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Innovativeness and Technological Pedagogical Content Knowledge in Physical Education: A Study of Teacher Competencies

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ABSTRACT

This research aimed to examine the innovativeness and Technological Pedagogical Content Knowledge (TPCK) levels of physical education and sports teachers (PE teachers) and to reveal the relationship between innovativeness and TPCK levels. The study sample comprises 182 PE teachers. “General Information Form,” “Innovativeness Scale (IS),” and “TPCK Scale” were used as data collection tools. General Information Form includes questions prepared to identify the PE teachers participating in the study variables of the gender (male and female), age (24-30 years, 31-40 years, and 41-50 years), professional experience (1-10 years and 11 years and above), the school level (secondary and high school), and educational status (undergraduate and graduate). PE teachers’ innovativeness and TPCK levels are above the scale average scores. There were no significant differences in innovativeness and TPCK levels regarding gender, age, professional experience, school level, and educational status ($p > .01$). A negative and positive relationship existed between the IS and its sub-dimensions and a positive relationship between the TPCK scale sub-dimensions ($p < .01$). The IS scores only showed a significant positive relationship with the sub-dimensions of CK and PCK ($p < .01$). PE teachers exhibit high levels of innovativeness and TPCK, so we recommend designing educational environments open to innovation and support technology.

Keywords: Education, innovation, pedagogy, teaching, technology.

Introduction

Education is a process that develops and changes individuals' behaviors while regulating their relationships with society (Ekici & Ekici, 2014). The success of educational activities depends on various factors, including the identification of educators' needs and the provision of services to meet these needs. Teachers should be trained as individuals proficient in the technology relevant to current conditions, possess subject-specific knowledge, and are competent in pedagogy (Gül, 2015). Recognizing their potential, updating their knowledge individually, and determining their levels of innovativeness and TPCK are crucial in addressing societal needs and resolving related problems.

Global changes and developments have required individuals to adapt to new circumstances and exhibit innovative attitudes that differ from other members of society (Yılmaz-Öztürk & Summak, 2014). This change in mindset and approach has become necessary to meet the changing conditions and challenges in the modern world. Individuals strive to live by the era's requirements, particularly the concept of innovation. Innovation, linked to knowledge, is defined as changing, taking risks, and even going beyond what is known (Demirel & Seçkin, 2008). The innovation concept has always taken its place as an auxiliary and supportive factor in achieving competitive advantage.

Individuals aware of their talents and skills can easily identify problems, produce solutions, provide the necessary opportunities, have high communication skills, and are open to innovations (Işık & Tükmendağ, 2016). Individual innovativeness refers to situations where an individual is open to new things, adaptable, positive, and open to experience (Korucu & Olpak, 2015). In addition to the situations mentioned here, there are many other areas where innovation is related and directly affects education and training processes. Recent studies have focused on how innovativeness can be used effectively in education. For example, Karahan and Gedik (2021) reported that participation in innovativeness-related training activities positively affected teachers' innovativeness levels. A significant positive correlation exists between innovativeness, self-confidence, and risk-taking (Karahan et al., 2021). The findings indicate a statistically important

positive correlation between teachers' innovativeness and their preference to utilize learner-centered instructional approaches and methods (Çetin, 2020). This suggests that more innovative teachers are more likely to adopt teaching strategies that empower and engage students in the learning process. Educators find all these concepts related to innovativeness crucial and connect them to technology.

Teachers with high levels of TPCK exhibit greater interest in educational technologies, develop behavioral intentions to use these technologies, and perceive themselves as more proficient in technology integration (Dikmen & Demirer, 2022). A moderate, positive, significant relationship exists between teachers' knowledge of technology, pedagogy, and classroom management skills (Ekici & Çoruk, 2019). A strong relationship has been identified between PE teachers' techno pedagogical competencies and instructional strategies in the educational environment (Türkeli, 2022). Sullivan et al. (2024) found that most teachers use limited digital technology in teaching Primary Physical Education, even though many examples of technology are used in the primary curriculum in all schools. The use of digital technologies in physical education can increase teachers' professional knowledge, strengthen their ability to monitor students' physical development and improve their communication skills with all actors in the educational process (Maksimović & Lazić, 2023).

