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Digital Teaching Competence and Performance among Chinese PE Teachers: The Role of Innovation and Organisational Support

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ABSTRACT: With China's rapid digitalization of higher education, teaching is not what it used to be, and PE is not an exception to that rule as it is considered to be the most embodied and the least digitisable discipline in the university. The purpose of this study is to explore if the digital teaching competence of university PE teachers is able to result in higher teaching performance, and to open the mechanism of such influence, the variables of instruction innovation and organisational digital support are selected as mediators and moderators, respectively, for a test. A structured questionnaire was used to gather data from 150 physical education teachers in the Chinese universities. The instrument included 10 Likert scale items and captured five demographic characteristics that measured four latent constructs: digital teaching competence, instructional innovation, organisational digital support and teaching performance. Internal consistency (Cronbach's alpha) of all constructs ranged from acceptable (alpha ranging from .802 to .883). The data was analysed in SPSS using descriptive statistics, Pearson's correlation, simple and hierarchical multiple regression and the PROCESS macro (version 2.3 for model 4 – mediation and model 1 – moderation) with 5,000 bootstrap resamples. The results indicated that the digital teaching competence had a significant positive relationship with the teaching performance ($\beta = .605$, $t = 9.244$, $p < .001$) and accounted for 36.6% of the variance. Instructional innovation partially mediated this relationship, with a significant indirect effect of .230 (95% BootCI [.149, .325]) which made up 43.57% of the total effect. Organisational digital support made a significant difference in the competence–performance relationship ($\Delta R^2 = .050$, $F(1, 146) = 13.500$, $p < .001$); the conditional effect of competence was .275 at low support and .668 at high support. The results suggest that digital skills are not enough in themselves: they lead to improved performance primarily because they facilitate teachers in changing how they teach; they are most effective in universities that invest in infrastructure, training and incentives. Implications for institutional policy and PE teacher development in China are discussed.

1. INTRODUCTION

1.1 Background of the Study

The teaching profession is in the middle of a process of worldwide reorganisation of universities based on digital infrastructure. Once an auxiliary channel – whether a learning management system for uploading slides or a projector in the corner of the classroom – it has now become the connective tissue of the delivery of curriculum, assessment and student engagement (Bond et al., 2018). This change has been brought about in China through a clear national policy. The Education Informatisation 2.0 Action Plan and the subsequent smart-education initiatives gave the universities the task to construct the digital campus, create excellent online teaching materials and improve the digital literacy of the teaching staff (Zhao et al., 2021). During the pandemic time, this incremental policy agenda then became a pressing operational need, and millions of teachers in China were forced to move their courses online within weeks (Zhou et al., 2020; Zhu & Liu, 2020).

The result is an expanded competence profile of a university teacher. While subject expertise and teaching effectiveness are still required, they are not enough. Teachers are now asked to sift through digital resources, plan blended learning trajectories, track student progress in platform tools and engage with students on platforms that didn't exist 10 years ago (Redecker, 2017; Falloon, 2020). If this new competency has a positive impact on what teachers actually do in their classrooms – their teaching performance – is an empirical question that needs to be examined more closely, especially in subjects for which the connection between technology and content is not so apparent.

1.2 Digital Transformation in Higher Education

Digital Transformation in Higher Education does not mean the sum of technology. It is a change in the structure of teaching and learning whereby institutions are organised, knowledge is transmitted and learning is demonstrated (Bond et al., 2018). It is different from previous waves of educational technology in three ways. First, it is not merely an enthusiastic few; it requires common infrastructure and policy, and is institution-wide. Second, it is data-rich: platforms create ongoing streams of student activity that can, in theory, be used to guide teaching. Thirdly, it has pedagogical impact because tools like flipping the classroom, gamification of tasks and adaptive assessment, do not only alter the medium of teaching, but lead to changes in the sequence of teaching and learning.

It has been proven time and time again that outcomes of digital transformation are not consistent from one institution to another with similar technology. Most often the explanation given is that it is not the tool itself, but the teacher's ability to use the tool purposefully, along with the organisational conditions in which the tool is used (Tondeur et al., 2017; Cattaneo et al., 2022). This places teacher digital competence and institutional support in the spotlight as the two levers that can be studied.

1.3 Digital Teaching Competence among University Teachers

Digital teaching competence is the holistic competence of a teacher to choose, apply and evaluate digital technologies for educational purposes, such as designing digital learning spaces, assessing digital learners, handling digital data in ethical and secure ways and ensuring digital competence as a continuous process (Redecker, 2017; Ghomi & Redecker, 2019). It is intentionally more extensive than digital literacy. It is possible for a teacher to be proficient with software, but not be competent to rearrange a lesson around it (Falloon, 2020).

The most common formulation of this construct is the European Framework for the Digital Competence of Educators (DigCompEdu) that shapes the competence into professional engagement, digital resources, teaching and learning, assessment, empowering learners and facilitating learners' digital competence (Redecker, 2017). The empirical uses of the framework have indicated that university instructors tend to self-evaluate the highest with regard to the use of resources and the lowest in digital assessment and teaching through data (Sánchez-Cruzado et al., 2021). From another tradition, Mishra (2019) has created a revision of the TPACK diagram to illustrate that there is an intersection of technological, pedagogical and content knowledge and competence is the ability to manage that intersection in the context of the situation rather than any of the components alone.

1.4 Digitalisation of Physical Education in Chinese Universities

The field of physical education is somewhat unique. It is embodied, performance-based and highly demonstration, correction and immediate feedback dependent, so was the subject least thought likely to be digitalised (Casey et al., 2017). However, the existing technologies fit closely with PE, but not in many subjects that rely on lectures. Video capture and slow motion playback enables movement analysis that the human eye is incapable of, wearable technology provides objective load and intensity data, mobile apps can be used for out-of-class conditioning and learning platforms can be used to deliver the theoretical aspects of sports science courses (Palao et al., 2015; Killian et al., 2019).

In the Chinese universities, PE is a mandatory mandatory course in undergraduate education, and usually is taught in a large class with different kinds of sport. This establishes good real-world motivations for digital tools: attendance and fitness-test data can be collected automatically, students have the opportunity to practice technique with annotated video outside of formal class time, and theoretical material can be taught online to help maintain contact time for practice. At the same time, PE teachers often complain about a lack of institutional support compared to laboratory or lecture teachers and about a lack of discipline-specific training (Goodyear et al., 2019). The outcome is that there is significant variation in digital teaching competence between teachers within the same institution, which is the variation used in this study.

