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Effect of Object Manipulation Ability and Basic Movement Ability on Mathematical Ability of Young Children

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Abstract

The aim of this study is to investigate the relationship between the object ability, basic movement ability, and mathematical ability of young children. Next, through this study, the influence of young children's object manipulation ability and basic movement ability on mathematical ability was investigated. The subjects of this study were 80 children aged 5 years old. As a research tool, the non-mobile movement and mobile movement, the basic movement development test scale, and the young children's picture-mathematical ability test scale were used. This survey was conducted from October 2018 to January 2019. For data analysis, correlation analysis and hierarchical multiple regression analysis were performed using the spss program. As a result of the study, it was found that there was a significant positive correlation between the non-mobile ability, movement ability, object manipulation ability and mathematical ability of young children. It was found that young children's ability to manipulate objects and non-movement abilities had positive effect on their mathematical abilities. The movement ability of young children had both negative and positive effects on mathematical ability, but it was not found to be statistically significant. This study is meaningful in that it investigated the effects of non-mobile movement, mobile movement ability, and object manipulation ability, which are sub-capabilities of basic movement ability, which had not been investigated so far, on the mathematical ability of young children.

Keywords: *Manipulate Object Ability, Non-mobile Movement Ability, Mobile Movement Ability, Mathematical Ability*

1. INTRODUCTION

Young children's movement experiences such as non-mobile movement, mobile movement, and object manipulation ability affect mathematical ability [1]. A mathematical experience including movement contents can stimulate young children's interest more than a single subject-oriented mathematical experience using only mathematics. The 2019 revised Nuri curriculum also guides learning through integrated play [2]. The studies conducted so far have been conducted by integrating movement activity-oriented movement experience and young children's mathematical ability [3-5]. It is necessary to conduct the study focusing on how the sub-contents of movement such as non-mobile movement, mobile movement, and object manipulation ability affect mathematical ability, respectively. Non-mobile movement, mobile movement, and object manipulation of young children can be measured as non-mobile movement, mobile movement, and object manipulation ability.

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Therefore, this study first examines the relationship between young children's non-mobile movement ability, mobile movement ability, object manipulation ability, and mathematical ability. Next, this study examines the relative influence of young children's non-mobile movement ability, mobile movement ability, and object manipulation ability on mathematical ability. The results of this study are expected to provide important basic data for finding ways to improve young children's mathematical abilities by examining the movement-related variables related to young children's mathematical abilities in a more dynamic and multifaceted way. The research questions for carrying out the purpose of this study are as follows.

Research Question 1. What is the relationship between young children's non-mobile movement ability, mobile movement ability, object manipulation ability and mathematical ability?

Research Question 2. What is the effect of the young children's ability to manipulate objects, non-mobile movement ability, and mobile movement ability on mathematical ability?

2. METHODS

2.1 Objects

In order to find out what kind of relationship between young children's basic movement ability and object manipulation ability on mathematical ability, this study sampled 80 5 years old children with the cooperation of kindergartens B and C in Area A. There were 44 males and 36 females, and the average age of the young children in the study was 72.5 months.

2.2 Tools

2.2.1 The Object Manipulation Ability Scale on Young Children

In this study, the scale used to measure young children's object manipulation ability was modified and supplemented movement development scale to suit the Korean situation [6]. The scale is scored by creating a situation in which the researcher can manipulate objects, and observing and recording the young children's 6 object manipulation movements.

It is a scoring system that gives '1' points if successful, and '0' points if not. The total score for the ability to manipulate objects is 0 to 24 points (24 questions). It consists of 6 sub-items which are hitting the ball (5 questions), bouncing the ball (4 questions), catching the ball (3 questions), kicking the ball (4 questions), overhand throwing the ball (4 questions), and rolling the ball (4 questions). The internal consistency coefficient of object manipulation ability was 0.925.

2.2.2 The Basic Movement Ability Scale on Young Children

In this study, a test tool developed by Ji Sung-ae was used to measure the basic movement ability of young children. The basic movement ability scale developed is divided into non-mobile movement ability and mobile movement ability [1]. This scale is an evaluation tool in which the teacher observes and measures young children's behavior. Each area was created on a 5-point rating scale. The total score of the non-mobile movement area is 14 to 70 points (14 questions). Each sub-element consists of 4 sub-domains: balancing on one foot (4 questions), walking on the balance beam (3 questions), bending and straightening (3 questions), and rolling forward (4 questions). The internal consistency coefficient of the non-mobile movement test was 0.978.