Teachers must integrate their subject and pedagogical knowledge with technology, holistically approaching innovativeness and technology while practising their profession. The literature shows limited studies addressing the relationship between innovativeness and TPCK among PE teachers. Studies with the participation of primary and secondary school teachers in various branches (Çoklar & Özbek, 2017) and pre-service teachers in different fields (Çuhadar et al., 2013) reported a positive and significant relationship between innovativeness and TPCK. However, in these studies, different branches/fields were evaluated in the same group. Therefore, the fact that our sample consists of PE teachers reveals the specific contribution of our study. In the literature, studies examine the effect of gender and school level on innovativeness (Güngör, 2019) and the effect of age and professional experience on TPCK (Çar & Aydos, 2022). In our study, the variables of gender, age, professional experience, and school level were analyzed similarly; additionally, we examined the effect of educational status. The aim of our research is to examine PE teachers' innovativeness and TPCK levels and reveal the relationship between them. The importance of our research lies in determining teachers' levels of innovativeness and TPCK and providing recommendations based on these assessments.

Method

Research Model

Within the scope of quantitative research, the survey research model was preferred. Survey research is a study in which the opinions or characteristics such as interests, skills, abilities, talents, and attitudes of the participants in the research on a subject or event are determined and are conducted with more comprehensive samples compared to other research (Büyüköztürk et al., 2014).

Research Group

The research group comprised 182 (150 male, 32 female) voluntary PE teachers from Batman Provincial Directorate of National Education schools. The researchers used simple random sampling to ensure equal selection probability for each teacher. The study was conducted with permission from the Ministry of National Education in Turkey, and teachers provided informed consent. Descriptive values of PE teachers in the research group are given in Table 1.

Table 1.

Descriptive Values of PE Teachers

Descriptive Variables	Frequency(N=182)		Age(years)	
	n	N %	M	sd
Gender				
Male	150	82.4	33.43	5.87
Female	32	17.6	30.59	3.78
Age				
24-30 years	71	39.0	27.61	1.53
31-40 years	88	48.4	34.47	2.85
41-50 years	23	12.6	43.48	2.54
Professional experience				
1-10 years	131	72.0	30.26	3.77
11 years and above	51	28.0	39.78	3.50
School level				
Secondary school	106	58.2	32.68	5.57
High school	76	41.8	33.28	5.80
Educational status				
Undergraduate	164	90.1	32.85	5.71
Graduate	18	9.9	33.67	5.25

Data Collection Techniques and Tools

In this research, data were collected by the use of a questionnaire. The "General Information Form," the "Innovativeness Scale (IS)," and the "Technological Pedagogical Content Knowledge (TPCK) Scale" were used to gather the data. The researcher obtained permission to use the scale.

General Information Form

The form includes questions prepared to identify the PE teachers participating in the study variables of the gender (male and female), age (24-30 years, 31-40 years, and 41-50 years), professional experience (1-10 years and 11 years and above), the school level (secondary and high school), and educational status (undergraduate and graduate).

Innovativeness Scale

This study utilized the "Innovativeness Scale" instrument, which was originally developed by Hurt et al. (1977) and subsequently adapted for use in the Turkish context by Kılıçer and Odabaşı (2010). The scale has a total of 20 items and is a 5-point Likert type. The scale has a four-factor structure consisting of "Resistance to Change (RC)," "Opinion Leading (OL)," "Openness to Experience (OE)," and "Risk Taking (RT)." As a result of the scores, five categories are obtained: "Innovators" (above 80 points), "Early Adopters" (80-69 points), "Early Majority" (68-57 points), "Late Majority" (56-46 points), and "Laggards" (below 46 points). The internal consistency coefficient of the adapted scale was determined to be .82, and on the sample in this study, after reverse scoring, the negative items were calculated to be .77.

