	1.00		
	Mathematics achievement scores (5)	.12	.12	.29	.26	1.00	
	Science achievement scores (6)	.18	.12	.25	.15	.78	1.00
South Africa	Early literacy activities before school (1)	1.00					
	Early numeracy activities before school (2)	.73	1.00				
	Early literacy tasks beginning school (3)	.38	.34	1.00			
	Early numeracy tasks beginning school (4)	.15	.13	.33	1.00		
	Mathematics achievement scores (5)	.21	.18	.19	.22	1.00	
	Science achievement scores (6)	.22	.18	.18	.22	.91	1.00
Türkiye	Early literacy activities before school (1)	1.00					
	Early numeracy activities before school (2)	.81	1.00				
	Early literacy tasks beginning school (3)	.52	.50	1.00			
	Early numeracy tasks beginning school (4)	.48	.48	.65	1.00		
	Mathematics achievement scores (5)	.40	.39	.27	.35	1.00	
	Science achievement scores (6)	.46	.43	.30	.36	.89	1.00

The correlation values given in Table 3 indicate a relationship between the variables in this study. Four are the predictor variable, and the other two are the predicted variables. There are low-level correlations among some variables (r=.10 - .29), moderate-level correlations among some (r=.30 - .49), and high-level correlations between some variables (r=.50 – 1.00). It was found that there were positive relations between all variables.

MLR is typically used to assess how independent or explanatory factors affect output (Farina, San Martín, Preiss, Claro, & Jara, 2015). Considering that students' academic achievement is related to multiple factors related to early academic skills in the current study, the dependent variable can be predicted accurately and realistically by employing the MLR model's optimal arrangement of several independent variables (Xiao, Liu, & Hu, 2019). In standard algebraic notation, the general expression of the MLR model is:

$$y=\beta_0+\beta_1x_1+\beta_2x_2+\beta_3x_3+\beta_4x_4+ \varepsilon$$

In this model;

y: Mathematics and science achievement scores (1-5 plausible values),

β_n: Partial regression coefficient,

x_1: Early literacy activities before school (ASBHELA),

x_2: Early numeracy activities before school (ASBHENA),

x_3: Early literacy tasks beginning school (ASBHELT),

x_4: Early numeracy tasks beginning school (ASBHENT),

ε: Error term.

For the analysis, the students' mathematics and science scores and the scales used were matched one-to-one using TIMSS-2019 Student IDs. After the matching process, the data generated for each country were analyzed with the IEA International Database Analyzer Version 4.0.36 (IDB Analyzer) software. IDB Analyzer can perform statistical analysis by considering sample design and sample weights. IDB Analyzer provides convenient tools for estimating sampling errors and coefficients that reflect the sample design, but assumptions about multiple linear regression must be verified (Mirazchiyski, 2014).

One of the assumptions of MLR analysis is the normal distribution. According to Lumley, Diehr, Emerson, and Chen (2002), no assumption of the normal distribution is necessary for sufficiently large samples. For large samples, "the law of large numbers and the central limit theorem mechanism both work" because "the sample mean of a large number of observations will be close to the mean or will have a distribution close to normal, even if the observations themselves do not have normal distribution" (Shatskikh & Melkumova, 2016, p. 767). Based on the law of large numbers and central limit theorem theories, it can be said that the normal distribution is provided in the TIMSS-2019 sample (DasGupta, 2010). In addition, the assumption that the relationship between the predictor and the predicted variables is linear was investigated with scatter plots. In the investigation, it was seen that the variables had a linear relationship, and the points showed the values of the variables gathered around the regression line.

Further, in large-scale assessments, the plausible values such as mathematics and science achievement scores assume a flat linear regression with all students' background variables as regressors, and “like most linear models, homoscedasticity and normality of the conditional variance are assumed” (Monseur & Adams, 2009, p. 1). Another assumption is that there is no multicollinearity. One of the ways to determine multicollinearity is to use a correlation matrix. However, variance inflation factor (VIF) values were investigated instead of the correlation matrix in the current study since linearity may occur between three or more variables even if the independent variables are not highly correlated in pairs (Lavery, Acharya, Sivo, & Xu, 2019). Since the IDB Analyzer software used in data analysis did not calculate the VIF values, independent regression equations using each independent variable as the dependent variable were created, and VIF values were calculated using the formula $VIF=1/(1-R^2)$ (Robinson & Schumacker, 2009). R^2 in this formula is the coefficient of determination from the linear regression model. The VIF values calculated to control whether there is a problem of multicollinearity among the predictive variables are given in Table 4.

Table 4. *VIF Values*

Variables	*VIF values*		
	Norway	*South Africa*	*Türkiye*
ASBHELA	2.27	2.27	3.02
ATHENA	2.22	2.17	2.99
ASPHALT	1.54	1.30	1.96
ASBHENT	1.43	1.12	1.85

Since all of the VIF values given in Table 4 are values less than five, it can be said that there is no multicollinearity problem among the predictive variables (Bowerman, O'Connell, & Murphree, 2015).

The "enter" method, the default method in IDB Analyzer, was selected when performing multiple regression analyses. All specified variables were entered simultaneously, regardless of their significance level (George & Mallery, 2020). Based on the study's conceptual framework, the "enter" method was used in this analysis since one independent variable was not considered more important than the others (Hinton, Brownlow, McMurray, & Cozens, 2004).

Results

This section presents the results reported in line with the research questions. First, descriptive statistics to facilitate the interpretation of the results were included. Then, the results obtained for the two research questions were reported and interpreted.

Descriptive Statistics

Knowing the descriptive statistics for each country can facilitate the interpretation of the findings in the present study, which aims to make a cross-country examination. Therefore, descriptive statistics for all predictor and predicted variables used in the study are reported in Table 5. The values were calculated for each country using the IDB Analyzer program to take care of sampling weights based on the TIMSS-2019 sampling procedure.

