Research Article

Development and Verification of a Pedagogical Content Knowledge of Physical Education Scale for Republic of Korea Teachers

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Abstract: This study aims to explore the structure of Pedagogical Content Knowledge of Physical Education (PCK-PE), develop a scale, and verify its validity. This study was divided into primary and secondary preliminary surveys and one main survey. First, a scale was developed through the Delphi verification process after data were collected through an open questionnaire administered to 97 physical education teachers in January 2020. Second, a descriptive statistical analysis and an exploratory factor analysis was performed on data collected from 163 physical education teachers in February 2020. Finally, a questionnaire was administered to 265 physical education teachers in March 2020. The reliability of the scale was analyzed. Through confirmatory factor analysis, convergent, nomological, and discriminant validity were verified. A correlation analysis was conducted to verify criterion-related validity. Based upon the analysis, a PCK-PE scale was developed with 21 questions and five factors: knowledge of curriculum, pedagogy, educational philosophy, education evaluation, and class environment. The reliability and validity of the developed scale were verified.

Keywords: Physical Education Scale; Pedagogical Content Knowledge (PCK); Instructional Expertise

1. Introduction

Teachers lie at the heart of successful education. Students' academic achievements are proportional to teachers' instructional expertise (Seo and Park, 2010). Classes facilitate students' understanding of content and serve to engage them in a variety of activities. Because the basic job of a teacher is to direct class activities (Kwon and Kim, 2011; You, 2004), teachers should have instructional expertise that is reflected in the classroom. Instructional expertise refers to an ability to combine and reconstruct the pedagogical content knowledge (PCK) and the pedagogical knowledge (PK) necessary to teach it in the classroom (Yu and Chae, 2009). Interest in instructional expertise first emerged when Shulman (1986) used the term PCK, defining it as "a method of expressing and formulating the pedagogical content to enhance the understanding of students." Specific subject matter, problems, or issues (such as a PE class's unique teaching-learning method, environment, and evaluation) of the pedagogical content are transformed into an organized expression for learners with varying levels of interest and competency, ensuring a harmonious blend of knowledge with the method used in class.

Given the importance of teaching expertise and developing a new perception of teacher identity, more systematic studies were conducted from an educational perspective in the 1980s. Schwab et al. (1978) attempted to restructure curriculum by reflecting the teachers' practical knowledge in the curriculum. They asserted that with theoretical knowledge, knowledge of on-site teaching practices should be included when constructing a curriculum. The curriculum should be constructed practically by comprehensively incorporating five factors: pedagogical content, learner, learning environment, teacher, and curricular composition process. Schwab's effort provided an opportunity to overcome the dualisms inherent in education—for example, theory and practice, and content and method—through the process of assessing the practical knowledge of a teacher (Schulman, 1987).

Shulman (1987) presented seven components of teachers' knowledge: content knowledge, curriculum knowledge, PCK, general pedagogical knowledge, knowledge of learners, knowledge of educational contexts, and knowledge of educational ends; along with their purposes and values and philosophical and historical grounds. These are similar to the five elements of the content aspects of the practical knowledge as discussed in Elbaz, 2018).

Shulman (1986) integrated the new elements of "content knowledge" and "curriculum knowledge" and developed "PCK" as a concept that combined these two elements instead of perpetuating the dichotomy between theoretical and practical knowledge. He investigated what constitutes the knowledge that represents instructional expertise, and thus created the concept of PCK. According to him, PCK combines the subject knowledge of a teacher and their knowledge of how to teach it to effectively foster students' understanding of the content. PCK is now widely accepted as a concept that represents a teacher's knowledge as a comprehensive phronesis (Creasy, Whipp and Jackson, 2012).

Most scholars who follow Shulman (Banks, Leach and Moon, 2005; Cochran, DeRuiter and King, 1993; Fernandez-Balboa and Stiehl, 1995; Koballa, et al., 1999) consider PCK to encompass the overall subject understanding and knowledge of a teacher from the perspective of curriculum behavior, which formulates the basis of teaching behavior. This implies that PCK should be recognized in the curriculum framework. If the meaning of the concept of PCK is extended to include curriculum, it encompasses teaching and curriculum behaviors. Accordingly, it has a synergistic effect in establishing a teacher's expertise, thus resolving the issue of the discrepancy between theoretical and practical knowledge.

In general, PCK as a teacher's unique knowledge of how to teach specific content (Shulman, 1986; 1987) is considered an indicator of the instructional expertise of a teacher (Loughran, Mulhall and Berry, 2004). Many scholars view it as the most essential element of teaching expertise (Gess-Newsome and Lederman, 1999; Schempp et al., 1998; Van Dijk, 2009). Since research on PCK normally relates to the perception process of teachers, most previous studies used a qualitative research method (Yu and Chae, 2009). Therefore, a quantitative study, one that identifies a teacher's PCK, and consequently, a highly valid PCK measurement tool for physical education (PE) teachers, is required. Meaning can be found through discussion of a teacher's knowledge base; the instructional activities applied can, directly and indirectly, affect students. That said, teachers reflect on their teaching activities, thereby improving activities, finding meaning in what they do, and gaining insight to develop a firm perspective on teaching.

