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The Effects of The Science Education Program based on Pedagogical Content Knowledge (PCK) of Kindergarten Teachers on Scientific Knowledge, Scientific Inquiry Skill, and Scientific Inquiry Attitude of Young Children in Korea

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Abstract. The purpose of this research was to analyze the effects of the science education program based on pedagogical content knowledge of kindergarten teachers on scientific knowledges, scientific inquiry skills, and scientific inquiry attitudes of young children in Korea. Research aimed to analyze the effect of science education program based on PCK of kindergarten teachers on young children' them. Research used a quasi-experimental non-equivalent control group design. The participants enrolled in this study were 36 five-year-old from S kindergarten in Busan City, in Korea. The data was analyzed with the analysis of covariance test using the SPSS 18.0 software. The results of the research are as fallows; the participating in this science education program based on PCK of kindergarten teachers showed significantly higher scores in scientific knowledges, scientific inquiry skills and scientific inquiry attitudes than those who participated in science activities from Nu-Ri curriculum in Korea. In conclusion, it was confirmed that this science education program for young children based on PCK of kindergarten teachers improves young children's scientific knowledges, scientific inquiry skills, and scientific inquiry attitudes.

Keywords: young children, science education program, pedagogical contents knowledge, scientific knowledges, scientific inquiry skills, scientific inquiry attitudes

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INTRODUCTION

Cognitive activities of kindergarten teachers continue not only in the implementation of class, but also in the design and preparation of class. The more effective a teacher is, the more effort is spent on planning class than on teaching class. In other words, kindergarten teachers intentionally design and implement classes, which is embodied as pedagogical content knowledge in class. PCK is the knowledge that kindergarten teachers rely directly on when teaching their children. This knowledge is a personal "practical knowledge" implied by kindergarten teachers for teaching on a particular subject based on their diverse background knowledge and teaching beliefs and experiences [1].

"Teaching" is a very uncertain, dynamic and ever-changing complex process for kindergarten teachers [2]. Unlike the curriculum-based elementary teaching, early childhood education in the Republic of Korea operates based on a play-based integrated curriculum. It is very important for kindergarten teachers to have knowledge related to the overall understanding of the teaching environment, including knowledge about the integrated curriculum, early childhood knowledge, and teaching and learning methods.

In Korea, kindergarten teachers should refer to the national curriculum and decide their curriculum autonomously and run the curriculum flexibly. One of the areas of curriculum in which kindergarten teachers complain the most difficulties is the science field [3]. Despite the increased emphasis on teacher expertise in these science education [4], kindergarten teachers are unable to cope with young children appropriately due to the lack of systematic knowledge of science subjects and have difficulty in teaching science fields [3,5,6]. Korean young children also have lost their interest in the science field [5]. This phenomenon is not only due to the lack of scientific environment in the field of early childhood education, lack of scientific tools and instruments, lack of resources and finances, but also lack of understanding of the teacher's own scientific knowledge and science teaching methods, and negative attitudes such as scientific anxiety and lack of teacher's confidence [7,8,9].

The kindergarten teacher's PCK of science provides useful information to understand how they interpret and apply the science subjects that they understand. It also contains insightful information about the knowledge they use to teach. Prior studies on PCK emphasize PCK as a prerequisite for such competent and qualified teachers [10,11]. In this regard, the education society of Korea also explains the nature and scope of PCK in various fields from the point of view that PCK is an essential element for teacher professional development. Studies on the necessity of PCK extension for teachers in the scientific field [12,13,14] have been conducted as well as studies on factors affecting teachers' PCK extension [13,14].

Although PCK related studies have been conducted, most previous studies have focused on the identification of PCK characteristics [15,16]. Several studies have devised ways to represent PCK in order to understand the reality of PCK [17,18], including the changes in PCK in teachers' classroom environments and the effects of these changes on teaching performance [19]. However, PCK-based program studies [20] are still scarce. In addition, these previous studies have limitations in explaining the PCK of early childhood teachers because teachers' PCK itself does not necessarily apply to their teaching practice.