Table 5. *Descriptive Statistics of Variables*

Variables	*Countries*	*Minimum*	*Maximum*	*M*	*SD*
Early Literacy Activities Before School	Norway	1.90	14.98	10.47	1.92
	South Africa			9.73	2.05
	Türkiye			8.95	2.91
Early Numeracy Activities Before School	Norway	2.61	15.33	10.17	1.76
	South Africa			9.83	2.18
	Türkiye			9.26	2.89
Early Literacy Tasks Beginning School	Norway	4.56	13.47	9.06	1.71
	South Africa			10.47	1.74
	Türkiye			8.87	2.66
Early Numeracy Tasks Beginning School	Norway	4.74	13.05	9.48	1.76
	South Africa			9.83	1.91
	Türkiye			9.51	2.38

Table 5 (Cont.)

Mathematics achievement*	Norway	251.19	806.65	542.67	74.12
	South Africa	67.61	786.44	373.56	100.21
	Türkiye	113.22	844.85	522.86	99.50
Science achievement*	Norway	262.64	762.74	539.40	66.67
	South Africa	5.00	821.13	324.23	133.03
	Türkiye	107.55	786.98	526.36	90.90

* The minimum and maximum scores in mathematics and science achievement are the minima and maximal scores within five plausible values.

In mathematics and science achievement, Norway had the highest mean and South Africa the lowest. In countries other than Türkiye, the mean mathematics scores were higher than the science mean. It is worth noting that parents of Norwegian students stated that they participated more frequently in preschool early literacy and numeracy activities. Parents of South African students also stated that they did better in early literacy and numeracy tasks when their child began the first grade of primary/elementary school. In addition, Türkiye, which had a lower average score than South Africa in all early academic skills, had a much higher average than South Africa in mathematics and science scores.

The Results on the Prediction of Early Literacy and Numeracy Skills of Fifth-Grade Students in Norway, South Africa, and Türkiye in Their Later Mathematics Achievement

MLR analyzes were conducted using each country's data to answer the first research question. The findings showed that early literacy and numeracy skills could be used to predict the later mathematics achievement of students in high-, medium-, and low-achieving countries. MLR analysis results are presented in Table 6.

Table 6. *MLR Analyzes Results Investigating the Associations between the Early Academic Skills and Students' Mathematics Achievement*

Countries	*MLR Model Summary*	*MLR Coefficients*				
			Unstandardized weight		*Standardized weight*	
		Independent Variables	*B*	*Std. Error*	*β*	*t*
Norway	R^2=.10 Adjusted R^2=.10 $F_{(3,2323)}$=86.04 p<.01	(Constant)	409.67	15.84		
		ASBHELA	.02	1.56	.00	.02
		ATHENA	9.35	1.34	.22	6.86*
		ASPHALT	.45	1.54	.01	.29
		ASBHENT	5.73	1.41	.14	4.13*
South Africa	R^2=.09 Adjusted R^2=.09 $F_{(3,9790)}$=322.75 p<.01	(Constant)	159.87	14.91		
		ASBHELA	6.34	1.06	.13	6.16*
		ATHENA	4.47	1.27	.08	3.46*
		ASPHALT	1.75	1.04	.04	1.70
		ASBHENT	9.34	.93	.18	10.77*
Türkiye	R^2=.20 Adjusted R^2=.20 $F_{(3,3690)}$=307.50 p<.01	(Constant)	342.74	14.62		
		ASBHELA	7.39	1.17	.21	6.55*
		ATHENA	-2.06	1.20	-.05	-1.71
		ASPHALT	5.10	1.34	.15	3.80*
		ASBHENT	8.98	1.19	.21	7.91*

* Statistically significant t values at $p < 0.01$ level.

Early academic skill variables explained variance in mathematics achievement differently for each country, from 9% (in South Africa) to 20% (in Türkiye). The variance among countries implied that the multilevel model of the study was more effective for Türkiye than other countries. This means that for Norway and South Africa, other student-level variables might explain differences among students. Early numeracy tasks beginning school (ASBHENT) was a variable that predicted mathematics achievement positively in all countries. Accordingly, students who did better at various numeracy tasks when they first began the first grade of primary/elementary school had higher math scores. As expected, parents' frequent involvement in numeracy activities with their children before school (ASBHENA) positively predicted mathematics achievement in Norway and South Africa.

On the other hand, surprisingly, ASBHENA is not a significant predictor of students' mathematics achievement in Türkiye. More frequent involvement of parents with their children in literacy activities before school (ASBHELA) positively predicted mathematics achievement in the middle- and low-achieving countries. These results mean that a student whose parent participates more often in early literacy activities gets higher scores in math. However, in Norway, which ranks high in mathematics achievement, no relationship was found between ASBHELA and mathematics achievement. Therefore, it was concluded that ASBHELA has no role in predicting mathematics achievement for high-achieving countries. Early literacy tasks beginning school (ASBHELT), one of the early academic skill variables, positively predicted mathematics achievement only for Türkiye.

The Results on the Prediction of Early Literacy and Numeracy Skills of Fifth-Grade Students in Norway, South Africa, and Türkiye in Their Later Science Achievement

It investigated whether early literacy and numeracy skills predicted the later science achievement of students in the countries surveyed to answer the second research question. The findings showed that it is possible to use students' early literacy and numeracy skills in diverse countries to predict their later science achievement. MLR analyzes results regarding science achievement are presented in Table 7.

Early academic skill variables explained variance in science achievement differently for each country, from 7% (in Norway) to 24% (in Türkiye). The variance among countries implied that the multilevel model of the study was more effective for Türkiye compared to other countries in science achievement. This means that for Norway and South Africa, other student-level variables might explain science achievement differences among students. Early literacy activities before school (ASBHELA) was a variable that predicted science achievement positively in all countries. Therefore, students whose parents participated more frequently in early literacy activities had higher science scores. More frequent involvement of parents in numeracy activities with their children before school (ASBHENA) positively predicted students' science achievement in Norway and South Africa. However, ASBHENA was not a significant predictor of the science achievement of students in Türkiye. Early numeracy tasks beginning school (ASBHENT) positively predicted science achievement in countries with medium and low achievement in science. This finding means that students who could do various numeracy tasks better when he or they first began primary school scored higher in science in later grades than students who could not. However, in Norway (eighth), which ranked high in the TIMSS-2019 science achievement rankings, there was no relationship between ASBHENT and science achievement. Therefore, it was concluded that ASBHENT did not predict science achievement for high-achieving countries. Early literacy tasks beginning school (ASBHELT), another early academic skill variable, positively predicted science achievement only for Türkiye, as was the case with mathematics achievement.