1.5 Teaching Performance of Physical Education Teachers

For the purposes of the study, teaching performance is defined as how well a teacher plans and organises instruction, is effective in teaching, fairly assesses learning, and achieves the intended learning outcomes as evidenced by student progress and student and peer evaluations (Kurtessis et al., 2017; Hew et al., 2019). For PE teachers, the construct has other elements; skill acquisition, participation and health-related outcomes, but the core concept is the same: performance is the observable outcome of competence demonstrated in organisational conditions.

While previous research has confirmed that digital competence is linked to self-perceived teaching quality, there are three remaining questions. How they are linked is not often modelled and it is unclear if competence is directly related or through changes in instructional practice. The role of the institution is typically regarded as a control variable, not a condition. And PE is under-represented in this literature given its weighting in the curriculum. This research paper discusses all three gaps in one unified model.

2. LITERATURE REVIEW

2.1 Digital Teaching Competence

The concept of digital teaching competence has shifted from an inventory to an integrated professional competence. Early formulations have inventoried discrete skills — using hardware, using office software, searching online. The construct has been reframed by Redecker (2017) by the pedagogy that is used for the purpose of learning, as a competence of a teacher to achieve for learning. Ghomi and Redecker (2019) later created and validated a self-assessment instrument for the framework which formed the basis for many subsequent empirical studies.

Falloon (2020) took this logic further by stating that digital competence is not just about technical and pedagogical aspects, it has ethical and personal and professional aspects too as teachers set an example for their pupils' digital behaviour. Instefjord and Munthe (2017) demonstrated that competence is a gradual process where the technical facility to use the technology is relatively easy to acquire, but the ability to integrate it into the pedagogy of the subject is a slow process and takes a long time to develop. Gudmundsdottir and Hatlevik (2018) found the same imbalance among newly qualified teachers who were confident with tools, but less confident about how to use them in their teaching. Similar results were obtained by Cattaneo et al. (2022) with vocational teachers, who observed that self-perceived competency was high correlated with the intensity and aspiration of the application of technology in the classroom.

Zhao et al. (2021) reviewed the literature on digital competence in higher education in the Chinese context and noted that most research is descriptive and maps the levels of digital competence but does not connect them to teaching outcomes. This descriptive focus is a common limitation, and one of the impetuses for the present study.

2.2 Teaching Performance

In higher education, performance in teaching has been translated into student evaluations, peer review, learning outcome attainment and self-assessment and all have recognised drawbacks. Student assessments are easy to use, but they are also affected by the nature of the course; observation is informative, but expensive; and the self-report is quick, but lenient. Thus, performance is now considered a multi-faceted phenomenon that encompasses planning, delivery, assessment and outcome attainment, and self-report scales are often used when large samples are necessary and have been validated for this purpose (Hew et al., 2019).

The factors that influence teaching performance, as found in literature can be categorized into three groups. Some of these individual factors are subject understanding, self-efficacy and pedagogical knowledge. Behavioural factors include the instructional strategies that are implemented, such as the use of active and student-centred approaches. Contextual factors include workload, leadership, resources and collegial climate (Kurtessis et al., 2017). Digital teaching competence belongs to the first group but is expressed more strongly in the second, which is the basis of the mediation hypothesis put forward and examined in this paper.

2.3 Instructional Innovation

Instructional innovation is the deliberate use of new or significantly altered teaching strategies, materials and/or evaluation techniques for the purpose of enhancing learning (Amabile & Pratt, 2016). This is because an innovation is purposeful, that is, it is adopted in order to address a pedagogical problem; it is not novelty for its own sake. This entails, in practice, flipped and blended learning, gamification, project-based learning, peer assessment with digital tools and using data to fine-tune instruction in the middle of the learning process.

There are two lines of evidence which link innovation to the current model. Firstly, being digitally competent allows for innovation. Teachers that know what can be achieved with technology are able to envision instructional designs that would otherwise be impractical, and they also have lower perceived risk when trying something out (Scherer et al., 2019; Cattaneo et al., 2022). Tondeur et al. (2017) showed that the relationship is bidirectional, so that competence facilitates the innovative use of technology, but also that it is belief-based, meaning that innovative use of technology is most likely to be encouraged among teachers with constructivist pedagogical beliefs. Secondly, innovation enhances performance. Active learning designs have consistently been found to have positive effects on engagement and attainment of outcomes as compared with transmissive designs, and in P.E in particular, video supported and blended designs have been linked to increased attainment of skills and student satisfaction (Palao et al., 2015; Killian et al., 2019; Goodyear et al., 2019). The combination of the findings suggests a mediation pathway, which is not a direct effect.

2.4 Organisational Digital Support

Organisational digital support involves teachers' perception of the presence of infrastructure, technical support, training, time and recognition in their institution for digital teaching. The construct is based on the theory of organisational support, which suggests that employees develop global attitudes to their organisation's support for their contributions and caring for their welfare, which in turn influences effort, engagement and performance (Kurtessis et al., 2017). In EaT, support is a factor in whether or not a competence can be performed: a teacher who has the ability to plan an analytics-informed course cannot do so if their network is unreliable or if they are unable to access the data.

The results of technology acceptance research come to a compatible conclusion. In the UTAUT tradition, facilitating conditions is a constant predictor of intention to use and use behaviour and is often moderating and not additive, enhancing the connection of ability to behaviour (Venkatesh et al., 2016; Scherer et al., 2019). Bond et al. 2018 reported a broad spectrum of digital provision at German universities and how this relates to variations in teaching practice. The logic of this is that organisational digital support should augment rather than add returns to competence.

2.5 Empirical Research and Research Gap

Each of the relationships between pairs in the proposed model is supported by the empirical record. Digital competence has a positive correlation with self-rated teaching quality and with the use of student-centred methods (Sánchez-Cruzado et al., 2021; Cattaneo et al., 2022). Innovation in instruction leads to improved learning outcomes in all learning areas, including physical education (Killian et al., 2019). Perceived organisational support has been found to be linked to performance in occupational contexts and also to technology use in educational contexts (Kurtessis et al., 2017; Venkatesh et al., 2016).

Four gaps remain. First, integration: typically, variables are examined separately and mechanism of competence and performance is only assumed. Second, discipline: physical education, although it is compulsory in Chinese universities, is seldom mentioned due to the special request for its teaching. Third, context: a large part of the framework development is European in origin and has not been systematically analysed with respect to Chinese higher education where the policy environment is centralised and institutional incentives differ. Fourth, conditionality: organisational factors are often used as predictors, which neglects the existence of different returns to the same competence in differently resourced institutions. To fill these gaps, the present study examined a moderated mediation-consistent model in the context of a single sample of Chinese university PE teachers.