The total score of the movement domain is 19-95 points (19 questions). For each sub-element, running (2 questions), horse running (4 questions), skipping (2 questions), high jump (3 questions), embracing (4 questions), and sliding (4 questions) were performed. It consists of 6 sub-areas. The internal consistency coefficient of mobile movement ability was .975.

2.2.3 The Mathematical Ability Scale on Young Children

The scale used to measure young children's mathematical ability in this study is the young children's drawing mathematics ability test scale developed [7]. This scale is an evaluation tool is measured by a researcher showing a picture to an young children, asking a question appropriate to the situation, and recording the answer. It is a scoring system that gives '1' point or '0' point. The total score of mathematical ability is 0 to 60 points (60 questions). Each sub-element consists of 4 sub-areas: logarithm (14 questions), number and calculation (18 questions), geometry (14 questions), and measurement (14 questions). The internal consistency coefficient for each sub-domain, the logarithm was 0.825, the number and calculation was 0.800, the geometry was 0.741, and the measurement was 0.783.

2.3 Procedure

A preliminary survey was conducted from August 13 to 20, 2018, targeting 10 5 years old kindergarteners in Area B. The main survey was conducted from October 2018 to January 2019 targeting 80 5 years old kindergarteners in Area A. The test to measure each variable was conducted by the researcher and research assistant. Researchers and research assistants performed pre-training on each test tool before this investigation. All tests were conducted 1:1 with the examiner and the young children.

2.4 Data analysis

Spss 21.0 was used for analysis. Descriptive statistical analysis was performed for the mean and standard deviation of the major variables, and correlation analysis was performed between the major variables. Hierarchical multiple regression analysis was performed to analyze the effect of young children's object manipulation ability and basic movement ability on mathematics ability. In the first stage, the object manipulation ability was input, and in the second stage, the non-mobile movement and mobile movement ability were input.

3. RESULT

3.1 Relationships among Young Children's Non-mobile Movement, Mobile Movement, Object Manipulation, and Mathematical Ability

Table 1 shows the results of calculating Pearson's correlation coefficients between variables in order to understand the relationship between young children's object manipulation ability, basic movement ability, and mathematical ability. The young children's non-mobile movement ability was positively correlated with the ability to manipulate objects (r=0.689, p<0.01), and had a positive correlation with logarithm among mathematical abilities (r=0.890, p<0.01). Among mathematical abilities, there was a positive correlation (r=0.938, p<0.01) in the relationship between numbers and calculations. Among mathematical abilities, a positive correlation in the relationship with geometry (r=0.895, p<0.01). Among mathematical ability, there was a positive correlation (r=0.908, p<0.01) in relation to the middle measurement.

The young children's mobile movement ability showed a positive correlation (r=0.676, p<0.01) in relation to the object manipulation ability. Among mathematical abilities, the relationship with logarithm (r=0.834, p<0.01), the relationship with numbers and calculations (r=0.905, p<0.01), the relationship with geometry (r=0.841, p<0.01), and the relationship with the measurement (r=0.886, p<0.01) showed a positive correlation.

The young children's ability to manipulate objects showed a positive correlation in the relationship with non-mobile movement (r=0.689, p<0.01) and the relationship with mobile movement (r=0.676, p<0.01). Among mathematical abilities, the relationship with logarithm (r=0.571, p<0.01), the relationship with numbers and calculation (r=0.649, p<0.01), the relationship with geometry (r=0.659, p<0.01), and the relationship with measurement (r=0.645, p<0.01) a positive correlation was found.