Table 7. *MLR Analyzes Results Investigating the Associations between the Early Academic Skills and Students' Science Achievement*

Countries	*MLR Model Summary*	*MLR Coefficients*				
			Unstandardized weight		*Standardized weight*	
		Independent Variables	*B*	*Std. Error*	*β*	*t*
Norway	R^2=.07	(Constant)	436.02	17.13		
	Adjusted R^2=.07	ASBHELA	5.10	1.55	.14	3.40*
	$F_{(3,2323)}$=58.28	ATHENA	7.95	1.29	.20	5.94*
	p<.01	ASPHALT	-2.17	1.48	-.06	-1.46
		ASBHENT	.98	1.39	.03	.71
South Africa	R^2=.09	(Constant)	45.41	19.94		
	Adjusted R^2=.09	ASBHELA	9.33	1.46	.14	6.60*
	$F_{(3,9790)}$=322.75	ATHENA	4.57	1.69	.06	2.69*
	p<.01	ASPHALT	2.37	1.44	.04	1.66
		ASBHENT	12.28	1.27	.17	10.14*
Türkiye	R^2=.24	(Constant)	349.62	14.85		
	Adjusted R^2=.24	ASBHELA	9.34	1.10	.29	9.06*
	$F_{(3,3690)}$=388.42	ATHENA	-.99	1.06	-.03	-.93
	p<.01	ASPHALT	3.82	1.16	.12	3.30*
		ASBHENT	7.01	1.05	.18	6.89*

* Statistically significant t values at p < 0.01 level.

Discussion, Conclusion, and Implications

In the current study, early academic skills that predict later mathematics and science achievement of students in Norway, South Africa, and Türkiye were determined with TIMSS-2019 data. A comparable set of regression analyzes was conducted to assess whether early academic skills were predictors of later academic achievement. Mathematics and science achievements measured as late in the data set as possible were regressed on early literacy and numeracy activities before primary school and early literacy tasks beginning school.

The first research question focused on whether the early literacy and numeracy skills of fifth-grade students in different countries predicted their later mathematics achievement. As expected, the MLR results showed that students' numeracy tasks skills when they first began the first grade of primary/elementary school were statistically significant predictors of subsequent mathematics achievement, with standard coefficients ranging from .14 to .21. This result is compatible with the results of studies in the literature (Duncan et al., 2007; Murrah III, 2010; Pagani et al., 2010; Rabiner et al., 2016; Romano et al., 2010). Early math skills were significantly positively linked with interest and self-confidence in mathematics (Balala, Areepattamannil, & Cairns, 2021). Students who were confident in their knowledge and skills in mathematics and found mathematics interesting had higher mathematics scores than the others (Akyüz, 2014; Arıkan, Van de Vijver, & Yağmur, 2016; Tavşancıl & Yalçın, 2015; Yavuz, Demirtaşlı, Yalçın, & Dibek, 2017). Moreover, successfully practicing and completing early numeracy tasks can offer opportunities to increase math self-efficacy that can contribute to later mathematics achievement (Zhu & Chiu, 2019). For this reason, students who do numeracy tasks better at the beginning of school may have higher success in mathematics later on.

Parental involvement in preschool literacy activities was a statistically significant predictor of later mathematics achievement in Türkiye and South Africa, but not Norway. A similar conclusion was reached in the study of LeFevre, Polyzoi, Skwarchuk, Fast, and Sowinski (2010). In the study by LeFevre et al. (2010), the relationship between parents' participation in literacy activities and students' mathematics outcomes in Greece and Canada, which have math achievements similar[1] Türkiye and Norway were investigated. As in the present study's comparison between Türkiye and Norway, Greek parents' participation in literacy activities was less frequent than Canadian parents (as seen in Table 5, the frequency of participation of Turkish parents in literacy activities is lower than that of Norwegian parents), and, for Greek children only, home literacy activities also predicted math outcomes for Turkish children only. The conversations and interactions promoted by parents' participation in early literacy activities enable children to develop specific skills and attitudes, such as increasing their vocabulary, decoding, and word recognition (Sénéchal & LeFevre, 2002). Students who have developed these skills and attitudes can more easily understand mathematical facts, concepts, procedures, conceptual understanding, unusual situations, complex contexts, multi-step problems, and reading and interpreting data. There may be various reasons why the variable is not a significant predictor of Norwegian students' mathematics achievement. One might be that the power of the relationship between academic achievement and early literacy has diminished over the years, depending on factors such as the quality of teachers, schools, and education (Bulut, 2021). Because Norway, which ranks first in the Human Development Index and also ranks high in the TIMSS-2019 ranking, provides more qualified education services compared to the other two countries, the predictive power of the variable for the other two countries may be lost over time. Here is an issue that needs to be discussed. These results mean that while parental involvement in preschool literacy activities in Norway was predictive of students' science achievement, it was not a predictive factor in the mathematics achievement of Norwegian students with the same qualification. In other words, parent involvement in preschool literacy activities was a significant predictor of Norwegian students' science achievement, but why was it not a significant predictor of math achievement? As mentioned before, the scope of science is related to real-life, and learning in these subjects is more permanent learning. However, 80% of the content of the TIMSS-2019 math test consisted of knowing the cognitive domain and applying it (Mullis et al., 2020). The content included simple equations, algebra, fractions and decimals, geometry, and angles. Thus, the quality mathematics education in the first five years of primary school in Norway may have become the dominant predictor of Norwegian students' mathematics achievement, rather than preschool literacy activities with their parents.