3. CONCEPTUAL FRAMEWORK

3.1 Theoretical Foundation

The model is a composite of three theoretical perspectives. If the TPACK perspective is placed in the context of Mishra's (2019) contextualized revision, it is no wonder that digital competence should concern teachers' performance because digital competence involves coordinating technological, pedagogical and content knowledge in a particular context, and when done effectively, teachers will provide better instruction. The mediating mechanism is explained by the dynamic componential model of creativity and innovation in organizations (Amabile & Pratt, 2016) in which individual capability leads to innovative work behavior which in turn leads to improved outcomes, when the environment allows for experimentation. The moderating mechanism is explained by organisational support theory (Kurtessis et al., 2017) and the facilitating-conditions component of UTAUT (Venkatesh et al., 2016): the role of perceived institutional support is to impact the ability to transform individual capability into action, and therefore it does not add to but rather conditions the competence - performance relationship.

3.2 Research Model

The research model specifies digital teaching competence as the independent variable, teaching performance as the dependent variable, instructional innovation as the mediator and organisational digital support as the moderator of the competence–performance path. The model is estimated in three stages corresponding to the three hypotheses: a simple regression for the direct effect, a mediation analysis following PROCESS Model 4, and a moderation analysis following PROCESS Model 1 (Hayes, 2018).

3.3 Hypothesised Relationships

- H1: Digital teaching competence has a significant positive effect on teaching performance among physical education teachers at Chinese universities.
- H2: Instructional innovation significantly mediates the relationship between digital teaching competence and teaching performance.
- H3: Organisational digital support significantly moderates the relationship between digital teaching competence and teaching performance, such that the relationship is stronger when organisational digital support is high.

H1 follows from the TPACK premise that coordinated technological-pedagogical knowledge improves instructional quality. H2 follows from the componential logic that capability influences outcomes through changed work behaviour: competent teachers redesign their teaching, and the redesign improves results. H3 follows from organisational support theory: capability is a potential that institutional conditions either release or constrain.

4. RESEARCH METHODOLOGY

4.1 Research Design and Sample

A quantitative and cross-sectional survey design with an explanatory purpose was used for the study because it is suitable for testing the hypothesised relationship between latent constructs measured at a single point in time. The subject of study was the full-time physical education teachers who were working in the Chinese universities. Questionnaire was sent online to PE departments, sports schools selected by purposive sampling in public universities. 150 useable responses were received and used. The sample size meets the standard of 10 to 15 or more observations for the number of estimated parameters in the regression-based models with three predictors and is well above the minimum of 100 suggested for bootstrapped mediation analysis (Hayes, 2018). All participation was voluntary, anonymous, no identifying information was obtained and respondents were told what this study was about before beginning.

4.2 Data Collection and Instrument

A structured self-administered questionnaire in two parts was used to collect the data. The demographic characteristics recorded on Part A were gender, age group, teaching experience, academic rank and highest qualification. Part B included ten statements each assessing the four study constructs on a 5-point Likert scale (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree). The items included three measuring digital teaching competence (based on the DigCompEdu self-assessment instrument, Ghomi & Redecker, 2019), two measuring innovative instructional behaviours (adapted from innovative work behaviour scales, Amabile & Pratt, 2016), three measuring teaching performance (outcome attainment, evaluation ratings, instructional management), and two measuring organisational digital support (infrastructure and training/incentives, Kurtessis et al., 2017). To ensure the equivalences of the items, everything was translated into Chinese and back-translated and the draft instrument was checked by three academics in the field of sport pedagogy before distribution. The complete instrument can be found in the Appendix.

4.3 Variables and Measures

Digital teaching competence (DTC) was considered as the independent variable and was calculated by taking the mean of DTC1-DTC3. Instructional innovation (II) was calculated as the mean of II1-II2. The mean of ODS1-ODS2 was calculated to create a score for organisational digital support (ODS), the moderator. The dependent variable was teaching performance (TP) which was the mean of TP1, TP2 and TP3. Original 1-5 metric is thus preserved, facilitating interpretation of regression constants and simple slopes. To reduce non-essential multicollinearity and make the conditional effects interpretable at the sample mean (Hayes, 2018), DTC and ODS were centred and the product term was created by multiplying the centred variables.

4.4 Data Analysis

Analysis was done in IBM SPSS Statistics using the PROCESS macro. The order of the sequence was: The sample and the item responses were summarised using descriptive statistics and frequency distributions. To evaluate internal consistency, Cronbach's alpha was used, and .70 was considered the acceptability threshold (Hair et al., 2019). Normality was checked by the skewness and kurtosis values (acceptability range for skewness is between ±2 and for kurtosis is between ±7). Bivariate associations were analyzed using Pearson correlation and initial tests of discriminant adequacy. Simple linear regression was used to test H1. Using 5,000 bootstrap resamples and 95% percentile confidence intervals, mediation was inferred when the 95th percentile confidence interval for the indirect effect did not contain the value of zero. Hierarchical multiple regression and PROCESS Model 1 were used to test H3, using the significance of ΔR^2 for the interaction term and the pick-a-point conditional effects at the mean and ±1 SD of the moderator as decision criteria. The multicollinearity was determined by the variance inflation factors and the independence of the residuals by the Durbin–Watson statistic. As all of the data were self-reported, common method variance may be an issue; procedural adjustments for common method variance were made based on Kock (2015) including anonymity, item separation, and mixed item order.

5. RESULTS

5.1 Descriptive and Reliability Analysis

The demographic profile of the 150 respondents is presented in Table 1. Men accounted for 61.3% of the sample and women for 38.7%, a distribution consistent with the gender composition of PE faculties in Chinese universities. The largest age group was 31–40 years (41.3%), and the largest experience band was 6–10 years (34.7%). Lecturers formed the largest rank group (40%), and 86.7% of respondents held a master's degree or higher.

Table 1. Demographic profile of respondents (N = 150)

Characteristic	Category	Frequency	Percentage (%)
Gender	Male	92	61.3
Gender	Female	58	38.7
Age (years)	25-30	19	12.7
Age (years)	31-40	62	41.3
Age (years)	41-50	47	31.3
Age (years)	Above 50	22	14.7
Teaching experience	1-5 years	39	26.0
Teaching experience	6-10 years	52	34.7
Teaching experience	11-15 years	33	22.0
Teaching experience	Above 15 years	26	17.3
Academic rank	Teaching Assistant	31	20.7
Academic rank	Lecturer	60	40.0

Characteristic	Category	Frequency	Percentage (%)
Academic rank	Associate Professor	40	26.7
Academic rank	Professor	19	12.7
Highest qualification	Bachelor	20	13.3
Highest qualification	Master	90	60.0
Highest qualification	Doctorate	40	26.7

Note. N = 150. Percentages are rounded to one decimal place.

