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Original Article

Development and validation of a testing instrument to assess pedagogical content knowledge of German preservice physical education teachers

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Abstract:
Purpose: Pedagogical content knowledge (PCK) is recognized as a core component of teachers' professional competence which predicts both the quality of teaching and the achievement of teaching goals. This is also relevant inPhysical Education (PE). To date, there has been a "selection bias" in the profound international research base on the PCK of PE teachers, as it reflects research mainly published in English and therefore lacks of different didactics foci in Europe. In addition, despite the importance of PCK, research on the PCK of PE teachers in German speaking countries is still at the beginning and thus there is little evidence of the PCK of PE teachers in those countries. The purpose of this study was to develop and validate the testing instrument PCK-PE to measure German preservice PE teachers' PCK. Material and Methods: The participants were 511 PETE students. Exploratory and confirmatory factor analysis (CFA) were conducted on two independent samples (initial validation sample = 300, cross-validation sample = 211). Results: Expert review provided content and face validity.The CFA showed that the constructs demonstrated a good fit to the model (χ^2 = 147.87, *df* = 89, *p* = .00, *CFI* = .97, *RMSEA* = .06), confirming their validity. The results showed moderate correlation between the PCK-PE and the GPK (a testing instrument towards general pedagogical knowledge)indicating conceptual distinction and discriminant validity, respectively.Conclusion: Since the PCK-PE comprises a German didactics focus, this study adds to the rich international research base on the PCK of PE teachers, as part of a bigger picture. To date, the PCK-PE is one of the few instruments in Germany whose validity has been extensively tested.
KeyWords*:* professional competence; preservice physical education teachers; physical education teacher education; Germany

Introduction

It is broadly accepted that teacher knowledge makes a significant contribution to effective teaching and student learning. Research on teaching and teacher education considers pedagogical content knowledge (PCK) to be a core component of professional competence which predicts both the quality of teaching and the achievement of teaching goals (Blömeke, Gustafsson, & Shavelson, 2015). Following the influential work by Shulman (1986; 1987) researchers have worked especially on PCK (Depaepe et al., 2013; Ward &Ayvazo, 2016). PCK is of critical importance, "since it deals with teachers' knowledge necessary to achieve the aims of teaching" (Depaepe et al., 2013, p. 15) by organizing, representing, and adapting content to the diverse interests and abilities of the learners and presented for instruction. There is evidence that PCK makes a great contribution to student progress (Baumert et al., 2010; Kim et al., 2018). Compared to other relevant components of teachers' professional competence (beliefs, enthusiasm, self-regulation), PCK predicts students' achievement most accurately (Kunter et al., 2013). In addition, scholars highlight the role of formal learning opportunities in fostering PCK, and in turn on students' achievement (Iserbyt, Ward & Martens, 2016; Iserbyt et al., 2020). Hence, it is important to assess the PCK of PE teachers as a decisive factor with respect to students' achievement. However, this research base contains a "selection bias" (Depaepe et al., 2013, p. 22; Ward &Ayvazo, 2016, p. 201) as it reflects research mainly published in English and lacks of significantly different didactics foci in Europe (MacPhail, Tannehill &Avsar, 2019). In addition, despite the importance of PCK, research on the PCK of PE teachers in German speaking countries is still at the beginning and thus there is only little evidence concerning the PCK of PE teachers in German speaking countries, whereas there are still outstanding claims (Meier, 2018; Vogler, Messmer &Allemann, 2017; Wibowo&Heemsoth, 2019).

Testing instruments concerning the PCK of PE teachers from a German point of view

Because of the differences in cultures and in traditions of PE, it should be mentioned that the current approach is based on a German research tradition on subject matter didactics (Van Driel& Berry, 2012). The few existing studies focusing on the PCK of PE teachers in German speaking countries can be summarized as

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follows. A study by Vogler et al. (2017) addresses the PCK of Swiss physical education teacher education (PETE)students (n = 113). However, in this Swiss study, the theoretical model of PCK could not be empirically validated due to a small sample size (in relation to items). Scholars did not study the validity via exploratory factor analysis (EFA) or confirmatory factor analysis (CFA) nor was there a report analysis of reliability. Recently, Heemsoth&Wibowo (2020) assessed the PCK of PETEstudents online-based as a homework (n = 290).