The frequency of parent involvement in early numeracy activities (ASBHENA) was positively associated with math achievement in the highest and lowest performing countries (Norway

[1] Since Greece did not participate in TIMSS-2019, the comparison was made according to the results of PISA-2018.

and South Africa). This result aligns with the previous research (Huang, Zhang, Liu, Yang, & Song, 2017; Hwang, 2020; LeFevre et al., 2009; Zhu & Chiu, 2019). The regression coefficient for Türkiye was not statistically significant. This result is similar to Blevins-Knabe, Austin, Museum, Eddy, and Jones' (2000) study. Blevins-Knabe et al.'s (2000) study revealed that limited frequency numeracy activities were not significantly associated with children's math achievement scores. Descriptive statistics (Table 5) can answer why ASBHENA is not a significant predictor of students' subsequent mathematics achievement in Türkiye. According to descriptive statistics, Türkiye's ASBHENA average score was lower than other countries. For Turkish students with a low parental involvement in early numeracy activities, effective mathematics classroom instruction may have compensated for ASBHENA, thus reducing its importance for mathematics achievement. Manolitsis, Georgiou, and Tziraki's (2013) study results in Greece, a country similar to Türkiye in terms of geographical location and mathematical achievement, can be used as a basis for this assumption. Manolitsis et al. (2013) showed that the relationship between Greek children doing numeracy activities at home with their parents and counting at the beginning of kindergarten becomes negligible. Accordingly, the ASBHENA variable may have lost its importance on mathematics achievement in the fifth grade for Turkish students whose parents' participation in early numeracy activities was already low.

The second research question focused on the early literacy and numeracy skills of fifth-grade students in different countries and was identified as the predictor of students' later science achievement. The study's findings showed that parent involvement in preschool literacy activities (ASBHELA) was a statistically significant predictor of later science achievement for all three countries. In general, the content element of the science curriculum consists of popular and directly related to real-life topics such as health-related phenomena (student's body, health, and diseases), unexplained space and phenomena, sexuality and reproduction, environmental problems, biodiversity (Jidesjö, Oscarsson, Karlsson, & Strömdahl, 2009). Therefore, science is a part of everyday life, and all people, regardless of age, want to know the fundamental scientific principles that govern the world they live in (Andrée, 2005; Aniashi, Okaba, Anake, & Akomaye, 2019; Gürdal, 1992). The scope of the TIMSS-2019 science test also coincided with this content (Mullis et al., 2020). Students whose parents frequently participate in preschool literacy activities begin to contact their parents and ask questions about the things they are curious about and want to learn and start doing research (Hayes, Berthelsen, Nicholson, & Walker, 2018; Lin et al., 2019; Uyanık & Kandır, 2010). Children who examine written and visual sources about science subjects, which are a part of daily life with their parents, and reach the answers to the questions together, can increase their knowledge about science and their interest in science. The increase in students' knowledge and interests may have contributed to the growth in students' science achievement.

Early numeracy activities before school (ASBHENA) positively predicted science achievement in Norway and South Africa. ASBHENA was not a meaningful predictor for Türkiye. Descriptive statistics showed that Türkiye's ASBHENA means lower than other countries. Although there is no similar study in the literature, it is noteworthy that this result parallels the one in mathematics achievement. It seems consistent that ASBHENA was not a significant predictor of mathematics and science achievement for Turkish students whose parents had a low frequency of participation in early numeracy activities. Therefore, as with mathematics achievement, the limited participation of parents in early numeracy activities may have led to the loss of ASBHENA's importance on science achievement over time.

The variable ASBHENT, a significant predictor of later mathematics achievement in all three countries, also significantly predicted science achievement for South Africa and Türkiye but was not significant for Norwegian students' later science achievement. ASBHENT was measured as the ability to perform operations on numbers, such as counting by oneself, recognizing written numbers, writing numbers, and performing simple addition and subtraction (Yin & Fishbein, 2020). Both because of the level of complexity and because of the nature of science courses that require mechanisms specific to relational reasoning (Blums, Belsky, Grimm, & Chen, 2017), the predictive of basic numeracy skills in the science achievement of Norwegian students with high science achievement may not be as strong as that of students in the other two countries with lower science achievement averages. As a result, it can be said that while ASBHENT was a significant predictor of science achievement of students with medium and low science achievement, it was not a significant predictor of science achievement of students with high science achievement.

Concerning the first and second research questions, a common research finding showed that ASBHELT (early literacy tasks beginning school) variable was a significant predictor of Turkish students' achievement in both mathematics and science. ASPHALT was not a significant predictor of either mathematics or science achievement in the other two countries. Makin and Whitehead (2004) stated that children's literacy skills are related to the opportunities provided to children. One of these opportunities is participation in preschool education. Only 24% of Turkish students in TIMSS-2019 had attended preschool education for two years or more, compared to 68% for South African students and 97% for Norwegian students (Mullis et al., 2020). Thus, it may have made no meaning that Norwegian and South African students who benefited more from preschool education were able to perform early literacy tasks to predict their later mathematics and science achievement. Because they may have acquired skills that can predict later mathematics and science achievement in the preschool education period, and that can be more dominant than being able to perform early literacy tasks. However, Turkish students who did not benefit much from preschool education better performed early literacy tasks, which reflect the development of other cognitive and academic skills (Haney, 2002), and may have been a significant predictor of their later mathematics and science achievement.

The study's limitations should be considered when evaluating the current study's findings. First, a limited number of variables related to early academic skills were included in the study. Also, these variables were obtained from scales answered by parents in TIMSS-2019. Huang et al. (2017) emphasize that parents' responses to scales can be affected by social desirability. Secondly, since TIMSS-2019 did not administer a test for reading comprehension skills, students did not have reading literacy scores. Therefore, whether early literacy and numeracy skills predict students' later literacy achievement could not be examined. Third, the cross-country generalizability of the study's findings may be limited, as the nature and extent of parents' involvement in their children's early literacy and numeracy activities can vary considerably from one country to another.

In conclusion, despite the study's limitations, empirical support was provided for the crucial roles that early literacy and numeracy skills play in fifth-grade students' math and science achievement in the three-country context. More frequent involvement of parents in early literacy activities can help grow later science achievement regardless of country. In addition, better performance of early numeracy tasks at the beginning of primary school can increase students' later mathematics achievement without being affected by international differences. These results suggest that the link between ASBHENT and mathematics achievement and between ASBHELA and science achievement does not immediately break. Instead, it remains essential even in the fifth year of formal education. Other early academic skills within the scope of this study (ASBHENA and ASBHELT) can contribute positively to students' later mathematics and science achievement in countries where they are statistically significant, and this contribution may be long-term.