Technological Pedagogical Content Knowledge Scale

This study used the "Technological Pedagogical Content Knowledge Scale" developed by Horzum et al. (2014). The scale has a total of 51 items and is a 5-point Likert type. The scale has a seven-factor structure: "Technology Knowledge (TK)," "Pedagogical Knowledge (PK)," "Content Knowledge (CK)," "Technological Content Knowledge (TCK)," "Pedagogical Content Knowledge (PCK)," "Technological Pedagogical Knowledge (TPK)" and "Technological Pedagogical Content Knowledge (TPCK)" respectively. All scale items are positive, and the total score calculated from the sub-dimension shows the sub-dimension level. As the score increases, the level of the relevant sub-dimension also rises. The internal consistency coefficient of the developed scale is between 0.84-0.89 for the seven factors that make up the scale. The internal consistency coefficient was calculated as 0.94 for the sample in this study.

The ethical process in the study was as follows:

- Ethics committee approval was obtained from Sinop University Ethics Committee (Date: 27.12.2021, Number: 2021/145)
- Informed consent has been obtained from the participants.

Data Analysis

The data were analyzed by IBM SPSS 21.0., with a significance threshold of $p < .01$. Normality was assessed using the Kolmogorov-Smirnov test, which indicated that the data did not exhibit normal distribution characteristics. Mann-Whitney U, Kruskal-Wallis, and Spearman Correlation tests were used.

Results

Descriptive values of the innovativeness and TPCK levels of the teachers participating in the study are given in Table 2.

Table 2.

Descriptive Values of İnnovativeness and TPCK Levels

Scales (N=182)	Min.	Max.	M	sd
RC	9	38	19.37	5.91
OL	9	25	21.13	2.70
OE	6	25	21.26	2.85
RT	2	10	6.89	1.87
IS	37	89	71.91	8.94
TK	10	30	24.99	3.72
PK	9	35	30.37	3.10
CK	8	40	34.65	3.81
TCK	7	30	25.02	3.20
PCK	8	40	34.35	4.04
TPK	8	40	33.49	4.10
TPCK	9	40	33.34	4.36

*Abbreviations: "*Mean rank values are given, RC=Resistance to Change, OL=Opinion Leading, OE=Openness to Experience, RT=Risk Taking, IS=Innovativeness Scale, TK=Technology Knowledge, PK=Pedagogical Knowledge, CK=Content Knowledge, TCK=Technological Content Knowledge, PCK=Pedagogical Content Knowledge, TPK=Technological Pedagogical Knowledge, TPCK=Technological Pedagogical Content Knowledge"

According to the data in Table 2, teachers' mean scores of innovativeness and TPCK are above the scale average. The comparison of innovativeness and TPCK levels according to gender with the Mann-Whitney U test is given in Table 3.

Table 3.

Comparison of Innovativeness and TPCK Levels By Gender

Scales (N=182)	Male (n=150)	Female (n=32)	U	Z	*p*
RC	91.69	90.59	2371.000	-.107	.914
OL	92.00	89.16	2325.000	-.280	.780
OE	94.35	78.16	1973.000	-1.594	.111
RT	91.99	89.20	2326.500	-.276	.783
IS	91.67	90.72	2375.000	-.092	.926
TK	93.31	83.03	2129.000	-1.007	.314
PK	89.41	101.28	2087.000	-1.165	.244
CK	88.92	103.59	2013.000	-1.439	.150
TCK	92.16	88.42	2301.500	-.367	.714
PCK	92.27	87.91	2285.000	-.427	.669
TPK	91.85	89.88	2348.000	-.193	.847
TPCK	90.07	98.20	2185.500	-.796	.426

Abbreviations: "Mean rank values are given, RC=Resistance to Change, OL=Opinion Leading, OE=Openness to Experience, RT=Risk Taking, IS=Innovativeness Scale, TK=Technology Knowledge, PK=Pedagogical Knowledge, CK=Content Knowledge, TCK=Technological Content Knowledge, PCK=Pedagogical Content Knowledge, TPK=Technological Pedagogical Knowledge, TPCK=Technological Pedagogical Content Knowledge"

The data in Table 3 revealed that there was no statistically significant difference in the innovativeness and TPCK levels of PE teachers in relation to the gender variable. No significant difference was detected between the mean rank scores of male and female teachers in all sub-dimensions (p > .01). This finding shows no significant difference in PE teachers' innovativeness and TPCK levels according to gender. Therefore, it can be said that the gender variable does not significantly affect the innovativeness and TPCK levels of these teachers.