Studies on the development of a PCK measurement tool have been conducted in fields such as elementary science (Park, 2003), early childhood science (Kim, 2007), early childhood mathematics (Hong, 2012), elementary practical arts (Choi, 2011), and home economics education (Lee and Yu, 2017). The development of such a tool would measure and examine the PCK level of teachers and its various variables, supporting the development of a practical educational program and thereby contributing to improving teachers' instructional expertise. Cho and Choi (2009) measured the PCK of pre-service environmental education teachers with a corrected and supplemented PCK measurement tool developed by Park (2003). They presented a plan to cultivate the PCK of teachers of environmental education through training programs that explored the levels of pre-service teachers by PCK area. In addition, studies that cultivate the PCK of science teachers by examining the relationship between related variables using the PCK measurement tool were actively conducted. Park (2003), who developed a PCK measurement tool for elementary science teachers, was the first to conduct such a study. Other studies include those of Kim (2007), who developed a PCK measurement tool for early childhood science teachers; Lim (2003), whose PCK measurement tool revealed the relationship between science teaching efficacy and teaching practice; Park (2006), who examined the relationship among secondary school teachers' teaching methods, self-efficacy, attitude, and PCK; and Seo (2014), who investigated the relationship between PCK and efficacy of elementary school science teachers. Lee (2011) and Oh (2009) explored PCK and the efficacy of early childhood science teachers by examining the relationship between elementary experiment training and PCK.

PCK provides a scope of knowledge that teachers should have in relation to curriculum education. For pre-service teachers, it contributes to providing the content and scope of knowledge that they should have to teach the subject effectively. This is because the PCK of a specific subject is a specialized area of expertise held only by teachers who teach the subject. PCK can be divided into content knowledge (CK), about the subject, and PK, which is required to teach it. Thus, PK forms a unique PCK for the subject by combining with CK. Accordingly, even if the PCK contents are similarly perceived, the PCK of science teachers and PE teachers differ. Therefore, if a pre-service teacher has acquired CK for the PE subject, he/she would be able to form a PCK unique to PE by combining it with the previously perceived PK. Because PCK is applied differently for each subject, studies on PCK need to focus on PCK for each subject (Song, Song and Lee, 2020).

Although studies related to PCK-PE have been reported (Cho, Hong and Kim, 2013; You and Cho, 2010; Lee, 2011; Jin, 2009), a study on scale development and validity verification for PCK-PE has not been conducted. Accordingly, considering the current emphasis on the instructional expertise of PE teachers, the development of a PCK measurement tool is needed.

Building upon existing studies related to the PCK-PE, Cho, Hong, and Kim (2013) conducted a study of structuring sub-elements and constructing achievement standards to examine how PE teachers form and develop PCK-PE in class. Lee (2011), Jin (2009), and You and Cho (2010) all conducted studies that investigated PCK formation processes and development in various settings (Song, Song and Lee, 2020). Thus, in addition to existing research, the development of a highly valid PCK-PE measurement tool for PE teachers is required. To develop this tool, the realm of PCK-PE needs to be explored—specifically, the knowledge base of PE teachers.

2. Methodology

2.1. Participants

This study used convenience sampling, a non-probability sampling method that samples subjects who can be accessed at a time and place convenient to the researcher. In this study, 537 PE teachers working in South Korea in 2020 were selected. The first preliminary survey, in January 2020, was conducted online with 100 PE teachers using an open questionnaire; data from 97 participants were used for analysis (three did not respond). The second preliminary survey, in February 2020, was also conducted online with 200 PE teachers; data from 168 participants were used for analysis (32 did not respond). Based on the data obtained from these surveys, the main online survey was conducted with 300 PE teachers in March 2020; data from 272 participants were used for analysis (28 did not respond). Different subjects were selected for the three surveys to avoid overlapping. Detailed demographic characteristics of the study subjects are presented in Table 1.

TABLE 1. DEMOGRAPHIC CHARACTERISTICS OF THE STUDY SUBJECTS

Variable	Category	1st preliminary survey	2nd preliminary survey	Main survey	total
Gender	Male	76 (78.4%)	141 (83.9%)	229 (84.2%)	446 (83.1%)
	Female	21 (21.6%)	27 (16.1%)	43 (15.8%)	91 (16.9%)
Age	20s	18 (18.6%)	22 (13.1%)	34 (12.5%)	74 (13.8%)
	30s	33 (34.0%)	83 (49.4%)	139 (51.1%)	255 (47.5%)
	40s	41 (42.3%)	58 (34.5%)	93 (34.2%)	192 (35.8%)
	Over the age of 50	5 (5.2%)	5 (3.0%)	6 (2.2%)	16 (3.0%)
Teaching experience	Less than 5 tears	21 (21.6%)	29 (17.3%)	45 (16.5%)	95 (17.7%)
	6-10 years	39 (40.2%)	47 (28.0%)	78 (28.7%)	164 (30.5%)
	11-20 years	34 (36.1%)	83 (49.4%)	139 (51.5%)	256 (47.7%)
	Over 21 years	3 (3.1%)	9 (5.4%)	10 (3.7%)	22 (4.1%)
total		97 (100.0%)	168 (100.0%)	272 (100.0%)	537 (100.0%)