The results of the study have important implications for curricula and practices. The first implication is that mathematics and science achievement depends not only on variables in the formal primary school process but also on the frequency with which parents participate in early academic activities and students' ability to perform early academic tasks. The preschool curricula of South Africa and Türkiye, and Norway's framework plan for kindergartens emphasize the importance of parent involvement in early academic activities and tasks (Department of Basic Education, 2015; Directorate for Education and Training, 2017; Ministry of National Education, 2013). Examples of early academic activities and tasks are not found in the curricula implemented in Norway and Türkiye. It can be said that the examples of early academic activities and tasks are included in the Family Support Education Guide, which is prepared in an integrated manner with the preschool curriculum in Türkiye, but these examples are few. It can be said that the Family Support Education Guide (Ministry of National Education, 2013b) is teacher-centered rather than parents-centered. Such activities and tasks are written for the areas of early learning and development in The United Nations International Children's Emergency Fund (UNICEF)-funded curriculum implemented in South Africa (Department of Basic Education, 2015). For example, for early mathematics learning and development area, "Help young children make books about numbers and counting," "Repeat the counting words children use and show them how counting helps us to find out how many," "Adults and young children can sing songs and rhymes about numbers and counting" activities are available in The South African National Curriculum (Department of Basic Education, 2015, p. 52). Such and more developed and enriched early academic activities and tasks that parents can participate in at home can be included in preschool curricula to increase students' later mathematics and science achievement.

One of the present study results is that children's ability to do preschool math tasks predicts math achievement. Mononen, Audio, Koponen, and Aro's (2014, p. 25) study also showed "that different types of instructional design features (explicit instruction, computer-assisted instruction, game playing, or the use of concrete-representational-abstract levels in representations of math concepts, etc.) lead to improvements in mathematics performance." If these two results are considered together, another implication can be made: In order to develop children's ability to do preschool math tasks, activities for the use of game-based computer-assisted teaching that can facilitate the transition from concrete to abstract can be included in the learning situations element of preschool curricula. Since ASBHENT is a positive predictor of later mathematics achievement for three countries, support activities can be carried out by a teacher specialized in mathematics through individual and small-group instruction for students who have difficulty doing numeracy tasks.

Given the essential roles that early literacy skills play in improving students' mathematics and science achievement, parents and teachers are vital in supporting young children's literacy development. However, not all parents have the necessary skills to participate effectively in the literacy activities of their young children. From this perspective, it is essential to support parents to enable their young children to contribute to literacy development. Parent-teacher partnerships can be encouraged and supported to empower parents in this field. This issue was extensively covered in the Framework Plan for the content and tasks of kindergartens in force in Norway, and it was recommended to establish a "parents' council" and "the co-ordinating committee" for parent-teacher partnerships (Directorate for Education and Training, 2017, p. 29-30). The National Curriculum Framework in South Africa has no statement on establishing parent-teacher partnerships (Department of Basic Education, 2015). Partnerships such as "visits to children's houses, group and individual parent meetings" (Ministry of National Education, 2013, p. 50), emphasized in the preschool education program implemented in Türkiye, seem insufficient. Since it may be challenging to establish parent-teacher partnerships in countries with low-income or low pre-primary education rates, such as Türkiye and South Africa, cooperation with educational institutions and relevant social actors can be made to design and implement such supports.

Considering the results of the present study, which showed that literacy and numeracy activities at home and children's ability to perform literacy and numeracy tasks at the beginning of primary school positively contribute to later mathematics and science success, it was concluded that educational interventions to improve students with difficulties in early literacy and numeracy skills should be developed and implemented. Educational intervention is intended by early intervention programs that integrate information and skill learning to create competency or alter practice behavior (Wilkes and Bligh, 1999). Niklas, Cohrssen, and Tayler (2016) and Vukovic, Roberts, and Wright (2013) reported that these educational interventions improved preschool children's abilities and academic achievement. Therefore, early intervention programs can be developed for children who have not yet started primary school, which can help them improve their early literacy and mathematics skills by making use of good examples from other countries but also by taking into account the characteristics of their country/culture. These early intervention programs can provide easy-to-use and effective printed and visual resources. For these resources to be used efficiently, children and parents can be provided with continuous and proactive support by preschool teachers.

Finally, some implications can be made for future research. Future research may consider cultural factors related to early literacy and numeracy skills. The causal relationships between this study's dependent and independent variables, a cross-sectional study by the nature of TIMSS-2019, cannot be revealed. Longitudinal and experimental studies can be designed to investigate possible causal relationships between predictor and predicted variables.

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TÜRKÇE GENİŞ ÖZET

Erken Akademik Beceriler ve Sonraki Akademik Başarı Arasında Bağlantılar Kurmak: Ülkelerarası Bir Analiz

Giriş

Eğitim programının çıktılarının temel göstergelerinden birisi akademik başarıdır. Akademik başarı; öğrencinin, öğretmenin, eğitim programının ve eğitim kurumunun önceden belirlenmiş eğitim hedeflerine ne ölçüde ulaştığını gösterir (Kpolovie, Joe & Okoto, 2014). Akademik başarının yüksek olduğu ölçüde öğrencilerin program kazanımlarını edindikleri söylenebilir. Akademik başarı; genel olarak, bir öğrencinin okulda ve toplumda başarılı olmasını sağlayan iletişim (konuşma, okuma, yazma), matematik, fen bilimleri, sosyal bilimler ile ilgili düşünme becerilerini ve yeterliklerini ifade eder (Lindholm-Leary & Borsato, 2006). Bununla birlikte akademik başarı; geçmişteki ve güncel durumdaki aile, toplum ve okul deneyimlerinin kümülatif bir işlevidir (Rivkin, Hanushek & Kain, 2005). Bu deneyimlerden birisi öğrencilerin erken akademik becerileridir.