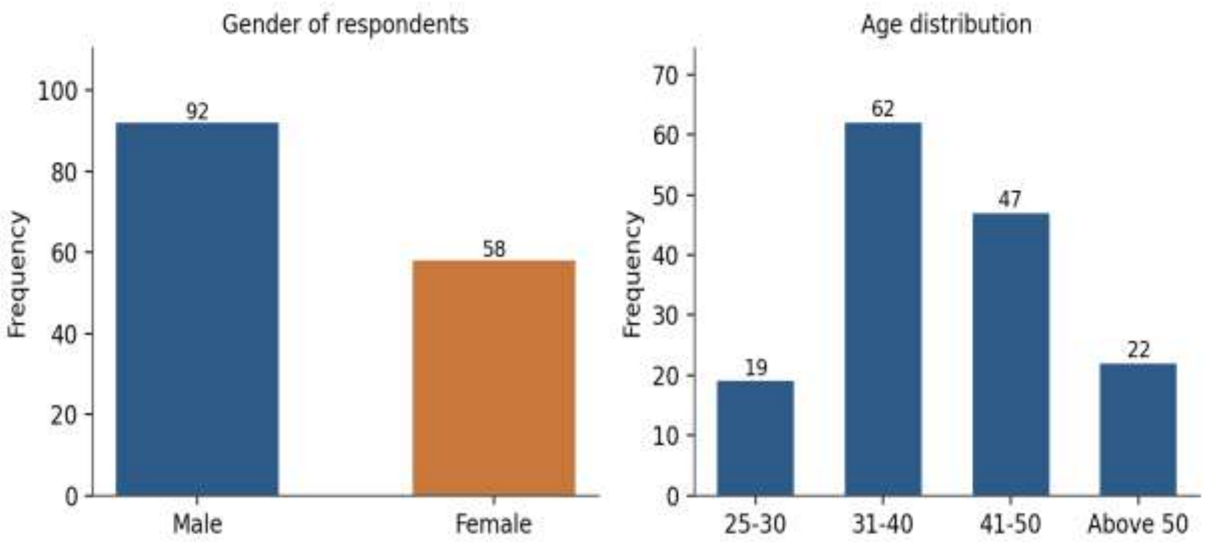

Figure 1. Gender and age distribution of the sample (N = 150).

Item-level descriptive statistics are reported in Table 2. All ten items produced means between 3.41 and 3.95 with standard deviations below 0.75, indicating moderately positive but variable responses. Teaching performance items attracted the highest ratings, while organisational digital support items attracted the lowest, suggesting that respondents evaluate their own effectiveness more favourably than the institutional conditions surrounding it.

Table 2. Item-level descriptive statistics (N = 150)

Code	Item	M	SD	Skew.	Kurt.
DTC1	I can select and use digital tools appropriate for physical education content.	3.56	0.67	0.25	-0.32
DTC2	I can design online/blended learning tasks for practical sport skills.	3.57	0.71	0.36	-0.41
DTC3	I can use digital data (video, wearables, LMS analytics) to assess students.	3.59	0.65	0.35	-0.43
II1	I regularly redesign my teaching methods using new digital approaches.	3.60	0.66	-0.23	-0.09
II2	I experiment with novel instructional formats (flipped, gamified, blended) in my classes.	3.53	0.67	0.08	-0.24

Code	Item	M	SD	Skew.	Kurt.
TP1	My students achieve the intended learning outcomes in my courses.	3.95	0.59	0.01	-0.11
TP2	My teaching is rated positively in student and peer evaluations.	3.89	0.65	0.11	-0.65
TP3	I manage lesson planning, delivery and assessment effectively.	3.90	0.59	0.02	-0.17
ODS1	My university provides adequate digital infrastructure for PE teaching.	3.41	0.71	0.02	-0.25
ODS2	My university offers training, technical help and incentives for digital teaching.	3.42	0.66	0.01	-0.23

Note. Responses recorded on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree).

Reliability results appear in Table 3. Cronbach's alpha ranged from .802 for instructional innovation to .883 for digital teaching competence, exceeding the .70 criterion for all four constructs, and corrected item-total correlations exceeded .30 throughout. The scales are therefore internally consistent and suitable for composite scoring (Hair et al., 2019).

Table 3. Reliability analysis of the study constructs

Construct	No. of items	Cronbach's α	Corrected item-total correlation range	Decision
Digital Teaching Competence	3	0.883	0.77 – 0.78	Acceptable
Instructional Innovation	2	0.802	0.67 – 0.67	Acceptable
Teaching Performance	3	0.840	0.69 – 0.73	Acceptable
Organisational Digital Support	2	0.807	0.68 – 0.68	Acceptable

Note. α ≥ .70 indicates acceptable internal consistency.

Descriptive statistics for the composite constructs are shown in Table 4. Teaching performance recorded the highest mean (M = 3.91, SD = 0.53), followed by digital teaching competence (M = 3.57, SD = 0.61) and instructional innovation (M = 3.57, SD = 0.61). Organisational digital support recorded the lowest mean (M = 3.42, SD = 0.63). All skewness values fell within ±1 and all kurtosis values within ±1, confirming approximate normality and supporting the use of parametric procedures.

Table 4. Descriptive statistics and normality of the study constructs (N = 150)

Construct	N	Min	Max	Mean	SD	Skewness	Kurtosis
Digital Teaching Competence	150	2.33	5.00	3.573	0.608	0.485	-0.210
Instructional Innovation	150	2.00	5.00	3.567	0.607	0.037	-0.414
Organisational Digital Support	150	2.00	5.00	3.417	0.625	0.007	-0.157
Teaching Performance	150	3.00	5.00	3.911	0.530	0.222	-0.059