The theoretical model of PCK could be empirically validated via CFA. Among other things, the authors conclude with theintention of investigation the relation between PCK and other dimensions of content knowledge (discriminant validity), and to study PCK more specifically (e.g. more in depth-testing with a limited number of movement fields) in future research (content and construct validity). Furthermore, from a methodological point of view, the authors discuss a potential bias (Heemsoth&Wibowo, 2020, p. 317) in their results since data was collected as homework without the control of whether students answered on their own or if there was additional support from outside (reliability). To sum up, there exists a lack of valid test instruments concerning the PCK of PE teachers in German speaking countries, although the situation has been changing over the last few years.

Framework for the testing instrument PCK-PE

In developing the testing instrument PCK-PE, we focus on Shulman's "two keycomponents of PCK" (Depaepeet al., 2013, p. 14): (1) knowledge of instructional strategies and (2) knowledge of students' (mis)conceptions and difficulties (Depaepeet al., 2013; Park & Oliver, 2008). In addition, the PCK-PE is conceptualized as a paper-pencil-test, and thus measures the PCK of German PE teachers more independently from the classroomcontext in which it is used. In this study we focus on the following knowledge bases informing the PCK-PE.

The first dimension, knowledge of instructional strategies, highlights the ways of making something comprehensible to others. With regard to Germany, the so-called "educational PE" didactic concept has been dominant country-wide since 2000 (MacPhail et al., 2019; Ruin &Stibbe, 2018). This concept highlights learning in and through PE, ensuring personal development as well as the development of sport specific competencies. In addition, it has been exported to and implemented in various other European countries, for example Austria and Luxemburg (Amesberger et al., 2014; MENFP, 2009). This concept highlights principles of teaching, especially "multiperspectivity" and "reflection" (e.g. Beckers, 2013). Multiperspective PE is designed to enable the students to gain new experiences outside established pathways (e.g. discovering PE in the sense of health, movement art, high performance). Connected to this, reflection is necessary to not only experience, but also to process, rethink or doubt the inherent meanings.

The second dimension, knowledge of students' (mis)conceptions and difficulties, emphasizes on strategies for organizing and reorganizing the (mis)understanding of learners. From the learners' perspective, preservice PE-teachers should particularly know about different conceptional ideas of "body" and "performance" in the field of sport and movement (Alkemeyer, 2002; Harvey & O'Donovan, 2013). In terms of the body, students should realize that conceptions of the body vary and are also interlinked to different roles of physical activity (Giese & Ruin, 2018; Grimminger-Seidensticker, Möhwald, Korte & Trojan, 2018). Strongly related to the body, performance is often understood as a central and somehow traditional sense of "sport" in German teaching methodology (Kurz, 1993). According to Alkemeyer (2002), it is permanently staged via the bodies of the actors in the field of sport and movement. In this regard, students perform the same task in a PE lesson, but the effort differs. Reflection about this should sensitize for different conceptions of both body and performance, and through that, foster the personal development of students.

In line with other findings (e.g. Blömeke& Kaiser, 2017; Baumert et al., 2010), we consider the PCK of PE teachers as distinct from general pedagogical knowledge (GPK). GPK includes knowledge about generic teacher tasks, not directly related to a specific subject (Blömeke, Busse, Kaiser, König & Suhl, 2016). Against this backdrop, the purpose of the current study is to develop and validate a testing instrument to measure German preservice PE teachers' PCK. The research questions asked by the study are: (1) Is it possible to clearly and concisely frame the PCK of German preservice PE teachers? (2) Is it possible to develop the valid testing instrument PCK-PE? (3) To what extent is the PCK-PE related to GPK?

Material & methods

The development of the PCK-PE scale was twofold. Step one consisted of the item construction, based on a focused literature review of the state-of-research on concepts and explanations for relevant aspects concerning the PCK of PE teachers (Meier, 2018).In step two, an expert review was provided to check content and face validity, clarity and conciseness as well as relevance for teaching PE to make sure that the test accurately represents all facets of what it is purported to measure (Ary, Jacobs & Sorensen, 2010). In order to address this, a panel of experts participated online via Delphi techniques and was asked to discuss, edit and revise the initial itemset. Here it was also checked which answer was expected to be right or wrong. The final itemset consists of a mixture of open ended and single answer questions.

