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Development of a web-based learning platform for preservice physical education teachers: effects on academic achievement, professional practice and knowledge retention

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Abstract

Background and Study Aim: Web-based learning enhances flexibility, accessibility, and digital competence in teacher education, making it a critical component of contemporary teaching practices. Technology integration presents unique challenges and opportunities in fields like physical education, where both theoretical knowledge and practical skills are crucial. This study aims to evaluate the impact of a web-based learning approach on preservice physical education teachers' academic knowledge, professional practice success, and knowledge retention.

Material and Methods: A quasi-experimental, control-group, posttest-only design was adopted. Fifty-nine preservice physical education teachers were assigned to an experimental group (n = 30; web-based learning) and a control group (n = 29; traditional). Data collection tools included an academic knowledge exam, a knowledge retention exam administered 12 months later, and a professional practice competency form. Analyses were conducted using frequentist and Bayesian repeated-measures ANOVA supported by effect size calculations.

Results: The web-based learning group achieved significantly higher academic knowledge scores than the control group ($p = 0.01$, ES = 1.08). Repeated-measures ANOVA revealed statistical significance for time ($p = 0.001$, $\eta^2p = 0.33$) and for the group × time interaction ($p = 0.04$, $\eta^2p = 0.05$). Bayesian analyses supported these findings, showing strong evidence for time effects (BFincl > 1.0×10^8) and moderate evidence for an interaction (BFincl = 6.80). No significant differences were found in professional practice ($p = 0.07$) or knowledge retention ($p = 1.00$). Knowledge scores decreased significantly in the web-based learning group on the retention test ($p = 0.01$, ES = 1.17).

Conclusions: Web-based learning significantly improves academic achievement but has limited effects on professional practice skills and long-term retention. Enhancing web-based learning platforms with interactive feedback, spaced repetition, and simulation-based practice can maximize both cognitive gains and practical skill development.

Keywords: preservice teachers, higher education innovation, digital pedagogy, teacher education, technology-enhanced learning

Introduction

The rapid digitalization of education has transformed how teachers acquire and deliver knowledge, promoting new pedagogical models that emphasize interactivity, accessibility, and technological integration. In this evolving landscape, web-based learning environments have become essential for developing the professional competence of future educators. For physical education teachers in particular, this shift presents complex challenges, as their training must balance the acquisition of theoretical understanding with the development of practical, performance-based skills that are traditionally taught through direct, hands-on experience.

In this context, the rapid digitalization of society necessitates lifelong learning to adapt to evolving technologies. Consequently, integrating technology into education enhances participation and accessibility by providing students with a more effective learning environment [1]. In higher education, technology-based approaches can support learning environments due to students' strong interest in technology. These approaches improve the quality of education, facilitate access to learning, and offer personalized educational experiences [2]. Additionally, technology-based methods simplify the monitoring of student progress and enable educators to implement a more effective feedback process [3]. One of these approaches, web-based learning, addresses the evolving educational needs of countries and prepares students for the future by providing innovative educational strategies [4]. Furthermore,

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this approach, which has gained significance in teacher education, enhances the professional development of teacher candidates and improves their pedagogical knowledge and skills [5]. It also facilitates the adaptation of teacher candidates to technology and fosters the development of their digital skills [6]. The web-based learning approach empowers teacher candidates to utilize digital tools more effectively while complementing and supporting traditional teaching methods [7].

While the web-based learning approach is favored by researchers across various disciplines [8], one notable field of application is physical education and sports teaching [9]. Physical education and sports teachers must possess specific competencies to support students' physical and social development, promote healthy lifestyle habits, and foster engagement in sports [10]. These competencies are developed through key components such as subject knowledge, pedagogical skills, and classroom management, which are cultivated in teacher training programs [11]. The integration of technology-based approaches into physical education teacher education (PETE) programs serves as an effective tool for developing the competencies required by teacher candidates and enhances their professional growth [12].

In disciplines that encompass both theoretical and practical components, such as physical education, the integration of technology-based approaches has the potential to enhance the educational process and improve the learning experience. A review of the literature shows that studies focusing on web-based learning approaches for physical education teacher candidates are limited in both scope and depth [13]. It is important to share more research-based experiences regarding the integration of technology into Physical Education Teacher Education (PETE) programs. In particular, transferring these teaching and learning experiences into the professional practices of preservice physical education teachers is of great significance [14]. In this context, the present research aims to contribute to the literature and to the educational processes of teacher candidates within technology-based learning environments.