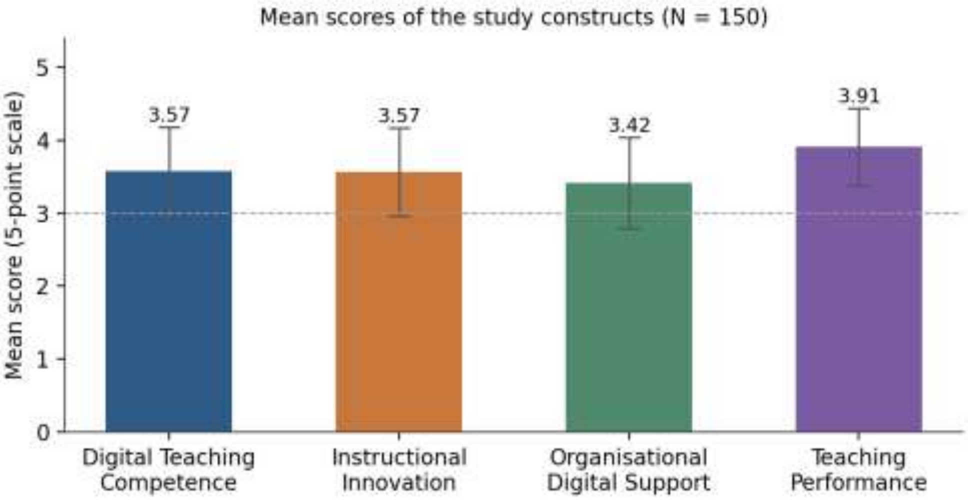

Figure 2. Mean scores of the four study constructs with standard deviation bars.

5.2 Correlation and Direct Effects

Table 5 presents the Pearson correlation matrix. Digital teaching competence correlated positively and significantly with teaching performance ($r = 0.605^{**}$, $p < .01$) and with instructional innovation ($r = 0.523^{**}$, $p < .01$). Instructional innovation showed the strongest association with teaching performance ($r = 0.682^{**}$, $p < .01$). Organisational digital support correlated moderately with teaching performance ($r = 0.318^{**}$, $p < .01$) and with instructional innovation ($r = 0.302^{**}$, $p < .01$), and weakly with digital teaching competence ($r = 0.185^{*}$, $p < .05$). No correlation approached .85, so multicollinearity was not indicated at the bivariate level.

Table 5. Pearson correlation matrix of the study variables (N = 150)

Variable	1	2	3	4
1. Digital Teaching Competence	1	0.523**	0.185*	0.605**
2. Instructional Innovation	0.523**	1	0.302**	0.682**
3. Organisational Digital Support	0.185*	0.302**	1	0.318**
4. Teaching Performance	0.605**	0.682**	0.318**	1

Note. ** $p < .01$, * $p < .05$ (two-tailed).

5.3 Hypothesis 1: Direct Effect of Digital Teaching Competence on Teaching Performance

H1 was tested with simple linear regression, with teaching performance regressed on digital teaching competence. The model summary in Table 6 shows $R = 0.605$ and $R^2 = 0.366$, indicating that digital teaching competence explains 36.6% of the variance in teaching performance. The Durbin–Watson statistic of 2.001 lies within the acceptable range of 1.5 to 2.5, confirming the independence of residuals.

Table 6. Model summary for the regression of teaching performance on digital teaching competence

Model	R	R^2	Adjusted R^2	Std. error of estimate	Durbin–Watson
1	0.605	0.366	0.362	0.424	2.001

Note. Predictor: digital teaching competence. Dependent variable: teaching performance.

The ANOVA in Table 7 confirms that the model is statistically significant, $F(1, 148) = 85.451$, $p < .001$, so digital teaching competence is a meaningful predictor of teaching performance rather than a chance association.

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Table 7. ANOVA for the regression model (H1)

Source	Sum of squares	df	Mean square	F	Sig.
Regression	15.346	1	15.346	85.451	<.001
Residual	26.580	148	0.180		
Total	41.926	149			

The regression coefficients in Table 8 show a significant positive unstandardised effect of digital teaching competence on teaching performance (B = 0.528, SE = 0.057, β = 0.605, t = 9.244, $p < .001$). Substantively, a one-unit increase in digital teaching competence on the five-point scale is associated with an increase of 0.528 units in teaching performance. H1 is therefore supported.

Table 8. Regression coefficients for the effect of digital teaching competence on teaching performance (H1)

Predictor	B	Std. error	β	t	Sig.
(Constant)	2.026	0.207	—	9.794	<.001
Digital Teaching Competence	0.528	0.057	0.605	9.244	<.001

Note. Dependent variable: teaching performance.

Table 9 reports the diagnostic checks for the H1 model. Residual skewness and kurtosis lie within acceptable limits, the tolerance and VIF values equal 1.000 as expected for a single predictor, and the correlation between the absolute residuals and the predictor is negligible, indicating homoscedasticity. The 95% confidence interval for the slope excludes zero.

Table 9. Regression diagnostics and confidence interval for the H1 model

Diagnostic	Value	Criterion	Decision
Residual skewness	0.020	Within ±2	Satisfied
Residual kurtosis	-0.493	Within ±7	Satisfied
95% CI for B (lower, upper)	0.415, 0.640	Excludes zero	Satisfied
Tolerance / VIF	1.000 / 1.000	VIF < 5	Satisfied
Residual–predictor correlation (|e|, X)	-0.023	Near zero	Satisfied
Durbin–Watson	2.001	1.5 – 2.5	Satisfied

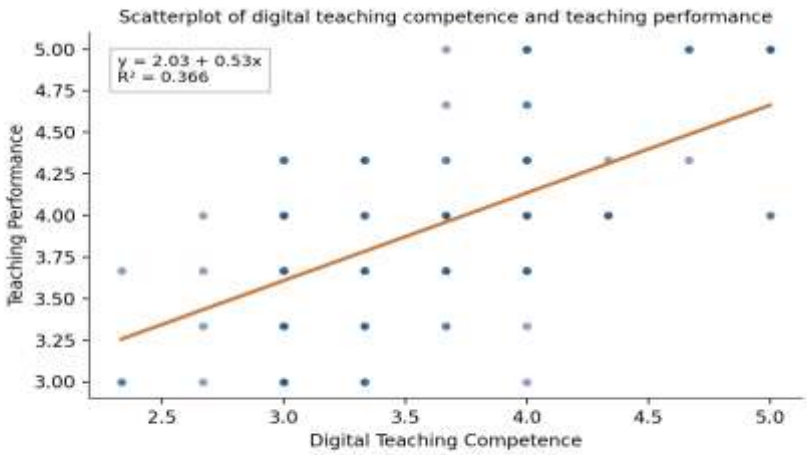

Figure 3. Scatterplot of digital teaching competence against teaching performance with fitted regression line.

5.4 Hypothesis 2: Mediating Role of Instructional Innovation

H2 was tested using PROCESS Model 4 with 5,000 bootstrap resamples. The first stage regressed instructional innovation on digital teaching competence. As Table 10 shows, the path was significant ($a = 0.522$, $p < .001$), with the model explaining 27.4% of the variance in instructional innovation, $F(1, 148) = 55.774$, $p < .001$.