In comparing the innovativeness and TPCK levels of the teachers in the study according to their ages, the Kruskal-Wallis test was used and given, as seen in Table 4.

Table 4.

Comparison of Innovativeness and TPCK Levels According to Age

Scales (N=182)	24-30 years (n=71)	31-40 years (n=88)	41-50 years (n=23)	χ^2	p
RC	94.11	88.62	94.48	.513	.774
OL	83.46	99.90	84.15	4.410	.110
OE	83.56	97.62	92.61	2.869	.238
RT	90.09	95.47	80.67	1.565	.457
IS	83.78	98.73	87.67	3.308	.191
TK	99.54	85.26	90.54	2.925	.232
PK	91.56	93.11	85.13	.424	.809
CK	90.97	94.16	82.93	.850	.654
TCK	90.71	91.22	95.02	.123	.940
PCK	85.41	93.82	101.43	1.957	.376
TPK	97.11	86.87	91.91	1.497	.473
TPCK	93.78	90.52	88.22	.255	.880

*Abbreviations: "*Mean rank values are given, RC=Resistance to Change, OL=Opinion Leading, OE=Openness to Experience, RT=Risk Taking, IS=Innovativeness Scale, TK=Technology Knowledge, PK=Pedagogical Knowledge, CK=Content Knowledge, TCK=Technological Content Knowledge, PCK=Pedagogical Content Knowledge, TPK=Technological Pedagogical Knowledge, TPCK=Technological Pedagogical Content Knowledge"

Based on the data in Table 4, no significant difference in innovativeness and TPCK levels was observed among age groups. No significant difference was detected between the mean rank scores of teachers in the 24-30, 31-40, and 41-50 age groups in all sub-dimensions (p > .01). Therefore, the age variable does not significantly affect these teachers' innovativeness and TPCK levels.

Innovativeness and TPCK levels are compared according to professional experience with the Mann-Whitney U test and shown in Table 5.

Table 5.

Comparison of Innovativeness and TPCK Levels According to Professional Experience

Scales (N=182)	1-10 years (n=131)	11 years and above (n=51)	U	Z	p
RC	90.87	93.11	3258.500	-.258	.797
OL	91.72	90.93	3311.500	-.092	.927
OE	87.98	100.54	2879.500	-1.459	.145
RT	90.63	93.74	3226.500	-.362	.717
IS	91.20	92.26	3301.500	-.122	.903
TK	93.89	85.35	3027.000	-.987	.324
PK	92.16	89.81	3254.500	-.271	.786
CK	91.57	91.31	3331.000	-.030	.976
TCK	91.05	92.67	3281.000	-.188	.851
PCK	89.66	96.24	3099.000	-.760	.447
TPK	93.34	86.77	3099.500	-.758	.448
TPCK	92.03	90.13	3270.500	-.220	.826

Abbreviations: "Mean rank values are given, RC=Resistance to Change, OL=Opinion Leading, OE=Openness to Experience, RT=Risk Taking, IS=Innovativeness Scale, TK=Technology Knowledge, PK=Pedagogical Knowledge, CK=Content Knowledge, TCK=Technological Content Knowledge, PCK=Pedagogical Content Knowledge, TPK=Technological Pedagogical Knowledge, TPCK=Technological Pedagogical Content Knowledge"

Based on the data in Table 5, no statistically relevant difference was detected in the mean rank scores of innovativeness and TPCK levels in terms of professional experience variable. No significant difference was detected between the mean rank scores of 1-10 years and 11 years and above teachers in all sub-dimensions (p > .01). This finding shows that PE teachers' innovativeness and TPCK levels are the same according to professional experience.