2.2 Procedure and data analysis

To develop the PCK-PE scale and verify its validity, this study conducted a (1) conceptual, (2) internal structure, and (3) external relationship review, as proposed by Benson (1998) for scale development. To thus achieve the research objective, data were collected through the preliminary and main surveys. In the first preliminary survey, data collected through an open questionnaire were consolidated into questions and content validity of the expert group was verified through the Delphi technique, producing 43 preliminary questions. In the second preliminary survey, data were collected through preliminary questions produced from the first survey. A descriptive statistical analysis of mean and standard deviation, skewness, and kurtosis was then performed on the collected data. Next, an exploratory factor analysis (EFA) was conducted to ensure construct validity of the scale. In the main survey, data were collected through questions obtained in the preliminary surveys (first and second). The reliability of the acquired data was verified through Cronbach's α and the fitness and validity of the scale model (convergent, nomological, and discriminant validity) through confirmatory factor analysis (CFA). Finally, the study verified criterion-related validity through verification of the relationship with the teaching efficacy scale (Lee, 1998). Overall, 560 questionnaires were distributed and 537 questionnaires (response rate 95.9%) were used for analysis. The data obtained were analyzed using SPSS and AMOS 18.0 program (IBM Corp., Armonk, NY, USA). The study was conducted with the approval of the Jeonju National University of Education IRB (JNUE-IRB-2020-012).

3. Results

3.1 First Preliminary Survey: Open Survey and Delphi Verification

One example of the questions is as follows: 'What kind of PCK-PE do you think teachers should have in PE class?' Inductive content analysis was performed on the 97 responses obtained. The questions focused on content with high frequency among the acquired data. Responses with representativeness were selected, and 85 questions were produced.

Next, for the Delphi Verification, a group of ten experts (one PE professor, three Ph.D. scholars in pedagogy, and six PE teachers with master's degrees in pedagogy) were surveyed using a two-point closed scale (Yes or No). In the process, question items that did not meet the 50% standard were removed; 42 questions were deleted and 43 questions were used as preliminary questions. The details of the preliminary questions extracted in the first preliminary survey are shown in Table 2.

TABLE 2. DEVELOPED PRELIMINARY QUESTIONS

Questions	
PCK1	I think my physical education class helps students solve real life problems.
PCK2	I think my physical education class helps students navigate their career and make career choices.
PCK3	I think my physical education class develops students' ability to lead and be creative.

PCK4	I think my physical education class helps students develop communication skills and helps them build desirable relationships.
PCK5	I think my physical education class improves the sense of community for students.
PCK6	I think my physical education class allows students to learn the skills necessary for real life.
PCK7	I understand the composition of the physical education curriculum.
PCK8	I understand the connection between the units of the PE curriculum.
PCK9	I can integrate and reorganize PE curriculum content to fit the subject.
PCK10	I understand how to use PE textbooks and curriculum materials.
PCK11	I understand how the PE curriculum is related to the curriculums of other subjects.
PCK12	I understand the connection of the PE curriculum for each grade.
PCK13	I am reorganizing the PE curriculum by reflecting social issues in class.
PCK14	I reorganize the physical education curriculum in consideration of the organic relationship between the subject, students, and society.
PCK15	I reorganize by considering the balance of the areas (psychomotor, cognitive, and affective) presented in the curriculum.
PCK16	Considering PE curriculum, I can prepare effective teaching-learning guidance for each subject.
PCK17	I prepare a regular procedure for managing physical education classes.
PCK18	I plan class lessons for safety.
PCK19	I have a plan to secure the actual learning time by minimizing the waiting time of students during class.
PCK20	I have a plan to minimize unnecessary administrative time during class.
PCK21	I use a teaching method to improve students' critical thinking skills.
PCK22	I use a teaching method to teach students in an interesting way.
PCK23	I use a variety of teaching-learning methods suitable for the PE content.
PCK24	I know what students do and do well in class.
PCK25	I use a variety of teaching-learning methods to build students' character in class, including collaboration.
PCK26	I understand each student's perception and attitude toward PE.
PCK27	I understand each student's aptitude and interest in PE.
PCK28	I understand the level of students and proceed with the class accordingly.
PCK29	I understand the individual differences in each student's holistic development.
PCK30	I evaluate by comprehensively considering psychomotor, cognitive, and affective areas.
PCK31	I evaluate by understanding and considering the students' developmental stages.
PCK32	I evaluate by reflecting both process evaluation and outcome evaluation.
PCK33	I evaluate by reflecting on teacher evaluation, peer evaluation, and self-assessment.
PCK34	I comprehensively evaluate practical tests, writing, and assignments.
PCK35	I reflect the five areas presented in the curriculum in assessments in a balanced way.
PCK36	I evaluate by considering inter-grade sequence.
PCK37	I create a class environment considering the weather.
PCK38	I create a class environment considering the season.
PCK39	I prepare class equipment in accordance with the annual class plan at the beginning of the school year.
PCK40	I organize a lesson plan considering the environmental conditions of the school I work at.
PCK41	I create a class environment before class starts.
PCK42	I have a regular procedure in place to create and organize the classroom environment.
PCK43	I adjust the class environment for the safety of students.