In this regard, it requires a concrete understanding of the PCK of the kindergarten teacher. Through exploring the nature and components of PCK in science subjects, efforts are needed to analyze the process of formation and development of PCK or to embody this in science subjects. The higher the level of the PCK in the kindergarten teacher's science curriculum, the more likely the implementation of the science education program will positively affect the child's scientific knowledge, scientific inquiry skills, and scientific inquiry attitude. In other words, if the child's PCK in the science curriculum is assured and it is properly applied in the classroom, the science learning of young children will be done properly. Therefore, in this study, we developed an early childhood science education program based on kindergarten teacher's PCK, which can be easily and straightforwardly applied to early childhood science class. We attempted to verify the effects of the developed program on young children's scientific knowledges, scientific inquiry skills, and scientific inquiry attitudes.

The research questions of this were as follow:

1. Was there any effect of the science education program based on pedagogical content knowledge of kindergarten teachers on scientific knowledge of young children?
2. Was there any effect of the science education program based on pedagogical content knowledge of kindergarten teachers on scientific inquiry skill of young children?
3. Was there any effect of the science education program based on pedagogical content knowledge of kindergarten teachers on scientific inquiry attitude of young children?

1. Experimental setup

1.1 Participants

The participants enrolled in this study were 36 5-year-old from S kindergarten, located in Busan city. Classes were selected and assigned to the experimental group (18 5-year-old) and the control group (18 5-year-old) in table 1. In order to maintain the homogeneity of the experimental group and the control group, both groups were to comprise of the same age children of the same kindergarten.

Table 1. Age distribution of experimental group and control group

Division	**N**	**Male: Female**	**Min.**	**Max.**	**M**	**SD**
Experimental group	18	9 : 9	5.05	6.04	5.50	.49
Control group	18	9 : 9	5.05	6.04	5.45	.47
Total	36	18 : 18	5.05	6.04	5.47	.47

2.2. Instruments

2.2.1. The Matrix System Model of PCK

The matrix system model of the early childhood science education program based on PCK of kindergarten teachers, was developed by referring to the composition of the early childhood mathematics activity matrix based on pedagogical content knowledge and the questionnaire on recognition and actual condition of pedagogical content knowledge on the early childhood art activities. In addition, we referenced books, domestic journals and foreign journals related to scientific activities such as preceding studies related to early childhood science education program [21]. The matrix system model of the early childhood science education program based on PCK of kindergarten teachers is shown in Figure 1.

Living subject	subject	Sub-topic	Activity date

Education goal	Scientific knowledge	Scientific inquiry skill	Scientific inquiry attitude

Education contents					
	Science topics		**Type of learning task**	**Inquiry skill**	**Inquiry attitude**
	Various objects	Electricity	Fact Learning	Observation	Curiosity
	Various substances	Air	Conceptual learning	Classification	Rationality
	Color	Sound	Principle learning	Measurement	Objectivity
	Magnet	My body	Procedure Learning	Communication	Reservation of judgment
	Heat	Nature material	Learning of Relationship understanding	Prediction	Criticality
	Machine	Animal	Problem solving ability	Inference	Openness
	Tool	Plant	Creative thinking ability	Generalization	Honesty
	Water	Day and night			Humility and conference
	Light	Change of seasons			Cooperation
					Accuracy
					Acceptance of failure

teaching method

Type of activity	
Grouping strategy	Large group activities
	Small group activities
	Free choice activities
Interaction	Teacher-led
	Young children-led
	Teacher-children interaction

Environment for Scientific Activities
Basic facility
Plant
Animal
Insect
Various objects and materials
Common tools and machine
Tools for measurement
Tool for safety

Approach to Science Activities
Heuristic approach
Approach to physical knowledge activity
Representation & discussion-centric approach
A literary approach
Multimedia approach
Natural exploration-centric approach

Time Planning of Science Activities	
Conformity	Depending on the activity
	Depending on the age
	According to the level of young children
	Depending on the time of activity
Activities time	10-20 minutes
	21-30 minutes
	31-40 minutes

Pre-activity	Relevance to this activity

This	Introduction	Question	Reaction technique	Wrap-up

	activity		technique		
		Recall of prior activities	Cognitive-memory questions	Simple positive or negative	Check of activity Goal
		Riddle			
		Resource description	Convergent question	Clarify request	Guide to re-activities
		Exploring material	Divergent question	Proof requirements	
		Songs related to the activity		Explain expand answer	Various representation activities
		literature relate d to the activity	Evaluative question	Ask another children	
	Extension activity		Activities to help you integrate this activity	Problem solving science activity	Creative thinking science activity
Assessment methods	Verbal interaction		Observation	Analysis of activity sheet	Analysis of work