Table 1. Relationships among non-mobile movement, mobile movement, object manipulation, and mathematical ability

	Non-mobile movement	Mobile movement	Object manipulation	Mathematical ability			
	1	2	3	4	5	6	7
1	-						
2	0.965**	-					
3	0.689**	0.676**	-				
4	0.890**	0.834**	0.571**	-			
5	0.938**	0.905**	0.649**	0.877**	-		
6	0.895**	0.841**	0.659**	0.854**	0.861**	-	
7	0.908**	0.886**	0.645**	0.879**	0.882**	0.864**	-
Mean	37.96	48.16	19.98	9.43	12.94	8.76	9.74
SD	14.40	14.33	8.36	3.09	2.67	2.90	2.55

**p<0.01

1. Non-mobile movement ability, 2. Mobile movement ability, 3. Object manipulation ability,
4. Mathematical ability: logarithm, 5. Mathematical ability: number and calculation,
6. Mathematical ability: geometry, 7. Mathematical ability: measurement, 8. Mean

3.2 Effect of Young Children's Object Manipulation, Non-mobile Movement, and Mobile Movement Ability on Mathematical Ability

3.2.1 Hierarchical Regression Results for Logarithm

Hierarchical regression analysis was performed to examine the influence on logarithm ability, which is a sub-variable of young children's mathematical ability. As a result of inputting the object manipulation ability in the first stage of the regression model, it was found that the logarithm ability was predicted statistically significantly (β=0.571, p<0.001). The object manipulation ability for logarithm, a sub-variable of young children's mathematical ability, was found to account for 32.6% of the total variance, and the analysis model was also found to be significant (R^2=0.326, F=37.646, p<0.001).

As a result of adding non-mobility and mobility to step 2 of the hierarchical regression model, it was found that only non-mobility predicted logarithm ability statistically significantly (β=1.280, p<0.001). When non-moving ability and movement ability were added, the explanatory amount increased by 47.8% (ΔR^2=0.478), and 80.3% of the total variance by adding non-moving ability and movement ability to the object manipulation ability for logarithm ability, a sub-variable of mathematical ability, and was found to be statistically significant (R^2=0.803, F=103.578, p<0.001). The results of the hierarchical regression analysis for logarithms are

presented in Table 2 below.

Table 2. Mathematical ability: Results of hierarchical regression analysis for logarithms (*N*=80)

Dependent variable	Step	Independent variable	*B*	*SE*	*β*	*t*	R^2	ΔR^2	*F*
Mathematical Ability: Logarithm	1	(Constant)	5.215	0.743		7.017***	0.326		37.646***
		Object manipulation	0.211	0.034	0.571	6.136***			
	2	Non-mobile movement	0.275	0.043	1.280	6.443***	0.803	0.478	103.578***
		Mobile movement	-0.076	0.042	-0.353	-1.804			

***p<0.001

3.2.2 Hierarchical Regression Results for Number and Calculation

As a result of inputting the object manipulation ability in the first stage of the regression model, it was found that the number and calculation abilities were predicted statistically significantly (β=0.649, p<0.001). The object manipulation abilities for number and calculation, a sub-variable of young children's mathematical ability, was found to explain 42.2% of the total variance, and the analysis model was also found to be significant (R^2=0.422, F=56.907, p<0.001).

As a result of adding non-mobility and mobility to step 2 of the hierarchical regression model, it was found that only non-mobility predicted statistically significant numbers and computational power (β=0.941, p<.001). When non-moving ability and movement ability were added, the explanatory amount increased by 45.8% (ΔR^2 =0.458), and 88.3% of the total variance by adding non-moving ability and movement ability to the object manipulation ability for algebraic ability, a sub-variable of mathematical ability, and was found to be statistically significant (ΔR^2=0.880, F=185.349, p<0.001). The results of the hierarchical regression analysis for numbers and operations are presented in Table 3 below.

Table 3. Mathematical ability: Results of hierarchical regression analysis for number and calculation (N=80)

Dependent variable	Step	Independent variable	*B*	*SE*	*β*	*t*	R^2	ΔR^2	*F*
Mathematical Ability: Number and calculation	1	(Constant)	8.789	0.596		14.756***	0.422		56.907
		Object manipulation	0.208	0.028	0.649	7.544***			
	2	Non-mobile movement	0.175	0.029	0.941	6.053***	0.880	0.458	185.349
		Mobile movement	-0.002	0.029	-0.008	-0.053			

***p<0.001

3.2.3 Hierarchical Regression Results for Geometry

As a result of inputting the object manipulation ability in the first stage of the regression model, it was found that the geometric ability was predicted statistically significantly (β=0.659, p<0.001). The object manipulation ability for geometry, a sub-variable of young children's mathematical ability, was found to explain 43.4% of the total variance, and the analysis model was also found to be significant (R^2=0.434, F=59.893, p<0.001).