Data collection

A two-site cross-sectional survey design with two independent samples was conducted (initial validation sample $n = 311$, cross-validation sample $n = 200$). Undergraduate PETE students attending two public universities in North-Rhine Westphalia (Germany) participated in the survey. Data collection took place in classes during regular 90-minute courses. After receiving approval from the programme directors, paper surveys were brought to the courses by two members of the project group. Surveys were conducted by trained test administrators as power tests without time limits. To make sure every participant received the same information, administrators were briefed about how to introduce the study and complete the survey in advance. Participation was on a voluntary basis and taking part in the survey implied consent. The questionnaire itself included a cover letter with information about the purpose of the study, benefits of participating in the study, and ethical issues related to anonymity and voluntariness. Incentives or compensation for taking part in the survey were not offered. There was no effort to determine the response rate. The average time to complete the questionnaire was about 50 minutes.

Participants

As shown in table 1, the global number of participants was 511 PETE students aged between 18 and 34 years ($M = 22.14$, $SD = 2.82$). Both, the initial validation sample as well as the cross-validation sample comprised of more males than females. Most of the participants were in the second year of study. Both samples seem to be very similar: Most of the PETE students wanted to become a teacher on International Standard Classification of Education (ISCED) level3. All students were aiming for their initial teaching license in a PETE program in a university or equivalent institution. The German teacher education system is separated into two phases: a university-based phase and a classroom-based induction phase. Although both samples were not collected randomly, they display representative characteristics of PETE students at public universitiesin Germany.

Table 1: Demographic characteristics of participants by sample

		Initial validation sample ($n = 311$)		Cross-validation sample ($n = 200$)	
		n	*%*	*n*	*%*
Gender	Female	102	32.8	84	42.0
	Male	209	67.2	116	51.3
Age[a]		22.24 (*M*)	2.86 (*SD*)	23.26 (*M*)	2.76 (*SD*)
Qualifying for school type[b]	Primary (ISCED 1)	4	1.3	18	9.4
	Secondary (ISCED 2)	36	11.9	36	18.8
	Upper Secondary (ISCED 3)	247	81.5	124	64.6
	Post-secondary non-tertiary (ISCED 4)	16	5.3	14	7.3
	no information	79	25.4	56	28.2

Notes:[a]2 missing values in sample 1, 1 missing value in sample 2; [b]8 missing values in sample 1, 8 missing values in sample 2

Data analysis

All items were coded independently by two trained raters using a standardized manual, especially developed for the PCK-PE. The data processing and frequency analyses were conducted using SPSS. Correlation and multivariate analyses were calculated with Mplus (Muthén&Muthén, 2017). Also, the complete data set was screened for missing data. Across both samples, none of the items had a missing value greater than 3%. Any missing values within the data that occurred, because some participants skipped one of the assessments, was handled by applying the full information maximum likelihood (FIML) procedure implemented in Mplus.

Validation

The Kaiser-Meyer-Olkin (KMO) value (KMO = .76) and Bartlett's test of sphericity ($x^2 = 2254.84$, $df = 190$, $p < .001$) indicated that the total dataset was sufficient for avalidation step (Tabachnick&Fidell, 2013). After that, we conducted a principal component analysis (PCA) on the initial validation sample to determine the optimal number of factors to retain. We kept factors with eigenvalues greater than 1.0 and inspected the scree plot as criteria to identify and retain underlying factors as suggested by the PCA. All in all, these results suggested four factors. Based on this, we ran an EFA with a four-factor solution to explore the factor structure and to also figure out the most relevant PCK-PE items from the total itemset as well (Asparouhov&Muthén, 2009). For the EFA we used an oblique rotation (geomin) and allowed factors to be correlated since we hypothesized that both underlying PCK-PE constructs would be interrelated. We investigated eigenvalues loadings and cross loadings (Kline, 2010). Next, a CFA on the cross-validation sample was calculated using robust conditions to assess and verify the factorial structure extracted through the PCA and EFA (compared to the alternative G-factor-model). Both the initial and cross-validation samples were independent, to prove if the proposed factor model from the EFA would generalize well to new data. The model fit was evaluated using

multiple fit indices (cf. Hair, Anderson, Tatham & Black, 2010; Hu &Bentler, 1999), including the Comparative Fit Index (CFI acceptable > .90) and the Root-Mean-Square Error of Approximation (RMSEA acceptable < .08, good fit < .05). Non-significant chi-squares are considered as acceptable (Kline, 2010). Discriminant validity was assessed through correlational analysis of an abbreviated version of the GPK (König & Kramer, 2016). It was used to demonstrate that GPK measures distinct traits – general pedagogical knowledge vs. content specific (Blömeke et al., 2016). Therefore, we hypothesize low to medium correlations with the PCK-PE.