Figure 1. The matrix system model of early childhood science education program based on PCK of kindergarten teachers

2.2.2. Instruments

In order to measure the scientific knowledge, the topics and knowledge areas specified in the science area of the kindergarten curriculum were selected. The overall range of questionnaires and the questionnaires were determined. 'The scientific knowledge test' used by Lee and Han in 2010, in which two experts validate the content, was modified and supplemented for use in this study. In order to measure the knowledge of the curriculum, the scientific knowledge test consists of three fields - 'life and natural environment', 'objects and materials' and 'seasonal change', each of which has three questions so that a total of 9 questions were prepared for the test. In order to measure the scientific inquiry skills, 'the scientific inquiry skill test' that was supplemented based on Martin's scientific inquiry ability evaluation scale, was used in this study. A total of 25 questions including 7 subfields with five items of 'Observation', five items of 'Classification', four items of 'Measurement', five items of 'Discussion', two items of 'Prediction', two items of 'Inference', and two items of 'Generalization' were asked in this study. The reliability coefficient, Cronbach's α of scientific inquiry skills test were .82(.55~.69). In order to measure the scientific inquiry attitude, Martin's evaluation scale was revised and supplemented. The subfields of the scientific attitude test consist of nine components: curiosity, rationality objectivity, reservation of judgment, criticality, openness, honesty, Humility and conference, cooperation, accuracy and acceptance of failure. There are 27 questions in total, consisting of three questions in each sub-field. Reliability coefficients of scientific inquiry attitude subfactors were calculated from .48 to .68, and the reliability coefficient of the scientific inquiry attitude were .95.

2.3. Process

The program was offered three or four times a week, and there were 18 total sessions. The experimental group was offered with18 activities for the science education program based on PCK of kindergarten teachers. On the other hand, the comparison group was treated 18 science activities based on Nu-Ri curriculum in Korea.

2.4. Analysis

The data was analyzed by the SPSS 18.0 software. First, the reliability coefficient Cronbach's α coefficient was calculated and the Pearson correlation analysis was conducted to determine the reliability of the test device. Second, in order to verify the effectiveness of this program, the covariance analysis was conducted to control the difference of the post-scores between the experimental group and the control group after controlling the prior score of the two groups.

2. Result Discussion

3.1. The Effects of This Program based on PCK on Scientific Knowledges

Table 2 compared the adjusted scientific knowledges post-scores between the experimental group and the control group.

Table 2. The mean and standard deviation of post scores and adjusted post-score scores of scientific knowledges

Division			Post-scores of scientific knowledges subfactor		Adjusted post-scores of scientific knowledges subfactor	
			M	*SD*	*M*	*SD*
Life and natural environment	Fact	Experimental group	1.00	.00	1.01	.50
		Control group	.83	.38	.82	.50
	Concept	Experimental group	1.28	.58	1.24	.12
		Control group	.83	.51	.87	.12
	Rule	Experimental group	.72	.46	.69	.09
		Control group	.28	.46	.31	.09
	Total score	Experimental group	3.00	.77	2.94	.16
		Control group	1.94	.94	2.00	.16
Objects and materials	Fact	Experimental group	1.00	.00	1.00	.08
		Control group	.67	.49	.67	.08
	Concept	Experimental group	1.67	.59	1.57	.11
		Control group	1.11	.58	1.21	.11
	Rule	Experimental group	.33	.49	.34	.09
		Control group	.06	.24	.05	.09
	Total score	Experimental group	3.00	.84	2.90	.18
		Control group	1.83	.86	1.94	.18
Natural phenomenon	Fact	Experimental group	.94	.24	.96	.07
		Control group	.83	.38	.81	.07
	Concept	Experimental group	1.39	.50	1.38	.11
		Control group	1.00	.49	1.01	.11
	Rule	Experimental group	.83	.38	.82	.10
		Control group	.50	.51	.51	.10
	Total score	Experimental group	3.17	.71	3.17	.19
		Control group	2.33	.97	2.33	.19
Overall scientific knowledges		Experimental group	9.17	1.51	8.98	.32
		Control group	6.11	1.75	6.30	.32

As shown in Table 2, the adjusted post scientific knowledges scores of the experimental group were higher than those of the control group. Table 3 shows the results of the covariance analysis on the scientific knowledges post scores between the experimental group and the control group.