3.2 Second Preliminary Survey: Descriptive Statistics Analysis and EFA

After the descriptive statistical analysis (see detailed results in Table 3), the second survey was conducted on a five-point scale. The mean was distributed from 3.71 to 4.52, and the standard deviation was distributed from 0.57 to 0.89. Next, skewness and kurtosis were examined. The absolute value of skewness was distributed from 0.53 to 1.78, and the absolute value of kurtosis was distributed from 0.86 to 3.91. It met the skewness of $< \pm 3.0$

(West, Finch & Curran, 1995) and the kurtosis of < ± 10.0 (Kline 2011), which are criteria for violation of univariate normality of skewness and kurtosis.

TABLE 3. DESCRIPTIVE STATISTICAL ANALYSIS OF PRELIMINARY QUESTIONS

Question	Mean	Standard deviation	Skewness	Kurtosis
PCK1	4.37	0.67	-0.72	-0.05
PCK2	4.12	0.72	-0.57	0.27
PCK3	4.24	0.74	-0.59	-0.31
PCK4	4.52	0.59	-0.96	0.90
PCK5	4.49	0.58	-0.61	-.60
PCK6	4.20	0.69	-0.40	-0.41
PCK7	4.19	0.72	-0.50	-0.24
PCK8	4.00	0.80	-0.77	0.86
PCK9	4.01	0.71	-0.31	-0.15
PCK10	4.04	0.73	-0.35	-0.24
PCK11	3.82	0.89	-0.72	0.45
PCK12	4.03	0.75	-0.40	-0.17
PCK13	3.80	0.86	-0.36	-0.44
PCK14	4.02	0.70	-0.34	-0.03
PCK15	4.03	0.77	-0.37	-0.40
PCK16	4.10	0.74	-0.43	-0.23
PCK17	4.17	0.68	-0.22	-0.84
PCK18	4.42	0.61	-0.56	-0.59
PCK19	4.29	0.59	-0.37	0.38
PCK20	4.20	0.61	-0.29	0.27
PCK21	3.89	0.79	-0.23	-0.50
PCK22	4.15	0.63	-0.13	-0.52
PCK23	4.13	0.63	-0.11	-0.54
PCK24	4.17	0.63	-0.15	-0.54
PCK25	4.24	0.57	-0.04	-0.37
PCK26	4.16	0.62	-0.12	-0.49
PCK27	4.14	0.57	0.01	-0.08
PCK28	4.19	0.62	-0.15	-0.50
PCK29	4.23	0.62	-0.20	-0.56
PCK30	4.08	0.72	-0.71	1.47
PCK31	4.17	0.64	-0.31	-0.06
PCK32	4.11	0.70	-0.47	0.15
PCK33	3.71	0.86	-0.28	-0.21
PCK34	3.79	0.89	-0.59	0.20
PCK35	3.98	0.78	-0.43	-0.16
PCK36	4.02	0.71	-0.33	-0.12
PCK37	4.27	0.57	-0.04	-0.48
PCK38	4.24	0.58	-0.08	-0.41
PCK39	4.20	0.65	-0.35	-0.10
PCK40	4.32	0.59	-0.24	-0.62
PCK41	4.21	0.58	-0.06	-0.34
PCK42	4.20	0.62	-0.17	-0.55
PCK43	4.33	0.57	-0.12	-0.67

Next, EFA was performed to construct sub-factors of the questions for PCK-PE. In this study, a principal component analysis was used for extracting constituent factors, and Varimax, an orthogonal rotation method, was used to simplify factor loading. In this study, an eigenvalue of 1.0 or more and factor loading of .4 or more were set as criteria.

To clarify, KMO's sample adequacy measure was found to be 0.910, which indicates that the size of the sample to be analyzed is suitable for the EFA. The result of the Bartlett's sphericity test was found to be 4952.680 (p=.000), which confirmed that it is appropriate enough to reject the null hypothesis that "correlation matrix is 0'" and to perform EFA between sample variables. In addition, the total variance explained was 63.568%, which suggests that seven factors account for 63.568% of the total variance.