As a result of adding non-mobility and mobility to step 2 of the hierarchical regression model, it was found that only non-mobility predicted geometric ability statistically significantly (β=1.163, p<0.001). When non-movement ability and movement ability were added, the explanatory amount increased by 37.7% (ΔR^2=0.377), and 81.2% of the total variance due to the addition of non-movement ability and movement ability to the object manipulation ability for algebraic ability, a sub-variable of mathematical ability, and was found to be statistically significant (R^2=0.812, F=109.244, p<0.001). The results of hierarchical regression analysis for geometry are presented in Table 4 below.

Table 4. Mathematical ability: Results of hierarchical regression analysis for geometry (N=80)

Dependent variable	Step	Independent variable	*B*	*SE*	*β*	*t*	R^2	ΔR^2	*F*
Mathematical Ability: Geometry	1	(Constant)	4.203	0.638		6.586***	0.434		59.893***
		Object manipulation	0.228	0.029	0.659	7.739***			
	2	Non-mobile movement	0.234	0.039	1.163	5.981***	0.812	0.377	109.244***
		Mobile movement	-0.069	0.039	-0.342	-1.786			

***p<0.001

3.2.4 Hierarchical Regression Results for Measurement

As a result of inputting the object manipulation ability in the first stage of the regression model, it was found that the measurement ability was predicted statistically significantly (β=0.197, p<0.001). The object manipulation ability for measurement, a sub-variable of young children's mathematical ability, was found to explain 41.5% of the total variance, and the analytical model was also found to be significant (R^2=0.415, F=55.438, p<0.001).

Table 5. Mathematical ability: Results of hierarchical regression analysis for measurement (N=80)

Dependent variable	Step	Independent variable	*B*	*SE*	*β*	*t*	R^2	ΔR^2	*F*
Mathematical Ability: Measurement	1	(Constant)	5.804	0.572		10.143***	0.415		55.438***
		Object manipulation	0.197	0.026	0.645	7.446***			
	2	Non-mobile movement	0.134	0.033	0.756	4.050***	0.827	0.411	120.844***
		Mobile movement	0.024	0.033	0.134	0.729			

***p<0.001

As a result of adding non-mobility and mobility to step 2 of the hierarchical regression model, it was found that only non-mobility predicted statistically significant ability (β=0.756, p<0.001). When non-movement ability and movement ability were added, the explanatory amount increased by 41.1% (ΔR^2=0.411), and 82.7% of the total variance due to the addition of non-movement ability and movement ability to the object manipulation ability for measurement ability, a sub-variable of mathematical ability, and was found to be statistically significant (R^2=0.827, F=140.844, p<0.001). The results of the hierarchical regression analysis for measurements are presented in Table 5 below.

4. DISCUSSION

The purpose of this study was to examine the effects of non-mobile movement, mobile movement, and object manipulation ability on young children's mathematical ability, and to investigate the effect between young children's non-mobile movement, mobile movement, object manipulation ability, and mathematical ability. I would like to conduct a discussion according to the research question.

First, as a result of examining the relationship between young children's non-mobile movement, mobile movement, object manipulation ability, and mathematical ability, the relationship between variables in this study was found to have a significant positive correlation. It was found that there was a positive correlation (r=0.689, p<0.01) between young children's non-mobile movement ability and the object manipulation ability. The research that the young children naturally acquire mathematical concepts in games or play situations through concrete manipulation activities [8], and that these mathematical experiences can acquire mathematical concepts meaningfully supports this research result. Among mathematical abilities, there was a positive correlation between algebra and relations (r=0.890, p<0.01), among mathematical abilities, there was a positive correlation between numbers and operations (r =0.938, p<0.01), and among mathematical abilities, geometry and there was a static correlation (r=0.895, p<0.01) in the relationship of and a static correlation (r =0.908, p<0.01) in the relationship with measurement among mathematical abilities.