Table 3. Covariance analysis of post scores of scientific knowledges between experimental group and control group

Division		Transformation	Sum of squares	Degrees of freedom	Mean square	*F*
Life and natural environment	Fact	Pre-test score(covariate)	.81	1	.81	15.81***
		Group(main effect)	.31	1	.31	6.05*
		Error	1.69	33	.05	
		Sum	33.00	36		
	Concept	Pre-test score(covariate)	2.04	1	2.04	4.71**
		Group(main effect)	1.15	1	1.15	4.71*

		Error	8.07	33	.25	
		Sum	52.00	36		
	Rule	Pre-test score(covariate)	2.07	1	2.07	13.25**
		Group(main effect)	1.28	1	1.28	8.17**
		Error	5.15	33	.16	
		Sum	18.00	36		
	Total score	Pre-test score(covariate)	10.37	1	10.37	23.50***
		Group(main effect)	7.81	1	7.81	17.68***
		Error	14.57	33	.44	
		Sum	255.00	36		
Objects and materials	Fact	Pre-test score(covariate)	.08	1	.08	.67
		Group(main effect)	.96	1	.96	8.05**
		Error	3.92	33	.12	
		Sum	30.00	36		
	Concept	Pre-test score(covariate)	4.43	1	4.43	19.89
		Group(main effect)	1.08	1	1.08	4.87
		Error	7.35	33	.22	
		Sum	84.00	36		
	Rule	Pre-test score(covariate)	.11	1	.11	.77
		Group(main effect)	.75	1	.75	5.09*
		Error	4.83	33	.15	
		Sum	7.00	36		
	Total score	Pre-test score(covariate)	5.59	1	5.59	9.75**
		Group(main effect)	7.76	1	7.76	13.53**
		Error	18.91	33	.57	
		Sum	247.00	36		
Natural phenomenon	Fact	Pre-test score(covariate)	.98	1	.98	13.09
		Group(main effect)	.20	1	.20	2.68
		Error	2.47	33	.08	
		Sum	32.00	36		
	Concept	Pre-test score(covariate)	.62	1	.62	2.66
		Group(main effect)	1.25	1	1.25	5.38
		Error	7.66	33	.23	
		Sum	61.00	36		
	Rule	Pre-test score(covariate)	1.61	1	1.61	9.85**
		Group(main effect)	.85	1	.85	5.20*
		Error	5.39	33	.16	
		Sum	24.00	36		
	Total score	Pre-test score(covariate)	3.81	1	3.81	6.08*
		Group(main effect)	6.25	1	6.25	9.97**
		Error	20.69	33	.63	
		Sum	303.00	36		
Overall scientific knowledges		Pre-test score(covariate)	30.30	1	30.30	16.67***
		Group(main effect)	62.36	1	62.36	34.31***
		Error	59.98	33	1.82	
		Sum	2275.00	36		

** p<.05, ** p<.01, *** p<.001*

As shown in Table 4, the scientific knowledges post-scores showed a significant difference between the experimental group and the control group (F=34.31, p <.001). The post-scores of life and natural environment (F=17.68, p <.001), objects and materials (F=13.53, p <.01), and natural phenomena (F=9.97, p <.01) showed significant differences between the experimental group and the control group.

The kindergarten teacher education program based on PCK has a positive effect on the acquisition of scientific knowledges such as life and natural environment, objects and materials, and natural phenomena of young children. This supports research results [10] that teachers with a lot of science pedagogy knowledges allows students to recognize the learning problem accurately and make full use of their knowledges in the classroom. In other words, an educational science program based on kindergarten teacher's PCK, is effective for the early childhood scientific knowledges formation. In this way, the children of the experimental group are gradually expanding their knowledges composition from prior knowledges to observation knowledges, constructing knowledges, and scientific knowledges through each activity of kindergarten teacher's PCK education.