Results

Initial validation by EFA

The EFA was used to investigate factor loadings (cut-off at .40), cross loadings, importance, sharing conceptional meaning, economy, and redundancy before retaining them for the following CFA (Kline, 2010). The EFA loaded on four factors (see table 2 for factor loadings, factor correlations, and model fit). The 4-factorial EFA model achieved an acceptable model fit and most of the test items could be clearly assigned to four factors. Factor 1 consisted of 4 items, with coefficients ranging from .41 to .80. It was named PCK-PE "multiperspectivity", since all items loading on that factor reflect knowledge about how to conceptualize PE in a multiperspective way. The second factor consisted of 7 items, with coefficients ranging from .25 to .97. Items 2a and 2b loaded very poorly, item 2d showed a concurrent higher loading on Factor 1, reflecting a different conceptual meaning. Therefore, we omitted these 3 items from further analysis. The remaining items built the factor named PCK-PE "reflection", since all of them represent knowledge about the principle of reflection with regard to PE-lessons. Factor 3 consisted of 5 items, with coefficients ranging from .22 to .97. Item 3d and 3e showed no relevant loadings. Therefore, both items were excluded for the following CFA. The remaining 3 items reflect the dimension knowledge of students' (mis)conceptions concerning performance in PE. Thus, this factor was named PCK-PE "performance". The fourth factor consisted of 4 items, with coefficients ranging from .48 to .60. It was named PCK-PE "body", since items that loaded on Factor 4 show what PETEstudents should know about students' conceptions and misconceptions concerning the body in PE. Although item 4d showed a cross loading on Factor 3, all items were retained for further analysis.

Table 2: Factor loadings, factor correlations and model fit values following EFA (initial validation sample)

PCK-PE subscale and item		F1	F2	F3	F4	PCK-PE subscale and item		F1	F2	F3	F4
PCK-PE multi-perspectivity	1a	**.41**	-.10	.13	.10	PCK-PE performance	3a	.08	-.07	**.97**	-.02
	1b	**.80**	-.01	-.01	-.01		3b	-.06	.04	**.95**	.10
	1c	**.71**	.03	-.06	-.20		3c	.01	-.01	**.95**	.01
	1d	**.64**	-.04	.04	-.08		3d	**.41**	.22	.22	-.04
							3e	**.45**	**.32**	.29	.18
PCK-PE reflection	2a	-.18	**.25**	-.02	-.06	PCK-PE body	4a	.21	-.03	-.01	**.48**
	2b	.18	.19	.12	-.23		4b	.07	-.03	.12	**.58**
	2c	.33	**.50**	-.22	.17		4c	-.04	.05	.03	**.55**
	2d	**.41**	**.30**	-.01	.06		4d	-.01	.03	**.29**	**.60**
	2e	-.04	**.97**	.04	-.05						
	2f	.02	**.63**	-.09	-.02						
	2g	.02	**.46**	.09	-.13						

	Factor correlations	1	2	3	4	Model fit: χ^2 = 125.49, *df* = 116, *p* = .26, *CFI* = .99, *RMSEA* = .02
	1 multiperspectivity					
	2 reflection	.32				
	3 body	.23	.10			
	4 performance	.29	.10	.37		

Notes: Factor loadings in bold significant at 5% level. Factors are statistically significant ($p < .001$)