The Mann-Whitney U test was used to compare the innovativeness and TPCK levels according to the level of the school they work in, as shown in Table 6.

Table 6.

Innovativeness and TPCK Levels According to School Level

Scales (N=182)	Secondary school(n=106)	High school(n=76)	U	Z	p
RC	87.33	97.31	3586.500	-1.263	.207
OL	88.66	95.46	3727.000	-.866	.387
OE	91.42	91.62	4019.000	-.026	.979
RT	92.75	89.76	3896.000	-.382	.702
IS	95.02	86.59	3655.000	-1.065	.287
TK	92.95	89.47	3874.000	-.442	.659
PK	92.77	89.72	3893.000	-.388	.698
CK	93.30	88.99	3837.500	-.547	.585
TCK	89.00	94.99	3763.000	-.762	.446
PCK	91.62	91.34	4015.500	-.036	.971
TPK	91.61	91.35	4016.500	-.033	.974
TPCK	94.20	87.74	3742.000	-.820	.412

Abbreviations: "Mean rank values are given, RC=Resistance to Change, OL=Opinion Leading, OE=Openness to Experience, RT=Risk Taking, IS=Innovativeness Scale, TK=Technology Knowledge, PK=Pedagogical Knowledge, CK=Content Knowledge, TCK=Technological Content Knowledge, PCK=Pedagogical Content Knowledge, TPK=Technological Pedagogical Knowledge, TPCK=Technological Pedagogical Content Knowledge"

Table 7.

Comparison of Innovativeness and TPCK Levels According to Educational Status

Scales (N=182)	Undergraduate (n=164)	Graduate (n=18)	U	Z	*p*
RC	92.50	82.42	1312.500	-.773	.440
OL	90.69	98.86	1343.500	-.630	.529
OE	91.30	93.36	1442.500	-.159	.873
RT	90.96	96.44	1387.000	-.426	.670
IS	90.51	100.53	1313.500	-.767	.443
TK	92.25	84.64	1352.500	-.585	.559
PK	89.95	105.61	1222.000	-1.205	.228
CK	90.49	100.72	1310.000	-.787	.431
TCK	90.54	100.28	1318.000	-.750	.453
PCK	89.89	106.17	1212.000	-1.251	.211
TPK	91.36	92.78	1453.000	-.109	.913
TPCK	92.29	84.33	1347.000	-.611	.541

Abbreviations: "Mean rank values are given, RC=Resistance to Change, OL=Opinion Leading, OE=Openness to Experience, RT=Risk Taking, IS=Innovativeness Scale, TK=Technology Knowledge, PK=Pedagogical Knowledge, CK=Content Knowledge, TCK=Technological Content Knowledge, PCK=Pedagogical Content Knowledge, TPK=Technological Pedagogical Knowledge, TPCK=Technological Pedagogical Content Knowledge"

From the data in Table 6, no significant difference in the innovativeness and TPCK levels of PE teachers according to school level. No significant difference was detected between the average scores of secondary and high school teachers in all sub-dimensions ($p > .01$). This finding shows that PE teachers' innovativeness and TPCK levels are the same depending on the school level at which they work. Therefore, the school level variable does not significantly affect these teachers' innovativeness and TPCK levels.

When comparing the innovativeness and TPCK levels according to their educational status, the Mann-Whitney U test was used, as shown in Table 7.

According to the data in Table 7, there was no significant difference in PE teachers' innovativeness and TPCK levels according to educational status. No significant difference was detected between the average scores of undergraduate and graduate teachers in all sub-dimensions ($p > .01$). This finding shows no significant difference in PE teachers' innovativeness and TPCK levels according to their educational status. Therefore, the educational status variable does not significantly affect the innovativeness and TPCK levels of these teachers.

The relationship between innovativeness and TPCK levels of the teachers in the study and sub-dimension and scale total scores was analyzed using the Spearman correlation test, as shown in Table 8.

Table 8.