3.2. The Effects of This Program based on PCK on Scientific Inquiry Skills

Table 4 compared the adjusted scientific inquiry skills post-scores between the experimental group and the control group.

Table 4. The mean and standard deviation of post-scores and adjusted post-scores of scientific inquiry skills

Division		**Post-scores of scientific inquiry skills subfactor**		**Adjusted post-scores of scientific inquiry skills subfactor**	
		M	*SD*	*M*	*SD*
Observation	Experimental group	17.28	1.53	17.34	.28
	Control group	16.22	2.10	16.16	.28
Classification	Experimental group	16.72	1.45	16.74	.31
	Control group	15.83	1.58	15.82	.31
Measurement	Experimental group	14.39	1.38	14.31	.30
	Control group	12.67	1.46	12.74	.30
Communication	Experimental group	16.72	1.57	16.55	.36
	Control group	15.17	1.86	15.34	.36
Prediction	Experimental group	7.28	1.07	7.25	.23
	Control group	6.33	.84	6.36	.23
Inference	Experimental group	6.33	1.03	6.32	.21
	Control group	6.22	.94	6.24	.21
Generalization	Experimental group	6.22	.81	6.22	.21
	Control group	5.89	.96	5.90	.21
Overall scientific inquiry skills	Experimental group	84.94	6.08	84.56	1.29
	Control group	78.33	8.07	78.72	1.29

As shown in Table 4, the adjusted post scientific inquiry skills scores of the experimental group were higher than those of the control group. Table 5 shows the results of the covariance analysis on scientific inquiry skills post scores between the experimental group and the control group.

Table 5. Covariance analysis of post scores of scientific inquiry skills between experimental group and control group

Division	Transformation	Sum of squares	Degrees of freedom	Mean square	*F*
Observation	Pre-test score(covariate)	68.05	1	68.05	48.11***
	Group(main effect)	12.43	1	12.43	8.79**
	Error	46.67	33	1.41	
	Sum	10225.00	36		
Classification	Pre-test score(covariate)	21.53	1	21.53	12.56**
	Group(main effect)	7.52	1	7.52	4.38*
	Error	56.58	33	1.72	
	Sum	9624.00	36		
Measurement	Pre-test score(covariate)	14.10	1	14.10	8.59**
	Group(main effect)	21.94	1	21.94	13.36**
	Error	54.18	33	1.64	
	Sum	6683.00	36		
Communication	Pre-test score(covariate)	26.43	1	26.43	11.84**
	Group(main effect)	12.70	1	12.70	5.70*
	Error	73.68	33	2.23	
	Sum	9274.00	36		
Prediction	Pre-test score(covariate)	.87	1	.87	.94
	Group(main effect)	6.87	1	6.87	7.37*
	Error	30.74	33	.93	
	Sum	1707.00	36		
Inference	Pre-test score(covariate)	6.05	1	6.05	7.37*
	Group(main effect)	.06	1	.06	.07
	Error	27.07	33	.82	
	Sum	1452.00	36		
Generalization	Pre-test score(covariate)	.32	1	.32	.40
	Group(main effect)	.91	1	.91	1.13
	Error	26.57	33	.81	
	Sum	1348.00	36		
Overall scientific inquiry skills	Pre-test score(covariate)	748.50	1	748.50	24.99***
	Group(main effect)	304.90	1	304.90	10.18**
	Error	988.45	33	29.95	
	Sum	242067.00	36		

** p<.05, ** p<.01, *** p<.001*

As shown in Table 5, there was a significant difference between the experimental group and the control group in post-scores of scientific inquiry skills (F=10.18, $p < .01$). Among sub-factors of scientific inquiry skills, the post-scores of observation (F=8.79, $p < .01$), classification (F=4.38, $p < .05$), measurement (F=13.36, $p < .01$), communication (F=5.70, $p < .05$) and prediction (F=7.37, $p < .05$) showed the significant difference between experimental and control group, but post scores of inference (F=.07, $p > .05$) and generalization (F=1.13, p > .05) showed no significant difference between the experimental group and the control group.