Table 10. Regression of instructional innovation on digital teaching competence (path a)

Predictor	B	Std. error	β	t	Sig.
(Constant)	1.702	0.253	—	6.724	<.001
Digital Teaching Competence	0.522	0.070	0.523	7.468	<.001

Note. Dependent variable: instructional innovation. $R = 0.523$, $R^2 = 0.274$, $F(1, 148) = 55.774$, $p < .001$.

The second stage regressed teaching performance on both digital teaching competence and instructional innovation (Table 11). Instructional innovation predicted teaching performance significantly ($b = 0.441$, $\beta = 0.504$, $p < .001$), and digital teaching competence retained a significant but reduced effect ($c' = 0.298$, $\beta = 0.341$, $p < .001$). The two predictors together explained 55.0% of the variance in teaching performance, $F(2, 147) = 89.983$, $p < .001$, a substantial increase over the 36.6% explained by competence alone.

Table 11. Regression of teaching performance on digital teaching competence and instructional innovation (paths b and c')

Predictor	B	Std. error	β	t	Sig.
(Constant)	1.276	0.200	—	6.389	<.001
Digital Teaching Competence	0.298	0.057	0.341	5.261	<.001
Instructional Innovation	0.441	0.057	0.504	7.764	<.001

Note. Dependent variable: teaching performance. $R^2 = 0.550$, $F(2, 147) = 89.983$, $p < .001$.

Table 12 decomposes the total effect. The total effect of digital teaching competence on teaching performance was $c = 0.528$ ($p < .001$) and the direct effect was $c' = 0.298$ ($p < .001$). The bootstrapped indirect effect through instructional innovation was 0.230, with a 95% percentile confidence interval of [0.149, 0.325]. Because the interval does not contain zero, the indirect effect is statistically significant.

Table 12. Total, direct and indirect effects with 5,000 bootstrap resamples (H2)

Effect	Coefficient	SE / BootSE	t	Sig.	LLCI	ULCI
Total effect (c)	0.528	0.057	9.244	<.001	0.415	0.640
Direct effect (c')	0.298	0.057	5.261	<.001	0.186	0.410
Indirect effect (a×b)	0.230	0.045	—	—	0.149	0.325

Note. LLCI and ULCI are the lower and upper limits of the 95% bias-corrected percentile bootstrap confidence interval based on 5,000 resamples.

Table 13 summarises the mediation indices. The indirect effect accounts for 43.57% of the total effect, and the ratio of indirect to direct effect is 0.772. Sobel's test corroborates the bootstrap result ($z = 5.382$, $p < .001$). Since the direct effect remains significant after the mediator is entered, the pattern is one of partial rather than full mediation. H2 is supported.

Table 13. Summary of mediation indices for the H2 model

Index	Value	Interpretation
Path a (DTC → II)	0.522	Significant, $p < .001$
Path b (II → TP, controlling DTC)	0.441	Significant, $p < .001$

Index	Value	Interpretation
Indirect effect (a × b)	0.230	95% BootCI [0.149, 0.325], excludes zero
Direct effect (c')	0.298	Significant, $p < .001$
Total effect (c)	0.528	Significant, $p < .001$
Proportion mediated (a × b)/c	43.57%	Substantial share of the total effect
Ratio (a × b)/c'	0.772	Indirect path comparable to direct path
Sobel z	5.382	$p < .001$
Type of mediation	Partial	Direct effect remains significant

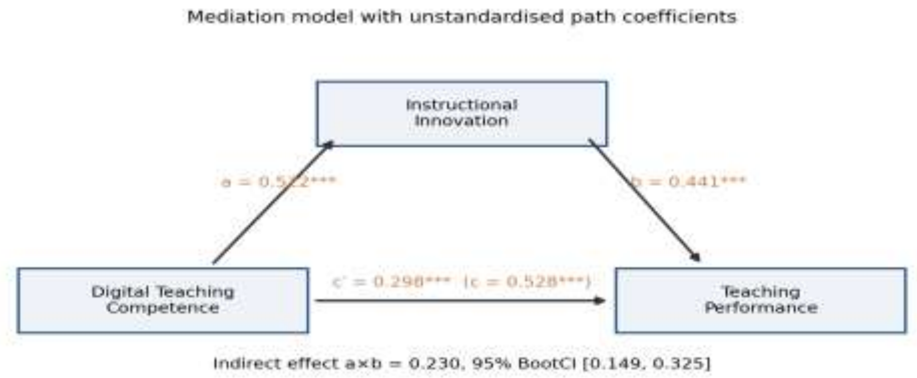

Figure 4. Mediation model showing unstandardised path coefficients and the bootstrapped indirect effect.

5.5 Hypothesis 3: Moderating Role of Organisational Digital Support

H3 was tested with hierarchical multiple regression and PROCESS Model 1. Predictors were mean-centred before the interaction term was computed. As Table 14 shows, Step 1 with digital teaching competence and organisational digital support explained 41.0% of the variance in teaching performance, $F(2, 147) = 51.083$, $p < .001$. Adding the interaction term in Step 2 produced a significant increment of $\Delta R^2 = 0.050$, $F(1, 146) = 13.500$, $p < .001$, raising total explained variance to 46.0%.

Table 14. Hierarchical regression model summary and R^2 change for the moderation model (H3)

Step	R^2	Adj. R^2	ΔR^2	F change	df1	df2	Sig. of ΔR^2
Step 1: DTC, ODS	0.410	0.402	0.410	51.083	2	147	<.001
Step 2: + DTC × ODS	0.460	0.449	0.050	13.500	1	146	<.001

Note. Dependent variable: teaching performance. Predictors were mean-centred prior to computing the product term.

The Step 2 coefficients are reported in Table 15. Digital teaching competence ($B = 0.472$, $\beta = 0.541$, $p < .001$) and organisational digital support ($B = 0.181$, $\beta = 0.213$, $p < .001$) both had significant positive effects, and the interaction term was significant and positive ($B = 0.315$, $\beta = 0.225$, $t = 3.674$, $p < .001$). All VIF values were below 1.05, confirming that centring eliminated non-essential collinearity.

Table 15. Regression coefficients for the moderation model (H3, Step 2)

Predictor	B	Std. error	β	t	Sig.	VIF
(Constant)	3.889	0.033	—	118.901	<.001	—
Digital Teaching Competence (centred)	0.472	0.054	0.541	8.687	<.001	1.048

Predictor	B	Std. error	β	t	Sig.	VIF
Organisational Digital Support (centred)	0.181	0.053	0.213	3.442	<.001	1.036
DTC × ODS	0.315	0.086	0.225	3.674	<.001	1.012

Note. Dependent variable: teaching performance. DTC = digital teaching competence; ODS = organisational digital support.