In this study, among mathematical abilities, there was a static correlation between logarithm and relationship (r=0.890, p<0.01), among mathematical abilities, there was a static correlation between number and calculation (r=0.938, p<0.01), and mathematical abilities. There was a positive correlation (r=0.895, p<0.01) in relation to geometry, and a positive correlation (r=0.908, p<0.01) in relation to measurement among mathematical abilities. This result is consistent with the study that mathematics education using non-mobility abilities had a positive effect on young children's mathematical concepts [9] and the study that young children’s acquired mathematical concepts through non-mobility abilities when body and mathematics education were integrated and provided [10].

Next, the mobile movement ability of young children was found to have a positive correlation (r=0.676, p<0.01) in relation to the object manipulation ability. While performing mobile movements, young children experience mathematical concepts such as space, geometry, and number concepts. This result is in the same vein as the study [11] that the movement motion activity of young children centered on spatial elements using figures has an effect on mathematical ability. It can be seen that young children can naturally acquire mathematical abilities while performing movement movements using figures or objects in a wide space.

Then, it was found that young children's ability to manipulate objects had a positive correlation with mathematical ability. Specifically, among mathematical abilities, there was a positive correlation in the relationship about logarithm (r=0.571, p<0.01), among mathematical abilities in the relationship between number and calculation (r=0.649, p<0.01), and in mathematical abilities. There was a positive correlation (r=0.659, p<0.01) in relation to geometry, and a positive correlation (r=0.645, p<0.01) in relation to measurement among mathematical abilities. This is in the same vein as the study that showed that young

children had a positive effect on acquiring spatial vocabulary when they performed activities that integrated the body and mathematics [12]. It can be seen that young children can acquire various mathematical abilities as well as space through the ability to manipulate objects.

Second, as a result of examining the influence of young children's object manipulation ability, non-mobile movement, and mobile movement on mathematical ability, this study found that the young children's object manipulation, non-mobile movement, and mobile movement ability had a significant effect on mathematical ability. The object manipulation ability, non-movement ability, and mobility ability of young children are the contents of movement education [13], which is consistent with the results of studies that motion activity has a positive effect on mathematical ability [8, 14, 15].

As a result of this study, non-mobile movement ability was found to affect mathematical ability. It was found that mobile movement ability did not affect overall mathematical ability. As a result of this study, there was also a difference in the detailed ability of young children's mathematical ability. The non-mobile movement ability of young children was found to have a positive correlation with the logarithm (β=1.280), number and calculation (β=0.941), geometry (β=1.163), and measurement (β=0.756) of mathematical ability, also degree (p<0.001) was also high. The mobile movement ability of young children was negatively correlated with the logarithmic ability (β=-0.353), number and operation (β=-0.008), and geometry (β=-0.342), but was not significant (p>0. 05).

The study [16] that non-movement motions with limited flexibility can secure motion diversity supports the result that non-movement motions affect mathematical ability. On the other hand, the study [17] that infants search for each part of the body but move quickly when they are moving supports that the movement does not have a significant effect on mathematical ability. Although the effect of mobile movement ability on mathematical ability was not significant in this study (p>0.05), the logarithm of mathematical ability (β=-0.353), number and calculation (β=-0.008), and geometry (β=- 0.342) was negatively correlated, and measurements (β=0.134) were positively correlated.

As a result of previous studies that young children's mobile movements occur at high speed [17], it may be difficult for young children to experience mathematical experiences such as logarithm, number and operation, and geometry while performing movement movements. Instead, it seems that it is possible to have a mathematical experience such as measuring the length of a stride while performing a mobile movement.

5. CONCLUSION

The conclusion of this study is that first, non-mobile movement ability of young children has a positive correlation with object manipulation ability and mathematical ability. In addition, the mobile movement ability of young children has a positive correlation with object manipulation ability and mathematical ability. As such, it is easy to link with other areas because young children like movement and prefer movement activities. If movement activities including object manipulation, non-mobile movement, and mobile movement ability are provided to teachers, it is expected that the teacher will be able to apply movement activities including object manipulation, non-mobile movement, and mobile movement ability in connection with mathematical concepts in the field.