Early childhood science education program based on PCK of kindergarten teachers has a positive effect on the improvement of scientific inquiry skills of young children. Our results are in the same context as the results of several previous studies. For example, integrated activities that combine drawing and science activities using various expression methods [22], integrated activities of aesthetic and scientific inquiry elements [23], the early childhood science education program using mathematical representation [24], science and art convergence education activities using fairy tales [25] have positive effects on young children's scientific inquiry skills. On the other hand, kindergarten teacher's PCK-based early childhood science education programs had no effect on inference and generalization. Reasoning requires very abstract thinking and is not as simple as 'prediction' so that it is still difficult to judge the authenticity of young children's reasoning. In addition, generalization refers to young children's learning of a scientific principle or law and applying it to every life or other activities. Eighteen sessions of scientific activities may not be sufficient to gauge the effect of this scientific inquiry function. Since the scientific inquiry skills are not formed suddenly at any moment, it is composed through continuous process of experiencing cognitive conflict in daily life and searching for solutions or alternatives.

3.3. The Effects of This Program based on PCK on Scientific Inquiry Attitudes

Table 6 compared the adjusted scientific inquiry attitudes post-scores between the experimental group and the control group.

Table 6. The mean and standard deviation of post-scores and adjusted post-scores of scientific inquiry attitudes

Division		Post-scores of scientific inquiry attitude subfactor		Adjusted Post-scores of scientific inquiry attitude subfactor	
		M	*SD*	*M*	*SD*
Curiosity	Experimental group	10.33	1.24	10.39	.21
	Control group	9.44	1.38	9.38	.21
Rationality	Experimental group	10.00	1.09	10.00	.22
	Control group	9.00	1.33	9.00	.22
Objectivity	Experimental group	10.22	1.00	10.22	.21
	Control group	8.89	1.37	8.89	.21
Reservation of judgment	Experimental group	10.11	1.08	10.16	.23
	Control group	8.94	1.11	8.90	.23
Criticality	Experimental group	10.11	1.28	10.07	.27
	Control group	9.06	1.26	9.09	.27
Openness	Experimental group	10.17	1.04	10.15	.20
	Control group	8.78	1.06	8.79	.20
Honesty	Experimental group	10.28	1.18	10.30	.24
	Control group	9.11	1.08	9.08	.24
Humility and conference	Experimental group	6.67	.84	6.77	.19
	Control group	5.89	.96	5.79	.19
Cooperation	Experimental group	10.22	1.22	10.28	.25
	Control group	8.83	1.15	8.78	.25
Accuracy	Experimental group	10.33	1.14	10.36	.28
	Control group	8.94	1.39	8.92	.28
Acceptance of failure	Experimental group	9.83	1.10	9.89	.25
	Control group	8.83	1.04	8.77	.25
Overall scientific inquiry attitudes	Experimental group	108.28	9.46	108.75	1.70
	Control group	95.72	10.69	95.25	1.70

As shown in Table 6, the adjusted post scientific inquiry attitudes scores of the experimental group were higher than those of the control group. Table 7 shows the results of covariance analysis on post scores of scientific inquiry attitudes between the experimental group and the control group.

Table 7. Covariance analysis of post scores of scientific inquiry attitudes between experimental group and control group

Division	Transformation	Sum of squares	Degrees of freedom	Mean square	*F*
Curiosity	Pre-test score(covariate)	32.34	1	32.34	40.88***