The specific results of the EFA were extracted to create seven factors, shown in Table 4. However, question PCK32 was not tied to any factors, and for the seventh factor, two questions were grouped into one factor; thus, the factor was deleted. If there are less than three observed variables in one latent variable, there may be a problem with the validity and identification of the model (Bentler and Chou 1987); thus, at least three observed variables are required for one latent variable. Through this process, three questions (PCK3, PCK4, and PCK32) were deleted. Based on the questionnaire items of six factors extracted through this process, each sub-factor was named by an expert group. Previous studies related to PCK-PE (Cho, Hong, and Kim 2013) suggested various components of PCK-PEs (PCK3, PCK4, and PCK32) were deleted. Of these, Kice (2007) presented six components: knowledge of PE as a subject, curriculum, pedagogy, learners for physical activity, evaluation of PE, and PE environment. With reference to the previous studies, the sub-factors were named (1) curriculum knowledge, (2) pedagogical knowledge, (3) educational philosophy knowledge, (4) class management knowledge, (5) educational evaluation knowledge, and (6) class environment knowledge by an expert group.

TABLE 4. RESULTS OF THE EFA

Question	Component						
	1	2	3	4	5	6	7
8	0.803	0.010	0.189	0.071	0.106	0.199	0.068
7	0.790	0.217	0.035	0.156	0.012	-0.015	0.164
9	0.769	0.157	0.180	0.102	0.178	0.172	-0.022
10	0.752	0.303	0.080	-0.008	0.225	0.011	0.124
12	0.699	0.227	0.054	0.049	0.261	0.157	0.077
11	0.644	0.055	0.255	-0.063	0.352	0.228	-0.063
16	0.611	0.303	0.173	0.327	0.114	0.058	0.106
15	0.533	0.114	0.332	0.480	0.115	0.141	0.027
13	0.447	0.117	0.415	0.082	0.438	-0.008	-0.161
27	0.132	0.706	0.224	0.182	0.049	0.226	-0.034
24	0.142	0.696	0.098	0.097	0.005	0.413	0.093
22	0.155	0.649	0.163	0.251	0.216	0.130	0.217
28	0.229	0.621	0.145	0.119	0.380	0.127	0.196
26	0.299	0.575	0.377	0.085	0.111	0.206	0.025
25	0.232	0.567	0.105	0.332	0.231	0.186	0.180
23	0.299	0.564	0.176	0.309	0.269	0.128	0.026
19	0.344	0.454	0.136	0.387	0.096	0.248	0.120
29	0.154	0.454	0.253	0.427	0.158	0.192	-0.032
30	0.281	0.453	0.101	0.277	0.428	0.278	0.093
1	0.147	0.119	0.780	0.174	0.134	-0.129	0.121
3	0.157	0.149	0.660	-0.017	0.260	0.140	0.183
6	0.116	0.184	0.646	0.169	0.035	0.193	0.175
2	0.190	0.214	0.638	-0.027	0.217	0.121	0.045
14	0.422	0.195	0.441	0.141	0.282	0.066	-0.015
37	-0.005	0.208	0.034	0.716	0.156	0.240	0.077
38	0.006	0.328	0.058	0.664	0.173	0.237	0.136
36	0.241	0.261	-0.002	0.485	0.460	0.091	0.131
17	0.220	0.357	0.237	0.471	-0.033	0.270	-0.037
32	0.274	0.011	0.203	0.397	0.261	0.329	-0.113
34	0.186	0.078	0.148	0.200	0.757	-0.033	0.093
33	0.208	0.146	0.293	0.030	0.647	0.266	-0.077
21	0.327	0.285	0.292	0.066	0.536	0.213	-0.166
35	0.302	0.154	0.203	0.303	0.525	0.228	0.176
31	0.212	0.459	0.132	0.205	0.524	0.192	0.212
42	0.179	0.260	0.203	0.280	0.188	0.651	0.018
41	0.108	0.358	0.163	0.172	0.238	0.634	-0.014
39	0.156	0.327	0.002	0.236	0.105	0.609	0.128
43	0.085	0.242	-0.048	0.322	0.116	0.557	0.450
20	0.344	0.371	0.229	0.304	-0.041	0.466	0.033
40	0.165	0.237	-0.153	0.450	0.236	0.451	0.270
18	0.114	0.269	0.235	0.331	0.024	0.406	0.309
4	0.151	0.138	0.451	-0.037	0.165	0.087	0.670
5	0.118	0.165	0.403	0.283	-0.115	0.142	0.605
Eigenvalue	5.802	5.229	3.824	3.714	3.642	3.416	1.706
Variance (%)	13.494	12.161	8.893	8.637	8.470	7.943	3.967
Cumulative variance (%)	13.494	25.656	34.549	43.186	51.657	59.600	63.568

3.3 Main Survey: Validation of reliability and validity

In this survey, reliability and validity analyses were conducted based on the results of the preliminary surveys. The main survey was conducted on a five-point scale. First, a reliability analysis was performed. The results of each sub-variable based on the results derived from six factors in the second preliminary survey are presented in Table 5. Cronbach's α were as follows: factor 1 (curriculum knowledge), 0.915; factor 2 (pedagogical knowledge), 0.916; factor 3 (educational philosophy knowledge), 0.821; factor 4 (class management knowledge), 0.753; factor 5 (educational evaluation knowledge), 0.846; and factor 6 (class environment knowledge), 0.873. However, in all factors, the total Cronbach's α was found to be higher than the Cronbach's α with items removed which implies that no questions hindered reliability. Through these results, no questions were deleted in the reliability analysis.