Second, as a result of this study, it was found that non-mobile movement ability had an effect on mathematical ability, whereas mobile movement ability did not affect overall mathematical ability.

There is a difference in the speed and magnitude of movement between non-mobile movement and mobile movement of young children. Due to the difference between non-mobile movement and mobile movement, it can be seen that non-mobile movement affects mathematical ability in this study, and mobile movement does not significantly affect mathematical ability.

The limitations of this study are as follows. First, this study looked at how non-mobile movement, mobile

movement, and object manipulation ability had an effect on mathematical ability, but did not examine young children's mathematical attitude. In subsequent studies, it is necessary to consider the effect on young children's mathematical attitudes. Second, this study looked at mathematical abilities focusing on the concept of movement. In subsequent studies, it is necessary to consider the relationship with mathematical abilities focusing on concepts in other areas such as music and literature.

REFERENCES

[1] S.A. Chi, "Validating a Motor Proficiency Test for Young Children," *Korean Journal of Early Childhood Education*, Vol. 27, No. 4, pp. 355-377, August 2007.

[2] Ministry of Education and Ministry of Health and Welfare, *2019 revised Nuri Curriculum Commentary*, Ministry of Education, Ministry of Health and Welfare, 2019.

[3] S.H. Ryu and Y.K. Ahn, "The Effect of Mathematics Education through Physical Activities on Mathematical Concept Development in Early Childhood," *The Journal of Korea Open Association for Early Childhood Education*, Vol. 11, No. 6, pp. 135-152, December 2006.

[4] Y.M. Park and I.S. Choi, "The Effect of the Mathematics-Physical Connected Activities on Toddler's Mathematical Concepts," *Journal of Early Childhood Education & Educare Welfare*, Vol. 19, No. 3, pp. 271-291, September 2015.

[5] H.K. Hong, *Early Childhood Mathematical Ability Development and Education*, Yangseowon, 2010.

[6] D.A. Ulrich, *Test of Gross Motor Development(2nd eds,)*, Pro-ed, Inc, 2000.

[7] H.I. Hwang and H.J. Choi, *Drawing Mathematics Ability Test of Young Children*, Yangseowon, 2007.

[8] E.E. Holmes, *Children learning mathematics*, Prentice Hall, 1985.

[9] Y.A. Kim, The Effect of the instruction in mathematics with motion activity to mathematical concept of infants, MA. Thesis. University of Kyungnam, Changwon, Korea., 2008.

[10] Y.J. Sung and H.K. Hong, "The Effect of Integrated Activities through Physical and Mathematics Education on Mathematics Ability of Preschoolers," *Korean Journal of Children's Media*, Vol. 9, No. 1, March 2010.

[11] S.K. Oh, The Development and Effects of Movement Education Program centered on Spatial Elements Using Geometry for Young Children, Ph. D. Thesis. University of Chungang, Seoul, Korea., 2012.

[12] Y.J. Kim, A Teaching Device for Increasing Topologic Vocabulary by Means of the Mathematical Instruction based on Physical Activities, MA. Thesis. University of Chungang, Seoul, Korea., 2003.

[13] D.L. Gallahue and J.C. Ozmun, *Understanding Motor Development(6th eds,)*, Mcgraw-Hill, 2006.

[14] M.S. Kim, The Effects of Music and Math Integrated Activities that Utilize Movements on Young Children's Music Aptitude and Math Concept, MA. Thesis. University of Keimyung, Daegu, Korea., 2016.

[15] A.E. Kim, The Effects of the Mathematical Education through Collaborative Physical Activity on Young Children's Mathematical Ability, Mathematical Attitude, and Pro-social Behavior, MA. Thesis. University of Chungang, Seoul, Korea., 2018.

[16] J.Y. Choi, and J.L. Lee, "Physical Activities Using Korean Dance and Motor Ability in Young Children," *Korean Journal of Child Studies*, Vol. 33, No. 6, pp. 21-34, December 2012.

[17] H.J. Kim, "Study on Meaning and Pedagogical Content Knowledge of Movement Activity of Beginning Kindergarten Teacher," *CNU Journal of Educational Studies*, Vol. 39, No. 4, pp. 147-181, November 2018.