	Group(main effect)	9.14	1	9.14	11.56**
	error	26.11	33	.79	
	Sum	3586.00	36		
Rationality	Pre-test score(covariate)	21.45	1	21.45	24.79***
	Group(main effect)	9.00	1	9.00	10.40**
	error	28.55	33	.87	
	Sum	3308.00	36		
Objectivity	Pre-test score(covariate)	22.10	1	22.10	27.23***
	Group(main effect)	16.00	1	16.00	19.71***
	error	26.79	33	.81	
	Sum	3352.00	36		
Reservation of Judgment	Pre-test score(covariate)	8.56	1	8.56	14.49**
	Group(main effect)	14.12	1	14.12	14.49**
	error	32.16	33	.98	
	Sum	3321.00	36		
Criticality	Pre-test score(covariate)	11.96	1	11.96	9.23**
	Group(main effect)	8.61	1	8.61	6.65*
	error	42.76	33	1.30	
	Sum	3371.00	36		
Openness	Pre-test score(covariate)	13.56	1	13.56	18.61***
	Group(main effect)	16.57	1	16.57	22.74***
	error	24.05	33	.73	
	Sum	3285.00	36		
Honesty	Pre-test score(covariate)	9.35	1	9.35	9.06**
	Group(main effect)	13.36	1	13.36	12.95**
	error	34.04	33	1.03	
	Sum	3439.00	36		
Humility and conference	Pre-test score(covariate)	6.60	1	6.60	10.28**
	Group(main effect)	8.18	1	8.18	12.74**
	error	21.18	33	.64	
	Sum	1452.00	36		
Cooperation	Pre-test score(covariate)	12.06	1	12.06	11.19**
	Group(main effect)	20.03	1	20.03	18.59***
	error	35.55	33	1.08	
	Sum	3333.00	36		
Accuracy	Pre-test score(covariate)	8.73	1	8.73	6.23*
	Group(main effect)	18.75	1	18.75	13.39**
	error	46.22	33	1.40	
	Sum	3417.00	36		
Acceptance of failure	Pre-test score(covariate)	3.70	1	3.70	3.46
	Group(main effect)	10.90	1	10.90	10.19**
	error	35.30	33	1.07	
	Sum	3184.00	36		
Overall scientific inquiry attitudes	Pre-test score(covariate)	1753.83	1	1753.83	33.90***
	Group(main effect)	1631.81	1	1631.81	31.54***
	error	1707.39	33	51.74	

	Sum	379424.00	36		

As shown in Table 7, there was a significant difference between the experimental group and the control group in the post scores of scientific inquiry attitudes (F=31.54, p < .001). The post scores of the curiosity (F=11.56, p <. 01), rationality (F=10.40, p < .01), objectivity (F=19.71, p < .001), reservation of judgment (F=14.49) , p < .01), criticality (F=6.65, p < .05), openness (F=22.74, p< .001), honesty (F=12.95, p < .01), humility and conference (F=12.74, p < .01), cooperation (F=18.59, p < .001), accuracy (F=13.39, p < .01) and acceptance of failure (F=10.19, p < .01) were significantly different between the experimental group and the control group.

The result of this study supports the following previous research; the integrative activities of aesthetic and scientific inquiry elements [23], the early childhood science education program based on creativity techniques [21], and the early childhood science education program based on the maker education [26] have positive effects on scientific inquiry attitudes of young children. Scientific inquiry attitudes formed during early childhood help predict behaviors related to science, and scientific inquiry attitudes formed during early childhood affect the interest in science throughout life. Since the scientific inquiry attitudes of young children is formed much earlier than other subjects, it is very important to provide science education that can develop their scientific inquiry attitudes in early childhood in order to develop a positive attitude to science education later. Therefore, it is necessary to consider the scientific inquiry attitudes when constructing an early childhood science education program based on PCK of kindergarten teachers.

3. Conclusions

The implications of this study are as follows. First, in order to reinforce kindergarten teacher's classroom design and execution capacity through PCK, it is necessary to devise ways to strengthen their science school PCK. Therefore, in order to develop the PCK of kindergarten teachers, it is necessary to systematically explore the practical knowledge made by the teachers who teach the early childhood and share their practical knowledge among the teachers. In other words, we propose class consulting or professional learning community for the science subject PCK that exposes, specifies and shares the science subject PCK possessed by the experienced teacher through the actual young children science class conducted in the early childhood education field. Second, a plan for the development of science school PCK for preservice kindergarten teachers should be provided. Preservice teacher education tends to focus on the content knowledge of each subject. The PCK should be developed into a class to raise an eye to consider the level of preservice teachers and the level required in the curriculum.

In conclusion, the implications of this study are as follows: First, the theoretical basis for the basic concepts, characteristics, and elements of science subject PCK for Korean kindergarten teachers was provided. Basic materials were also provided to help study the composition, approach, and teaching and learning methods of science education programs for young children. Second, the practical science education program based on PCK of kindergarten teachers developed in this study is an effective teaching and learning method that can improve young children's scientific knowledge, inquiry ability and inquiry attitude. The possibility of active application is presented. The potential application in the real educational field is presented. Third, educationally, this study provided basic materials for developing the programs and curriculum for kindergarten teacher education in early childhood nurturing institutes responsible for early childhood education and for science education training and conservative education.

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