TABLE 5. CRONBACH'S A OF EACH SUB-VARIABLE

	Component	Cronbach's α
1	Curriculum knowledge	0.915
2	Pedagogical knowledge	0.916
3	Educational philosophy knowledge	0.821
4	Class management knowledge	0.753
5	Educational evaluation knowledge	0.846
6	Class environment knowledge	0.873

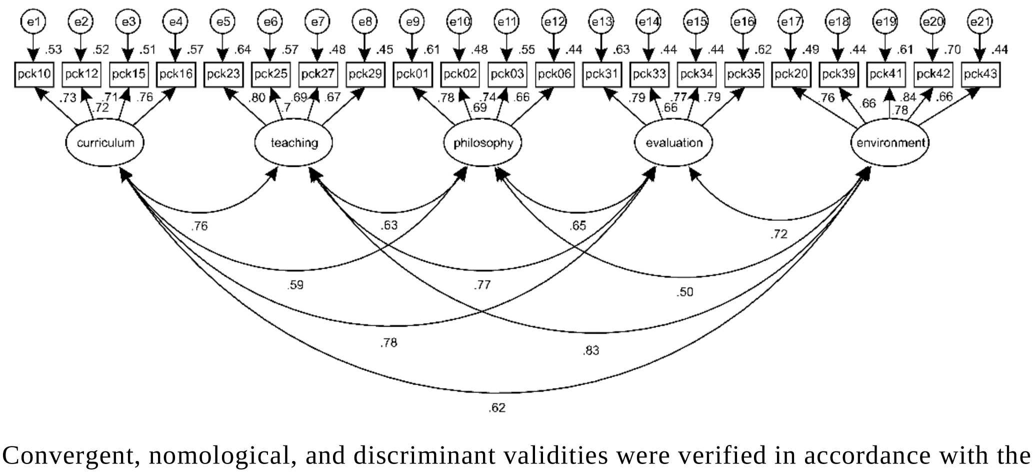
Next, validity was verified by conducting CFA based on factors and questions extracted from the preliminary surveys. Regarding the fitness of the CFA, x2/DF value was set to be lower than 2.0; GFI, IFI, TLI, and CFI values were set to 0.90 or higher; RMR value was set to 0.05 or lower; and RMSEA value was set to be lower than 0.08 (Bae 2019). The results of the CFA are presented in Table 6.

TABLE 6. FITNESS OF THE CFA

Index	Initial fitness	Final fitness
x^2/DF	3.085	2.357
RMR	0.038	0.025
GFI	0.724	0.880
IFI	0.791	0.915
TLI	0.773	0.899
CFI	0.789	0.914
RMSEA	0.088	0.071

Overall, the model's fitness index was found to be inadequate. Accordingly, the questions with an SMC value of less than .4 were sequentially removed one-by-one, and 22 questions were deleted. The subsequent final fitness results are presented in Table 6. Although some goodness-of-fit indices (x2/DF and GFI) were found to be below the baseline, RMSEA (0.071) and CFI (0.914), which are the most significant goodness-of-fit indices in CFA, were above the baseline. x2/DF and GFI were heavily influenced by sample size; thus, CFI and RMSEA, unaffected by the sample size, are used to verify the degree to which the model corresponds to the actual data (Hong 2000). By applying this fact as an important basis for the model's goodness-of-fit determination, it was determined to have good fitness indices overall. The model diagram of the CFA is illustrated in Figure 1.

Figure 1. CFA of the Model



Convergent, nomological, and discriminant validities were verified in accordance with the results of the CFA presented in Figure 1. Regarding convergent and discriminant validities, measured values are evaluated against each other rather than compared with an external standard, and convergent validity can be considered to be present if the internal correlation between a series of indicators designed to measure the same concept is at least at an appropriate level (Bae 2019). As a condition to secure convergent validity, Sung (2019) claimed that (1) standardized coefficients of all variables should be higher than .5, or (2) concept reliability should be higher than .7. Accordingly, because the standardized regression coefficients

(0.663 to 0.800) of all questions were higher than the standard values (0.500) and concept reliability (0.985~0.994) was also higher than the standard value (0.700), the model can be evaluated as having convergent validity. Table 7 presents the specific results of the CFA and convergent validity verification.