Cross-validation via CFA

Based on the EFA results, a CFA was performed on the cross-validation sample to cross-validate and confirm the structure derived in the analysis, using the initial validation sample. A good but not excellent model fit was observed (Hu &Bentler, 1999): $\chi^2 = 109.39$, *df* = 84, *p* = .03, *CFI* = .99, *RMSEA* = .04. The full four-factor model did fit the data significantly better than a single-factor solution ($\chi^2 = 207.10$, *df* = 90, $p < .001$, *CFI* = .94, *RMSEA* = .08).Since we theoretically hypothesize that these four knowledge bases inform the two key components of PCK, we performed an additional two-factor solution differentiating between the PCK-PE "instruction" ("multiperspectivity" and "reflection") and the PCK-PE "students" ("performance" and

"body")dimension($\chi^2 = 147.87$, $df = 89$, $p < .001$, $CFI = .97$, $RMSEA = .06$), which also fitted the data. As expected, all indicators showed significant positive factor loadings with coefficients ranging from .40 to .98. There were significant positive correlations among both PCK-PE factors on a medium level ($r = .48$). In addition, both PCK-PE-factors correlate moderately with GPK, indicating conceptual distinction ($r = .28$).

Discussion

The predominant objective of the current study was to outline the development and validation of the testing instrument PCK-PE to measure the PCK of German preservice PE teachers. The PCK-PE is based on a focused literature review and expert panel discussions. Validity was tested via EFA and CFA on two independent samples.

The expert panel discussion points out that most of the items constructed are clear and concise and relevant for teaching PE, which highlights content validity. However, the experts stress on a limitation and specification of the PCK-PE, which is in line with findings from a current study in PE (Heemsoth&Wibowo, 2020). From a conceptual point of view, it must be mentioned that the PCK-PE measured PCK through a test and thus, independently from the classroom-context. In this regard, future measurement tools (e.g. authentic performance, video analysis tools) could be developed based on the PCK-PE or added to the PCK-PE to observe teacher's actions in real-life situations more closely (Blömeke, Gustafsson& Shavelson, 2015).

The results of the factor analysis provided substantial support for the validity of the scores derived from the new PCK-PE. The EFA showed that the majority of items loaded on their intended factors, and thus, the subscales were clearly defined. Based on the EFA results, a CFA on the cross-validation sample was performed to investigate the reliability of PCK-PE.The CFA confirmed the explored four-factor solution, compared to a single-factor solution. Based on conceptual reasons, further investigation showed that also a two-factor solution differentiating between knowledge of instructional strategies and knowledge of students' (mis)conceptions is acceptable. This is in line with theoretical assumptions, as it highlights the two key components of PCK (Depaepeet al., 2013; Park & Oliver, 2008). In addition, the moderate correlation between these twofactors indicates a meaningful relation. Cross-validation ensures the reliability of the PCK-PE. However, since data were collectedfrom onlytwo public universities in one out of sixteen federal states, further research is needed to determine whether the factorial structure is replicable with other samples from other universities. In addition, future research with larger sample sizes should be continued to test the validity of the PCK-PE by assessing factorial invariance (e.g. gender, across studied school type).

Furthermore, we studied the relation between the PCK-PE and the GPK as recommended (Heemsoth&Wibowo, 2020). The results showed moderate correlation between both second level PCK-PE-factors and GPK, indicating conceptual distinction and discriminant validity, respectively.

Conclusions

Among other things, PCK is a key component of teacher competence that affects both the quality of teaching and the achievement of teaching goals. Despite the importance of PCK, research on the PCK of PE teachers in German speaking countries is still at the beginning. Therefore, one of the strengths of this study is the development and validation of the testing instrument PCK-PE for PETE students in Germany. This is a first step to providing a comprehensive picture concerning the role ofPCK and student achievement. A second strength of this study lies in the empirical testing of the PCK-PE. Expert review provides content and face validity.This is among the first studies of the PCK of German preservice PE teachers to provide a two-site cross-sectional survey design with two independent samples to check construct validity.Hence, the PCK-PE is an eligible measure to assess PETE students PCK in both the "instruction" and the "students" dimension. Furthermore, correlational analysis between the PCK-PE and the GPK reveal discriminant validity.Finally, since the PCK-PE comprises of a German didactics focus, this study adds to the rich international research base on the PCK of PE teachers, as part of a bigger picture. To date, the PCK-PE is one of the few instruments in Germany whose validity has been extensively tested.

Conflicts of interest

The authors have no conflicts of interest to declare. This work was supported by German Research Foundation under Grant 273342642.

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