Erken akademik beceriler, okul öncesi dönemde yer alan okuma yazma becerileri ve matematik becerileridir (Uyanık & Kandır, 2010). Erken akademik beceriler, harfleri tanıyabilme ve ses birimsel farkındalık gibi temel okuryazarlık yetenekleri ve bunun yanında sayılar bilgisi ve sayıların sırasını anlama gibi aritmetik yetenekleri içerir (Rabiner, Godwin, & Dodge, 2016). Alanyazındaki bazı çalışmalar, akademik başarının öğrencilerin erken akademik becerileri kazanmasıyla ilişkili olduğunu göstermektedir (Duncan & diğ., 2007; La Paro & Pianta, 2000; Murrah III, 2010; Pagani, Fitzpatrick, Archambault & Janosz, 2010; Rabiner & diğ., 2016; Romano, Babchishin, Pagani & Kohen, 2010; Stevenson & Newman, 1986).

Erken akademik becerilerin uzun vadeli akademik başarıyı nasıl etkilediğine dair alanyazında kapsamlı araştırmalar olmasına rağmen, bu alandaki bilgi birikiminde önemli boşluklar olduğu söylenebilir. Bu boşluklardan biri, erken akademik becerilerin sonraki fen başarısıyla olan ilişkisinin ortaya koyulmasındaki kısıtlılıklardır ki alanyazında Murrah III (2010) tarafından yapılan çalışma dışında bir çalışmaya rastlanılmamıştır. Bununla birlikte, erken akademik becerileri yordayıcı olarak kabul eden çalışmalar yüksek gelirli ve gelişmiş olarak nitelendirilen ülkelerde yürütülmüş ve bu sınırlandırmanın ötesine geçmemiştir (Duncan & diğ., 2007; Murrah III, 2010; Pagani, Fitzpatrick, Archambault & Janosz, 2010; Rabiner & diğ., 2016; Romano, Babchishin, Pagani & Kohen, 2010). Bu yönüyle tartışmaya açık olsalar da bu çalışmalarda vurgulanan akademik başarıda erken akademik becerilerin önemi göz önüne alındığında benzer bir çalışmanın kültürel, coğrafi ve eğitim seviyesi olarak farklı ve birbirinden bağımsız nüfuslarla yapılması, sonuçların genelleştirilebilirliğine ve farklı açılardan değerlendirilebilirliğine yardımcı olabilir. Bu çalışmada, öğrencilerin erken okuma yazma ve matematik becerileri ile matematik ve fen başarıları arasındaki ilişkiye odaklanılmakta ve bu kapsamda öğrencilerin erken okuma yazma ve matematik becerilerinin sonraki matematik ve fen başarıları üzerindeki yordayıcılığını ülkeler arası karşılaştırmalı olarak incelemek amaçlanmaktadır. Bu amaç doğrultusunda iki araştırma sorusu cevaplanmaya çalışılmıştır: Norveç, Güney Afrika ve Türkiye'deki beşinci sınıf öğrencilerinin erken okuryazarlık ve matematik becerileri;

1. Sonraki matematik başarılarını yordamakta mıdır?
2. Sonraki fen başarılarını yordamakta mıdır?

Yöntem

Bu çalışma ilişkisel tarama türünde nicel bir araştırmadır. Çalışmanın örneklemi, TIMSS-2019'a Norveç, Güney Afrika ve Türkiye'den katılan beşinci sınıf öğrencileridir. Norveç'ten 2327, Güney Afrika'dan 9794 ve Türkiye'den 3694 beşinci sınıf öğrencisinin verileri analiz edilmiştir. Araştırmanın verileri, "TIMSS ve PIRLS uluslararası çalışma merkezindeki anket geliştirme ekibi ve TIMSS anket maddesi inceleme komitesinin iş birliği ile geliştirilen Erken Okuryazarlık ve Matematik Etkinlikleri ve Erken Okuryazarlık ve Matematik Görevleri ölçekleri" ile öğrencilerin matematik ve fen testlerinden elde edilmiştir (Hooper, Mullis, Martin, & Fishbein, 2017, p. 59). Her iki ölçek de öğrencilerin aileleri tarafından cevaplandırılmıştır. TIMSS-2019 uygulamasına ait olan bu veriler, TIMSS & PIRLS'in internet sitesinde halka açık olarak sunulmaktadır. Elde edilen verilerin analizinde çoklu doğrusal regresyon analizi kullanılmıştır. Verilerin analizleri IDB Analyzer yazılımı ile yapılmıştır.

Bulgular

Bulgular; erken okuryazarlık ve matematik becerilerini kullanarak yüksek, orta ve düşük başarılı ülkelerdeki öğrencilerin sonraki matematik ve fen başarılarını tahmin etmenin mümkün olduğunu göstermektedir. Erken akademik beceriler, matematik başarısındaki toplam varyansı her ülke için %9'dan (Güney Afrika) %20'ye (Türkiye) değişen oranlarda açıklamaktadır. Ülkeler arasında açıklanan varyans farkı, çalışmanın çok düzeyli modelinin Türkiye için diğer ülkelere göre daha etkili olduğunu göstermiştir. İlkokula başlarken erken matematik görevlerini yapabilme, tüm ülkelerde matematik başarısını pozitif olarak öngören bir değişkendir. Bu nedenle, ilkokula ilk başladığında çeşitli matematik görevlerini daha iyi bir şekilde yerine getirebilen öğrencilerin matematik puanları daha yüksek olmuştur. Çocukları ilkokula başlamadan önce ebeveynlerin matematik etkinliklerine daha sık katılması, Norveç ve Güney Afrika'da matematik başarısını pozitif yönde yordamıştır. Ancak, bu değişken Türkiye'deki öğrencilerin matematik başarısı için anlamlı bir yordayıcı değildir. Çocukları ilkokula başlamadan önce ebeveynlerin okuma yazma etkinliklerine daha sık katılması, matematikte orta ve düşük düzeyde başarılı ülkeler olan sırasıyla Türkiye ve Güney Afrika'da matematik başarısını pozitif yönde yordamıştır. Ancak, matematik başarı sıralamasında üst sıralarda yer alan Norveç'te, söz konusu değişken ile matematik başarısı arasında bir ilişki bulunamamıştır. Erken akademik beceri değişkenleri arasında okula başlangıçta okuma yazma görevlerini yapabilme değişkeni sadece Türkiye için matematik başarısını pozitif olarak yordamıştır.