The Relationship Between Innovativeness and TPCK Levels Sub-Dimension and Scale Total Scores

	1	2	3	4	5	6	7	8	9	10	11	12
1.RC	1.000	-.113	-.316**	-.034	-.818**	-.008	.048	-.069	.119	-.038	.099	.043
		.130	.000	.645	.000	.910	.517	.358	.110	.607	.184	.563
2.OL		1.000	.462**	.051	.514**	.307**	.229**	.114	.139	.165	.135	.248**
			.000	.491	.000	.000	.002	.126	.061	.026	.069	.001
3.OE			1.000	.212**	.655**	.345**	.209**	.257**	.318**	.276**	.268**	.268**
				.004	.000	.000	.005	.000	.000	.000	.000	.000
4.RT				1.000	.286**	.044	.122	.153*	.212**	.271**	.097	.017
					.000	.559	.101	.039	.004	.000	.192	.821
5.IS					1.000	.179	.120	.199**	.082	.213**	.035	.107
						.016	.108	.007	.272	.004	.640	.149
6.TK						1.000	.280**	.278**	.475**	.235**	.452**	.512**
							.000	.000	.000	.001	.000	.000
7.PK							1.000	.412**	.294**	.457**	.399**	.339**
								.000	.000	.000	.000	.000
8.CK								1.000	.360**	.405**	.356**	.377**
									.000	.000	.000	.000
9.TCK									1.000	.269**	.574**	.524**
										.000	.000	.000
10.PCK										1.000	.312**	.264**
											.000	.000
11.TPK											1.000	.583**
												.000
12.TPCK												1.000

Abbreviations: "RC=Resistance to Change, OL=Opinion Leading, OE=Openness to Experience, RT=Risk Taking, IS=Innovativeness Scale, TK=Technology Knowledge, PK=Pedagogical Knowledge, CK=Content Knowledge, TCK=Technological Content Knowledge, PCK=Pedagogical Content Knowledge, TPK=Technological Pedagogical Knowledge, TPCK=Technological Pedagogical Content Knowledge, **$p < .01$"

When Table 8 is examined, according to the correlation analysis, it is understood that the relationship between the innovativeness scale and the other sub-dimensions is statistically negative and positively significant, while the relationship between the sub-dimensions of the TPCK scale is statistically positive ($p < .01$).

Discussion

When we consider the teachers' total mean scores of the IS, we understand from the data that they fall into the Early Adopters category, which ranks second among the five innovativeness categories. Their scores are above the scale average. The innovativeness levels of coaches and PE teachers are in the categories of Early Adopters, like our study (Atılgan & Tükel, 2021). We found that the scores of the participating teachers in each sub-dimension of the TPCK scale were higher than the sub-dimension average scores; therefore, their TPCK levels were above average. Baert and Stewart (2014) states that the level of perceptions toward TPCK is high among physical education teacher candidates, which aligns with our study's results. In contrast to the results of our study, Trabelsi et al., (2022) found that Tunisian physical education teachers have little knowledge about using information and communication technologies as a teaching tool, and their TPCK is low, but they state that technological competencies are valuable in the teaching-learning process. Regarding pre-service teachers, TPCK and its components are significantly higher in Australia than in Israel (Redmond & Peled, 2018). We see that the levels of TPCK differ according to the countries, and the unique characteristics of each country may explain the reason for this situation.

"H_{01}: The gender of PE teachers has no effect on their innovativeness and TPCK levels." hypothesis is accepted.

According to the data in Table 3, we understand that there is no statistically significant difference ($p > .01$) between male and female teachers' mean innovativeness scores when we analyze the IS regarding the gender variable. We can attribute this to the fact that increasing gender equality in educational and professional settings fosters similar opportunities and attitudes toward innovativeness for both males and females. Like our study, gender did not affect the level of innovativeness in the research in which Erzurum Provincial Directorate of Youth Services and Sports personnel participated (Kulanşi, 2019). In a different study involving coaches and PE teachers (Atılgan & Tükel, 2021), it is stated that men have higher scores in the RT sub-dimension of the IS sub-dimensions according to gender and statistically differ from women, while there is no statistical difference in other sub-dimensions. Although we found no statistical difference in our study, we observed that male teachers scored higher than female teachers in the risk-taking sub-dimension. We can suggest that social life and cultural structure are among the reasons men can take more risks.