TABLE 7. RESULTS OF THE CFA

			Standardized coefficients	Unstandardized coefficients	S.E.	C.R.	*p*	Concept reliability
curriculum	→	pck10	0.730	1	-	-	-	0.987
	→	pck12	0.723	1.067	0.097	10.993	$<0.001^{***}$	
	→	pck15	0.713	1.058	0.098	10.846	$<0.001^{***}$	
	→	pck16	0.758	1.061	0.092	11.483	$<0.001^{***}$	
teaching	→	pck23	0.800	1	-	-	-	0.992
	→	pck25	0.752	0.821	0.063	12.946	$<0.001^{***}$	
	→	pck27	0.692	0.757	0.065	11.723	$<0.001^{***}$	
	→	pck29	0.673	0.818	0.072	11.352	$<0.001^{***}$	
philosophy	→	pck01	0.779	1	-	-	-	0.987
	→	pck02	0.695	0.983	0.091	10.782	$<0.001^{***}$	
	→	pck03	0.739	1.049	0.092	11.445	$<0.001^{***}$	
	→	pck06	0.663	0.874	0.085	10.286	$<0.001^{***}$	
evaluation	→	pck31	0.792	1	-	-	-	0.985
	→	pck33	0.665	1.138	0.104	10.994	$<0.001^{***}$	
	→	pck34	0.665	1.220	0.111	10.991	$<0.001^{***}$	
	→	pck35	0.790	1.224	0.092	13.354	$<0.001^{***}$	
environment	→	pck20	0.698	1	-	-	-	0.994
	→	pck39	0.664	1.019	0.102	10.033	$<0.001^{***}$	
	→	pck41	0.781	1.090	0.093	11.659	$<0.001^{***}$	
	→	pck42	0.837	1.227	0.099	12.364	$<0.001^{***}$	
	→	pck43	0.663	0.893	0.089	10.018	$<0.001^{***}$	

$^{***}p< .01$

Next, nomological validity—the degree to which one construct predicts another construct based on the theoretical background—was verified. Researchers predicted the relationship between constructs in the positive (+) direction. As shown in Table 7, the relationship between the latent variables was significantly positive (+). Thus, the main survey's data can be evaluated to have secured nomological validity.

Next, discriminant validity was verified. This validity is deemed present if the correlation between factors inherent in a set of indicators, which are presumed to measure different concepts, is not strong (Bae 2019). Woo (2015) presented an evaluation through AVE as a method of obtaining discriminant validity. The detailed verification results of the correlation between the mean-variance and the construct are presented in Table 8.

TABLE 8. DISCRIMINANT VALIDITY VERIFICATION

Variable	Correlation between constructs					AVE
	curriculum	**teaching**	**philosophy**	**evaluation**	**environment**	
curriculum	1.000	-	-	-	-	0.952
teaching	0.614^{***}	1.000	-	-	-	0.970
philosophy	0.490^{***}	0.530^{***}	1.000	-	-	0.951
evaluation	0.618^{***}	0.606^{***}	0.532^{***}	1.000	-	0.941
environment	0.535^{***}	0.711^{***}	0.437^{***}	0.568^{***}	1.000	0.969

$^{***}p<.001$, tested by correlation analysis,

AVE = Average variance extracted

In the case of discriminant validity, verification between all variables is difficult. Thus, a pair that is generally and conceptually similar or has the highest correlation between variables is selected and verified representatively (Woo 2015). In Table 7, the square of the correlation coefficient of 'pedagogical knowledge ↔ class environment knowledge,' which has the highest correlation, is 0.506, which is lower than the AVE of pedagogical knowledge (0.970) and class environment knowledge (0.969); thus, the model can be evaluated to have secured discriminant validity.

Next, criterion-related validity was verified. This indicates the degree to which the developed scale is related to other measurement results, which becomes the criterion. In this study, criterion-related validity was analyzed by the Pearson correlation coefficient of each sub-variable of PCK-PE and teaching efficacy as shown in Table 9.

TABLE 9. CRITERION-RELATED VALIDITY VERIFICATION

Variable	**Correlation between constructs**				
	curriculum	**teaching**	**philosophy**	**evaluation**	**environment**
teaching efficacy	0.375***	0.353***	0.227***	0.494***	0.372***

***p<.001

All sub-variables of PCK-PE and the correlation coefficient of teaching efficacy showed the same direction and had statistically significant relevance in all factors. There was no problem with multicollinearity given the absence of a very high level of correlation greater than 0.900. As higher levels of PCK-PE are associated with higher teaching efficacy, the PCK-PE scale can be evaluated to have achieved criterion-related validity.