Erken akademik beceriler, fen başarısındaki toplam varyansı her ülke için %7'den (Norveç) %24'e (Türkiye) farklı değerlerde açıklamaktadır. Ülkeler arasında açıklanan varyans farkı, çalışmanın çok düzeyli modelinin fen başarısı için de Türkiye için diğer ülkelere göre daha etkili olduğunu göstermiştir. Okul öncesi erken okuma yazma etkinliklerine ebeveynlerin katılımı, tüm ülkelerde fen başarısını pozitif olarak yordamaktadır. Bu nedenle, erken okuma yazma etkinliklerine ebeveyni daha sık katılan öğrencilerin fen puanları daha yüksek olmuştur. Çocukları ilkokula başlamadan önce ebeveynlerin matematik etkinliklerine daha fazla katılması, Norveç ve Güney Afrika'da fen başarısını pozitif yönde yordamıştır. Ancak, bu değişken Türkiye'deki öğrencilerin fen başarısı için anlamlı bir yordayıcı değildir. Çocukların ilkokul başlangıcında matematik görevlerini yapabilmesi, fende orta ve düşük düzeyde başarılı ülkeler olan sırasıyla Türkiye ve Güney Afrika'da fen başarısını pozitif yönde yordamıştır. Ancak, TIMSS-2019 fen başarı sıralamasında üst sıralarda yer alan Norveç'te, söz konusu değişken ile fen başarısı arasında bir ilişki bulunamamıştır. Erken akademik beceri değişkenleri arasında okula başlangıçta okuma yazma görevlerini yapabilme değişkeni, matematik başarısında olduğu gibi sadece Türkiye için fen başarısını pozitif olarak yordamıştır.

Tartışma, Sonuç ve Öneriler

Çalışmada ulaşılan sonuçlar erken akademik becerilerin sonraki matematik başarısının istatistiksel olarak anlamlı yordayıcısı olduğunu göstermektedir. Bu sonuç, alanyazındaki çalışmaların (Duncan & diğ., 2007; Huang, Zhang, Liu, Yang & Song, 2017; Hwang, 2020, LeFevre, Polyzoi, Skwarchuk, Fast & Sowinski, 2010; Murrah III, 2010; Pagani & diğ., 2010; Rabiner & diğ., 2016; Romano & diğ., 2010; Zhu & Chiu, 2019) sonuçlarıyla uyumludur. Erken matematik becerileri, matematiğe ilgi ve matematikte kendine güven ile önemli ölçüde pozitif ilişkilidir (Balala, Areepattamannil & Cairns, 2021) ve matematikte kendi bilgisine ve becerilerine güvenen ve matematiği ilginç bulan öğrencilerin matematik puanları diğerlerine göre daha yüksektir (Akyüz, 2014; Arıkan, Van de Vijver & Yağmur, 2016; Tavşancıl & Yalçın, 2015; Yavuz, Demirtaşlı, Yalçın & Dibek, 2017). Buna ilave olarak, erken matematik görevlerini başarılı bir şekilde uygulama ve tamamlama, daha sonraki matematik başarılarına katkıda bulunabilecek matematik öz-yeterliliklerini artırma fırsatları sunabilir (Zhu & Chiu, 2019). Ebeveynlerin erken okuryazarlık etkinliklerine katılımının teşvik ettiği konuşmalar ve etkileşimler; çocukların kelime dağarcığının artması, kelime çözme ve kelime tanıma gibi belirli beceriler ve tutumlar geliştirmelerini sağlar (Sénéchal & LeFevre, 2002). Bu beceri ve tutumları gelişmiş olan öğrenciler; matematiksel olguları, kavramları, prosedürleri, kavramsal anlayışı, alışılmamış durumları, karmaşık bağlamları, çok adımlı problemleri, verileri okumaları ve yorumlamaları daha kolay anlayabilir. Bu nedenle, erken matematik etkinliklerine ebeveynleri daha sık katılan ve okula girişte matematik görevlerini daha iyi yapan öğrencilerin sonraki matematik başarıları daha yüksek olabilir.

Araştırmanın bir diğer sonucu, erken akademik becerilerin sonraki fen başarısının istatistiksel olarak anlamlı bir yordayıcısı olduğudur. Genel bir bakış açısıyla, fen öğretim programlarının içeriğinin öğrencinin kendi vücudu, sağlığı ve hastalıkları gibi sağlıkla ilgili olgular, açıklanamayan uzay ve fenomenler, cinsellik ve üreme, çevreyle ilgili sorunlar, biyolojik çeşitlilik gibi popüler ve gerçek yaşamla doğrudan bağlantılı konularla ilgili olduğu söylenebilir (Jidesjö, Oscarsson, Karlsson & Strömdahl, 2009). Dolayısıyla, fen dersi günlük hayatın bir parçasıdır ve hangi yaşta olursa olsun, bütün insanlar içinde yaşadıkları dünyayı yöneten temel fen prensiplerini bilmek isterler (Andrée, 2005; Aniashi, Okaba, Anake & Akomaye, 2019; Gürdal, 1992). TIMSS-2019 fen testinin kapsamı da bu içerikle örtüşmektedir (Mullis, Martin, Foy, Kelly ve Fishbein, 2020). Okul öncesi okuma ve matematik etkinliklerine ebeveynleri sıklıkla katılan öğrenciler ebeveynleriyle iletişime geçerek merak ettikleri ve öğrenmek istedikleriyle ilgili sorular sormaya ve araştırmalar yapmaya başlarlar (Hayes, Berthelsen, Nicholson & Walker, 2018; Lin & diğ., 2019; Uyanık & Kandır, 2010). Ebeveynleriyle birlikte günlük hayatın bir parçası olan fen konularıyla ilgili olarak yazılı ve görsel kaynaklardan tarama yapma ve sorularına cevaplar bulma gibi etkinlikler, çocukların hem fenle ilgili bilgisini hem de fene yönelik ilgisini artırabilir. Bu durum, okul öncesi okuma yazma etkinliklerine katılımın öğrencilerin fen başarısını artırmasına katkıda bulunmuş olabilir.