TPCK in terms of gender variable, it is understood from the data in Table 3 that there is no statistically significant difference ($p > .01$) between the scale score rank averages of males and females. We can attribute this situation to factors such as equality of educational opportunities, offering professional development programs regardless of gender, and similarities in access to technological tools. Studies involving PE teachers (Akkaya, 2021; Çar & Aydos, 2022) and teachers working in primary schools (Çam & Saltan, 2019), the statistical evaluation indicated no significant difference in TPCK according to gender.

"H_{02}: Age of PE teachers has no effect on their innovativeness and TPCK levels." hypothesis is accepted.

The data in Table 4 show no statistical difference between the mean rank scores on the IS when analyzed in terms of age variable ($p > .01$). We can attribute this situation to factors such as the prevalence of access to innovativeness and information in all age groups, continuous professional development programs for all teachers, and the promotion of innovative approaches in educational institutions. In addition, individual and professional motivation may affect the tendency to be innovative, regardless of age. In their study in which coaches and PE teachers participated, Atılgan and Tükel (2021) found a difference only in the RC sub-dimension and did not observe any differences in other sub-dimensions.

The data in Table 4 show that there is no statistically significant difference in the mean scores of TPCK when analyzed in terms of age variable ($p > .01$). The fact that teachers' age has no effect on their TPCK may be due to the fact that individuals can adapt to the use of technology at any age. Differently from our study, the age variable of PE teachers affects their TPCK (Tanucan et al., 2021). Ekici and Çoruk (2019) found a statistically meaningful difference in PK and PCK of teachers according to age, but there was no appreciable difference in the other sub-dimensions. Evaluating the studies in the literature, we see that there is a difference in a few sub-dimensions, but since the scale has seven sub-dimensions, age has no effect on the majority of sub-dimensions, which is consistent with our study.

"H_{03}: Professional experience of PE teachers has no effect on their innovativeness and TPCK levels." hypothesis was accepted.

The data in Table 5 show that there is no statistically significant difference ($p > .01$) between the mean rank scores when analyzing innovativeness in terms of the professional experience variable. We can attribute the lack

of difference in innovativeness based on the professional experience variable to the similarity in views on innovativeness, regardless of the years of professional experience. Atılgan and Tükel (2021) found no statistically significant difference in innovativeness between coaches and teachers, according to the variable of professional experience.

Table 5 shows no notable statistical difference was found in the mean rank scores when TPCK is analyzed in terms of the professional experience variable ($p > .01$). The fact that it is much easier to access technology today and the use of similar technologies in education may be the reason why professional experience does not affect TPCK. Teachers working for many years must also master the currently used instructional technologies. Çar and Aydos (2022) found that PE teachers' professional seniority did not affect their TPCK. Contrary to our study's findings, other studies indicate that professional experience affects knowledge of technology, field, and pedagogy. Tanucan et al. (2021) found that the teaching experience of physical education teachers (1-3 years, 4-9 years, 10-24 years, and 25+ years) affects their TPCK. The difference from our study's results may be due to the different year levels used to determine the teaching experience groups.

"H_{04}: The school levels where PE teachers work have no effect on their levels of innovativeness and TPCK." hypothesis was accepted.

When the innovativeness of the teachers is measured in terms of the school level variable, it is understood from the data in Table 6 that there is no statistically significant difference ($p > .01$) between the mean rank scores. Uniformity in professional development opportunities and access to technological resources across different school levels may explain the lack of a statistically significant difference in individual innovativeness based on the school level variable. Similar to our study, Güngör (2019) found that the type of school does not affect the level of innovativeness.

When the TPCK of the teachers in terms of the school level they work in is analyzed, it is understood from the data in Table 6 that there is no statistically significant difference ($p > .01$) between the mean scores. Similar instructional technologies are used at the secondary and high school levels, and the facilities of the schools do not differ. For these reasons, the fact that PE teachers work in secondary or high schools does not affect their TPCK level. Çam and Saltan (2019) stated in their study that there is no statistically significant difference in TPCK according to the primary and secondary school levels.