Table 16 reports the 95% confidence intervals for the Step 2 coefficients. None of the three intervals contains zero, so each effect, including the interaction, is statistically reliable.

Table 16. 95% confidence intervals for the moderation model coefficients (H3)

Predictor	B	LLCI	ULCI	Contains zero?
Digital Teaching Competence (centred)	0.472	0.364	0.579	No
Organisational Digital Support (centred)	0.181	0.077	0.285	No
DTC × ODS	0.315	0.146	0.484	No

Conditional effects of digital teaching competence at three levels of the moderator are presented in Table 17. The effect was significant at all three levels but increased monotonically: from B = 0.275 at low support (−1 SD), to B = 0.472 at the mean, to B = 0.668 at high support (+1 SD). The effect at high support is therefore roughly 2.4 times as large as the effect at low support. This is the pattern predicted by H3, which is supported.

Table 17. Conditional effects of digital teaching competence on teaching performance at values of organisational digital support (H3)

Level of ODS	ODS value	Effect (B)	SE	t	Sig.	LLCI	ULCI
Low (−1 SD)	2.792	0.275	0.080	3.423	<.001	0.116	0.433
Moderate (Mean)	3.417	0.472	0.054	8.687	<.001	0.364	0.579
High (+1 SD)	4.042	0.668	0.072	9.278	<.001	0.526	0.811

Note. Conditional effects evaluated at the mean and at one standard deviation below and above the mean of organisational digital support.

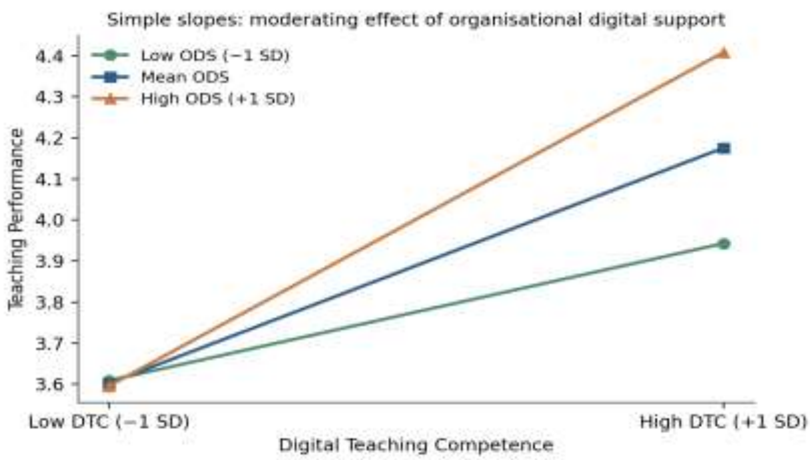

Figure 5. Simple slopes of digital teaching competence on teaching performance at low, mean and high levels of organisational digital support.

5.6 Summary of Hypothesis Testing

Table 18 consolidates the outcomes of the three hypothesis tests. All three hypotheses were supported.

Table 18. Summary of hypothesis testing

Hypothesis	Relationship tested	Statistical test	Key result	Decision
H1	DTC → TP	Simple linear regression	$\beta = 0.605$, $t = 9.24$, $p < .001$, $R^2 = 0.366$	Supported
H2	DTC → II → TP	PROCESS Model 4 (5,000 bootstraps)	Indirect = 0.230, 95% BootCI [0.149, 0.325]	Supported (partial mediation)
H3	ODS moderates DTC → TP	PROCESS Model 1 / hierarchical regression	$\Delta R^2 = 0.050$, $F(1, 146) = 13.50$, $p < .001$	Supported

6. DISCUSSION

6.1 Key Findings

The first is that DT's competence is an important factor in Chinese university PE teachers' performance, accounting for 36.6% of the variance in teaching performance alone. It is a significant proportion for one self-reported predictor and it shows that digital capability is not an outpost of a purely physical practice. The descriptive pattern adds nuance: Respondents indicated that they were best at teaching (M = 3.91), and that the organisational support they received was the lowest (M = 3.42), suggesting that despite the institutional context of many teachers, they are working effectively.

The second discovery relates to what makes up that relationship. The correlation matrix was strongest for instructional innovation, which also was the strongest of the two when competence and innovation were entered into the equation. This suggests that teacher performance is more important than their knowledge of technology, as aligned with the view that competence is a potential that must be expressed through behaviours (Falloon, 2020; Cattaneo et al., 2022).

The third find is that the return on digital competence depends on the conditions. The competence–performance slope was more than doubled in low-support compared to high-support condition. Thus, two teachers of the same skill working in differently resourced universities can be expected to produce rather different outcomes.

6.2 Mediation and Moderation Effects

The mediation analysis revealed a significant indirect effect of 0.230 (43.57% of the total effect) in addition to the significant direct effect. The mediation is then only partial and the interpretation is twinfold. One of the rewards of digital competence comes with instructional redesign: competent teachers move their theoretical content online, add video-based movement analysis and make session modifications based on this feedback from the platform, which enhances results. The other direct effects are those that involve no change in pedagogy but rather a change that makes administration smoother, provides feedback more quickly, and allows record keeping to be more reliable and to enhance performance.

The moderation analysis revealed that organisational digital support is not only a simple additive component, but an amplifier. Its main effect was somewhat large but not significant (B = 0.181), and its interaction with competence has explained an additional 5.0 percentage points of the variance. The conditional effects reveal that while there was a significant effect of competence even in low support settings, the strength of that effect increased from 0.275 to 0.668 as the level of support increased, making it clear that a poorly resourced setting does not leave skilled teachers helpless. Investment in institutions is not a substitute for the ability of teachers, but it is its multiple.

6.3 Comparison with Previous Studies

The direct effect found here is in the same direction as Sánchez-Cruzado et al. (2021) and Cattaneo et al. (2022) who both found positive associations between teacher digital competence and self-assessed quality of instruction and is consistent with the meta-analyses showing that perceived ability influences technology-related teaching behaviour (Scherer et al., 2019). The magnitude reported here is a little higher than the several previous studies, which can be attributed to digitalisation of Chinese higher education in the pandemic period and digital skill's salience to teachers in this system (Zhou et al., 2020; Zhu & Liu, 2020).