4. Discussion

This study aimed to provide basic data to promote teachers' professionalism by emphasizing the importance of PCK. Components of PCK-PE were identified. After developing 21 questions of five factors, the reliability and validity of the developed measurement tool (convergent, nomological, discriminant, and criterion-related validity) were verified. This study developed a scale for PCK-PE perception of PE teachers through a three-step procedure (conceptual review, internal structure review, and external relationship review) proposed by Benson (1998) and this verified its validity. First, components were collected for the PCK-PE through an open questionnaire. Preliminary questions were produced based on the collected content, and the conceptual review of PCK-PE was performed for a group of experts. Questions that appropriately explained the relevant variables through Delphi verification, by combining and re-analyzing the results of the previous studies, (Cho, Hong, and Kim 2013; Lee and You 2017; Hong 2012; Choi 2011; Kice 2007) were extracted. Factor structure and questions were determined through an internal structure review of 85 questions composed of preliminary measures. In EFA, the structure of 43 questions with six factors was determined by considering the eigenvalue of each factor, load and redundancy of the questions for each factor, conceptual representation, correlation between factors, and internal consistency of the questions. Whereas 22 question items were eliminated through a conceptual and statistical item analysis through CFA, 21 questions with five factors were determined as the final scale (Song, Song and Lee, 2020). Criterion-related validity was verified by substantiating the relationship with teaching efficacy.

Last, a comparison of the current study's results with those of previous studies confirmed factors and questions. Lee and You (2017) developed 22 questions in three areas relating to home economics knowledge reflecting the pedagogical content knowledge in home economics education, curriculum knowledge, and class strategy knowledge. Hong (2012) developed a mathematical PCK measurement tool for early childhood teachers and organized PCK into five domains: curriculum knowledge, content knowledge, knowledge on teaching and learning methods, knowledge of learners, and knowledge of professional development. Park (2003) explored the components of elementary school teachers' PCK of science and developed a measurement tool for it. Teaching method, expression, content, assessment, curriculum, and environmental context knowledge and knowledge of students were established as components of PCK of science. More extensive teaching experience was associated with greater PCK. Kim (2007) developed a measurement tool for PCK of science for early childhood teachers and composed the PCK domain to include curriculum knowledge, knowledge of learners, teaching-learning method knowledge, content knowledge, and teaching expertise. Such studies became the theoretical basis for the application of the sub-variables identified in this study. Kice (2007) presented knowledge on PE as a subject and identified five components of PCK-PE: curriculum knowledge, teaching method knowledge, knowledge of learners for physical activities, PE evaluation knowledge, and PE environment knowledge. Cho, Hong, and Kim (2013) analyzed the structuralization of sub-elements of PE and achievement standard components for six components. This theoretically supports the results of this study, which presented five factors, including curriculum knowledge, teaching method knowledge, educational philosophy knowledge, education evaluation knowledge, and class environment knowledge (Song, Song and Lee, 2020).

In the factor analysis process of this study, the partial factors (knowledge of learners, content knowledge, and expertise knowledge) presented by Kice (2007) were not observed; thus, the results differed. This may be because of a possible difference in perspective on the importance of PCK-PE required despite how teachers in the field operate a curriculum based on the developed standards of achievement.

Class management knowledge, which comprised one factor in EFA, was removed from the main survey. It was deemed a factor hindering fitness and deleted because it had internal characteristics similar to teaching environment and method knowledge. These results confirmed whether the item analysis and EFA of the internal structure are important in the internal structure review.

The external relationship of the developed scale comprising 21 questions of five factors was reviewed through a verification of the relationship with teaching efficacy. All sub-variables of PCK-PE and teaching efficacy had a positive correlation. This suggests that the validity of the external relationship of the scale was demonstrated overall (Song, Song and Lee, 2020).

The results confirm that PCK-PE perceived by PE teachers consists of five factors: knowledge of curriculum, teaching method, education philosophy, class evaluation, and class environment. This study verified the unique factors of the PCK of PE teachers through a systematic procedure. The scale developed in this study is expected to more accurately and properly evaluate PE teachers' PCK-PE as opposed to scales developed for other subjects or scales with modified questions.

5. Conclusion and Implications

The limitations and implications of this study are as follows: First, because the subject of the study was limited to PE teachers in middle schools and high schools in Korea, it is difficult to generalize the research results and apply them to PE teachers in other countries. Future studies need to verify the validity and feasibility of using the PCK-PE scale by including diverse participants from other countries. Second, a mixed study that simultaneously collects sufficient quantitative or qualitative data by using the PCK-PE measurement tool developed in this study is required. As the level of PCK-PE of PE teachers is measured using the developed tool, and various variables that affect the level of PCK-PE are explored, further studies can be undertaken by applying effective PE and teaching-learning methods. Third, how the PCK-PE that appropriately integrates content and pedagogical knowledge by PE teachers is conveyed to students may differ depending on students, subject content, class situation, and class environment. Thus, an exploration of the PCK-PE domain proposed here should continue. Fourth, the validity of this PCK-PE scale cannot be judged as perfect. Because the validity of a measurement tool is not verified in one study, continuous follow-up studies must be carried out. Fifth, based on the scope of the PCK-PE measurement tool proposed in this study, how the PCK-PE of PE teachers is developed and promoted needs to be discussed and used to develop enriching teacher education programs.

Acknowledgments

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