"H_{05}: The educational level of PE teachers has no effect on their innovativeness and TPCK levels." hypothesis was accepted.

The data in Table 7 indicate that there is no statistically significant difference ($p > .01$) between the mean rank scores when examining innovativeness in terms of the educational status variable. We can attribute the lack of effect of teachers' undergraduate or postgraduate education on their innovativeness levels to the similarity of in-service training and seminars received by teachers. Contrary to the findings in our study, there are studies in the literature in which educational status affects innovativeness. Atılgan and Tükel (2021) found that there was a statistically significant difference in RC, OL, and OE among the sub-dimensions of the IS according to the education level variable in their sample consisting of coaches and PE teachers.

Analyzing TPCK regarding educational status, it is evident from the data in Table 7 that there is no statistically significant difference between the mean scores ($p > .01$). We can attribute the lack of impact of the educational status variable on the level of TPCK to teachers receiving technology and pedagogy-based education at the undergraduate level and focusing on more academic and specialized fields of study at the graduate level. Higher education graduation (bachelor's, master's, and doctorate) of physical education teachers affects their TPCK except for the technological knowledge sub-dimension (Tanucan et al., 2021); the reason for the difference from the results in our study may be thought to be due to different education systems.

"H_{06}: There is no relationship between PE teachers innovativeness and TPCK levels." hypothesis was partially accepted.

According to the results of the correlation analysis, it is understood from the data in Table 8 that there is a statistically significant negative and positive relationship between the IS and other sub-dimensions and a statistically significant positive relationship between the sub-dimensions of the TPCK scale ($p < .01$). There is a negative relationship between RC and OE among the sub-dimensions of the IS because individuals who close themselves by showing resistance to change are not open to change and are closed to innovation. Similarly, a negative relationship exists between RC and the IS total. We found that the total scores of the IS showed a statistically significant positive relationship only with the sub-dimensions of CK and PCK. Innovative teachers are generally more competent in their content and how to teach this content. This innovative attitude does not have a direct effect on teachers' ability to use technology or their ability to integrate technology into

their teaching processes. In the levels of TPCK, we can attribute the fact that all sub-dimensions are positively correlated with each other to the increase in PK at the same time as the increase in TK and the increase in CK. Like our study, Gökbulut (2021) found a positive and statistically significant relationship between all sub-dimensions of teachers' TPCK.

Conclusion and Recommendations

In summary, the majority of participants were male, in the 31-40 age group, with 1-10 years of experience, employed at secondary schools, and having undergraduate degrees. Gender (male and female), age (24-30 years, 31-40 years, and 41-50 years), professional experience (1-10 years and 11 years and above), school level (secondary school and high school), and educational status (undergraduate and graduate) variables do not have any effect on innovativeness and TPCK levels of PE teachers. As a result of examining the relationship between PE teachers' innovativeness and TPCK levels, a negative and positive relationship was found between the IS and its sub-dimensions, a positive relationship between the IS and the CK and PCK sub-dimensions, and a positive relationship between the TPCK Scale sub-dimensions.

The study's main limitations include the sample size (number of participants) and the distribution of participants by gender. The fact that the research data (2021-2022 academic year) was collected during the pandemic (SARS-CoV-2) period has a restrictive effect. PE teachers exhibit high levels of innovativeness and TPCK, so we recommend designing educational environments open to innovation and support technology. In future studies on innovativeness and TPCK, variables such as gender, age, professional experience, school level, and educational status may not need to be prioritized. For example, the same innovativeness training can be provided to both male and female teachers without modifications. It would be helpful to create sharing environments with a high level of participation by developing online environments or different projects that allow teachers to produce innovative ideas and improve their TPK levels. The reasons for the non-correlation between teachers' innovativeness levels and their ability to use technology or integrate technology into teaching processes can be searched.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Sinop University (Date: December 27, 2021, Decision Number: 2021/145).
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