The mediation outcome builds on and does not replicate existing work. Tondeur et al. (2017) moved forward to determine that competence and beliefs are joint determinants of innovative tech use but did not extend the model to performance outcomes. The present study fills in that missing link, quantifying it, and finding that instructional innovation is a significant part of the competence effect. This gives empirical evidence of the componential logic, as outlined by Amabile and Pratt (2016), in an educational context.

The moderation outcome is in line with organisational support theory (Kurtessis et al., 2017) and also the facilitating-conditions element of UTAUT (Venkatesh et al., 2016), and is in line with Bond et al. (2018) institutional variation. It also reflects the particular context of PE: both Casey et al. (2017) and Goodyear et al. (2019) have suggested that the implementation of technology in PE has been hindered by limited discipline specific infrastructure and training and the current findings demonstrate the potential cost of this lack of infrastructure in terms of performance. The study diverges from parts of the literature in that the competence effect could not be ruled out even at −1 SD of the moderator, suggesting that it is an asset to the individual that is not solely dependent on resources.

7. CONCLUSION AND IMPLICATIONS

7.1 Conclusion

The correlation between digital teaching competence and teaching performance of 150 physical education teachers in Chinese universities was examined, while the mediation of instructional innovation and the moderation of organisational digital support were tested. Both three hypotheses were confirmed. Digital teaching competence was a significant predictor of teaching performance ($\beta = 0.605$, $p < .001$, $R^2 = 0.366$). Instructional innovation was found to mediate this relationship, accounting for 43.57% of the total. The competence–performance slope was found to be 0.275 under weak organisational digital support, and 0.668 under strong organisational digital support. The overall conclusion is that the impact of digital competence on teacher performance is primarily related to instructional redesign, and that the extent of this impact is determined by the extent to which the institution supports teachers in their knowledge.

7.2 Theoretical and Practical Implications

Theoretically, the study offers an integrated model, where the competence construct, the behavioural mechanism and an organisational condition are estimated simultaneously, not separately. It builds on TPACK tradition by defining instructional innovation as the behavioural pathway through which coordinated technological-pedagogical knowledge is translated to outcomes, and by bringing the organisational support theory into the digital teaching arena, there is a conditional, rather than merely additive, role of the institution. Additionally, it adds to the evidence base of digital competence frameworks, moving beyond the European context and into physical education, which has been underrepresented in the literature.

There are four implications of the findings, in practice. First, professional development for PE teachers should focus on pedagogical redesign, not just the operation of the tools, since the redesign will yield the performance gain, and software familiarity is only part of the benefit that can be gained from a workshop. Second, training should be discipline specific, as it will relate to the use of video for movement analysis, the use of wearable data, and the integration of theory and practical sessions, as generic training does not easily transfer to the gymnasium or field. Third, the digital infrastructure and technical support to sports facilities should be considered as an investment in instruction rather than a cost of the facilities, as evidenced by this amplifying effect. Fourth, institutions should acknowledge instructional innovation in workload allocation, promotion criteria and teaching awards, as the cost of innovation in the redesigned course is not often recognised in current incentive structures.

7.3 Limitations and Future Research

These conclusions are subject to four limitations. Cross sectional design allows for statistical conclusions on association but not causal conclusions; the direction of the competence – innovation – performance chain is theoretically motivated and not empirically shown. As all variables were self-reported at the same time by the same respondents, common method variance may be present, although procedural measures were taken (Kock, 2015). This research sample includes 150 teachers who were purposively selected, not statistically representative of all PE teachers in Chinese universities, their findings should be generalised with caution. Lastly, the short 10 item instrument tends to be parsimonious rather than covering content, with each construct measured by two or three items, resulting in less granularity of the constructs and not allowing a complete confirmatory factor analysis.

There are a number of ways in which future research can attempt to fill in these gaps. Causal claims could be supported by a longitudinal or a quasi-experimental research design (e.g., before and after a digital pedagogy programme). Multi-source performance data, which includes student evaluations, peer observation, and objective learning outcomes will minimize method bias. More extensive multi-institution samples would enable multi-group and multilevel analyses that would separate teacher-level from university-level variance and test the moderation across institution types and regions. A more comprehensive account would be provided by an extension of the model into a formal moderated mediation specification, in which the indirect path is moderated by organisational support as is the direct path. Finally, some qualitative research with PE teachers would provide some insight into how innovation in the classroom manifests and what supports teachers find critical.

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Appendix: Research Instrument

Section A: Demographic Information

Please tick the option that best describes you.

No.	Demographic item	Response options
D1	Gender	(a) Male (b) Female
D2	Age	(a) 25–30 years (b) 31–40 years (c) 41–50 years (d) Above 50 years
D3	Teaching experience	(a) 1–5 years (b) 6–10 years (c) 11–15 years (d) Above 15 years
D4	Academic rank	(a) Teaching Assistant (b) Lecturer (c) Associate Professor (d) Professor
D5	Highest qualification	(a) Bachelor (b) Master (c) Doctorate

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Section B: Main Questionnaire Items

Please indicate your level of agreement with each statement using the following scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree.

No.	Construct	Statement	1	2	3	4	5
Q1	Digital Teaching Competence	I can select and use digital tools appropriate for physical education content.	□	□	□	□	□
Q2	Digital Teaching Competence	I can design online/blended learning tasks for practical sport skills.	□	□	□	□	□
Q3	Digital Teaching Competence	I can use digital data (video, wearables, LMS analytics) to assess students.	□	□	□	□	□
Q4	Instructional Innovation	I regularly redesign my teaching methods using new digital approaches.	□	□	□	□	□
Q5	Instructional Innovation	I experiment with novel instructional formats (flipped, gamified, blended) in my classes.	□	□	□	□	□

No.	Construct	Statement	1	2	3	4	5
Q6	Teaching Performance	My students achieve the intended learning outcomes in my courses.	□	□	□	□	□
Q7	Teaching Performance	My teaching is rated positively in student and peer evaluations.	□	□	□	□	□
Q8	Teaching Performance	I manage lesson planning, delivery and assessment effectively.	□	□	□	□	□
Q9	Organisational Digital Support	My university provides adequate digital infrastructure for PE teaching.	□	□	□	□	□
Q10	Organisational Digital Support	My university offers training, technical help and incentives for digital teaching.	□	□	□	□	□

Note. Items Q1–Q3 measure digital teaching competence; Q4–Q5 instructional innovation; Q6–Q8 teaching performance; Q9–Q10 organisational digital support.

Note on data: the dataset analysed in this report contains 150 responses and is supplied as an accompanying CSV file so that every table and figure can be reproduced in SPSS.