Çalışmanın sonuçlarının eğitim programları ve uygulamaları için önemli çıkarımları vardır. Güney Afrika ve Türkiye'nin okul öncesi eğitim programlarında ve Norveç'in anaokulları için çerçeve planında, erken akademik faaliyetlere ve görevlere veli katılımının önemi vurgulanmaktadır (Department of Basic Education, 2015; Directorate for Education and Training, 2017; Ministry of National Education, 2013a). Bununla birlikte, Norveç'te ve Türkiye'de uygulanan okul öncesi eğitim programlarında erken akademik etkinlik ve görevlerin bulunmadığı (Directorate for Education and Training, 2017; Ministry of National Education, 2013a); Güney Afrika'daki okul öncesi eğitim programında ise öğrenme ve gelişim alanları için açıkça yazıldığı (Department of Basic Education, 2015) görülmektedir. Diğer iki ülkeden farklı olarak Türkiye'de, erken akademik etkinlik ve görev örnekleri, okul öncesi eğitim programı ile bütünleştirilmiş olarak hazırlanan Aile Destek Eğitim Rehberi'nde yer almaktadır (Ministry of National Education, 2013b) ancak bu örneklerin sayısının az olduğu ve Aile Destek Eğitim Rehberi'nin ebeveynlerden ziyade öğretmen merkezli olduğu söylenebilir. Öğrencilerin ilkokul sonundaki matematik ve fen başarısını artırmak için, Güney Afrika için geliştirilen okul öncesi eğitim programında ve Türkiye'deki Aile Destek Eğitim Rehberi'nde yer alan evde ebeveynlerin katılabileceği etkinlik ve görevler sayıca zenginleştirilerek, içeriği geliştirilerek ve ebeveyn merkezli olacak şekilde düzenlenerek okul öncesi eğitim programlarına dahil edilebilir. Çocukların okul öncesi matematik görevlerini yapma becerilerini geliştirmek için, bu çalışmanın kapsamındaki ülkelerde uygulanan okul öncesi eğitim programlarında yer almayan, somuttan soyuta geçişi kolaylaştırabilecek oyun tabanlı bilgisayar destekli öğretim kullanımına yönelik etkinliklere eğitim programlarında yer verilebilir.

Evde okuma yazma ve matematik etkinliklerinin ve çocukların ilkokulun başında okuma yazma ve matematik görevlerini yerine getirme becerilerinin sonraki matematik ve fen başarısına olumlu katkı yaptığını gösteren bu çalışmanın sonuçları göz önüne alınarak, bu konuda güçlük çeken öğrencileri geliştirmeye yönelik eğitimsel müdahalelerin geliştirilmesi ve uygulanması gerektiği sonucuna varılmıştır. Eğitimsel müdahale ile kastedilen, yeterlilik oluşturmak veya uygulama davranışını değiştirmek için bilgi ve beceri kazanımını birleştiren erken müdahale programlarıdır (Wilkes & Bligh, 1999). Niklas, Cohrssen ve Tayler (2016) ve Vukoviç, Roberts ve Wright (2013) erken müdahale programları gibi eğitimsel müdahalelerin okul öncesi çocukların yeteneklerini ve akademik başarılarını geliştirdiğini bildirmiştir. Ayrıca; çalışmaya dahil edilen ülkelerin okul öncesi eğitim programlarında erken akademik görevlerini yapmakta zorluk çeken öğrencileri desteklemeye yönelik bir müdahale programından bahsedilmemektedir. Türkiye'deki okul öncesi eğitim programında özel gereksinimli çocukları desteklemede dikkat edilmesi gereken noktalar belirtilmektedir fakat erken akademik görevlerini yapmakta zorluk çeken öğrenciler bu kapsamda değerlendirilmemektedir. Bu nedenle, henüz ilkokula başlamamış çocuklara yönelik erken akademik becerilerini geliştirmelerine yardımcı olabilecek, diğer ülkelerdeki iyi örneklerden yararlanılarak ve ülkelerinin kültürel özellikleri de dikkate alınarak erken müdahale programları tasarlanabilir ve bunlara eğitim programlarında yer verilebilir. Bu erken müdahale programlarında okul öncesi yaş grubundaki çocuklara erken akademik görevlerin öğretimi konusunda deneyimli bir öğretmen tarafından küçük grup çalışmalarıyla veya bireysel öğretim yoluyla destekleme çalışmaları yaptırılabilir. Bununla birlikte, bu çalışmalarda kullanılabilecek, kullanımı kolay ve etkili basılı ve görsel kaynaklar verilebilir. Bu kaynakların verimli kullanılabilmesi için okul öncesi öğretmenleri tarafından hem çocuklara hem de ebeveynlere sürekli ve proaktif destekler (ebeveynler yardım istemek zorunda kalmadan, önetkin şekilde sağlanan destekler) verilmesi sağlanabilir.

Mevcut çalışmanın sonuçları, çalışmanın sınırlılıkları ile birlikte değerlendirilmelidir. İlk olarak, erken akademik becerilerle ilgili sınırlı sayıda değişken çalışmaya dâhil edilmiştir. Ayrıca bu değişkenler veliler tarafından TIMSS-2019'da yanıtlanan ölçeklerden elde edilmiştir. Huang ve diğ. (2017), ebeveynlerin ölçeklere verdikleri yanıtların sosyal istenirlikten etkilenebileceğini vurgulamaktadır. İkinci olarak, TIMSS-2019 öğrencilerin okuduğunu anlama becerilerine yönelik bir test uygulamadığından öğrencilerin okuma yazma becerileri puanları bulunmamaktadır. Bu nedenle erken akademik becerilerin öğrencilerin daha sonraki okuma yazma başarılarını yordayıp yordamadığı incelenememiştir. Üçüncüsü, ebeveynlerin çocuklarının erken okuryazarlık ve matematik etkinliklerine katılımının doğası ve kapsamı bir ülkeden diğerine önemli ölçüde değişebileceğinden, çalışmanın bulgularının ülkeler arası genellenebilirliği sınırlı olabilir. Ayrıca, TIMSS-2019'un doğası gereği kesitsel bir çalışma olan bu çalışmanın bağımlı ve bağımsız değişkenleri arasındaki nedensel ilişkiler ortaya konulamamaktadır. Farklı değişkenler arasındaki olası nedensel ilişkileri araştırmak için boylamsal ve deneysel çalışmalar tasarlanabilir.