The effective integration of technology into educational environments is directly linked to teachers' positive attitudes, professional competence, and perceptions of self-efficacy [15]. In this context, web-based learning approaches in teacher education programs offer significant opportunities to enhance the academic success of teacher candidates, foster critical thinking skills, and strengthen their pedagogical competence. Specifically, the combination of Web 2.0 tools with problem-based learning methods increases active participation and the sense of responsibility for learning among teacher candidates, thereby making teaching processes more effective [16]. However, for these technologies to be successfully adopted, faculty members must possess high levels of technological competence, and sufficient institutional support must be ensured [17].

Studies have shown that web-based learning activities enhance teacher candidates' academic success, technology use, and professional competence development. For instance, one study found that teaching programs supported by virtual reality and Google Classroom improved both academic performance and the inclination to use information technologies among teacher candidates. Over the six-week period, a significant increase in the candidates' tendency to use information technologies was observed in the post-test results ($p < 0.05$) [18]. These findings indicate that virtual reality-supported teaching effectively strengthens candidates' ability to use technology in their future professional practices. Moreover, web-based platforms contribute to the development of teacher candidates' pedagogical competence by offering context-oriented professional development [19].

Technology-based distance education courses implemented during the COVID-19 pandemic have shown that preservice teachers significantly improved their Technological Pedagogical Content Knowledge (TPACK) and highlighted the critical role of Technological Knowledge (TK) in creating effective learning environments [20]. Furthermore, a study conducted in Saudi Arabia found that web-based platforms such as Google Classroom enhanced instructional design competencies and contributed to the professional development of preservice teachers by promoting cognitive ($p < 0.05$), behavioral ($p < 0.05$), and social participation ($p < 0.05$) [21].

Studies conducted on physical education teacher candidates generally provide theoretical frameworks for the use of technology in education and yield significant findings related to PETE processes [5, 14, 22]. For instance, the Technological Pedagogical Content Knowledge framework proposes a four-stage model to assist teacher candidates in integrating technology into their professional practice [5]. Additionally, sequential behavior analyses have examined the effects of technology use in teaching environments [23]. Blended learning models have introduced compatible approaches for the integrated delivery of theoretical and practical components [14]. In response to the COVID-19 pandemic, there has been a surge in studies focusing on online teaching and learning processes, evaluating the impacts of mentoring, digital portfolios, and multi-system interactions on teaching practices [22]. However, most web-based or technology-based educational applications for teacher candidates are based on literature reviews, with a clear lack of experimental studies that could directly contribute to teacher education processes [24].

Analysis of research findings has shown that technology-based learning approaches contribute to the professional growth, academic performance, and technological competence of preservice teachers. Researchers note that the integration of digital tools into teacher education supports pedagogical effectiveness and student engagement, particularly when theoretical and practical components are combined. However, the relationship between web-based learning, professional practice, and long-term knowledge retention in physical education teacher education remains insufficiently clarified. Further examination of this relationship may help refine digital learning environments that enhance the academic and professional competencies of future teachers.

Building on these considerations, technology needs to be integrated into PETE programs, and it is essential for teacher candidates to use technology effectively in their learning processes and to transfer the knowledge and skills they acquire to their professional practice. Therefore, the present study aims to evaluate the effect of a web-based learning approach on the academic knowledge, professional practice success, and knowledge retention of physical education teacher candidates compared with traditional learning methods.

The study is based on the hypothesis that a web-based learning approach leads to higher academic knowledge and professional competence and promotes better knowledge retention among preservice physical education teachers compared with traditional learning approaches.

Materials and Methods

Participants

In this study, the purposive sampling method was used as a subset of the convenience sampling strategy to form the study group [25]. This method allows the selection of participants with specific knowledge or experience appropriate to the research objectives [26]. The research group consisted of 29 preservice teachers who took the physical education and sports teaching course during the 2021–2022 fall semester (control group) and 30 preservice teachers who took the same course during the 2022–2023 fall semester (experimental group). The inclusion criteria were being a third-year student in the PETE program and active participation in the course. The exclusion criteria included being enrolled in another department, not having taken the course, failing due to absenteeism, or being a pedagogical formation student.

The sample size was determined using the G*Power program, taking into account the results of previous studies [9, 27]. The power analysis, which assumed a moderate effect size for web-based learning (effect size = 0.80, $\alpha = 0.05$, $\beta = 0.80$), indicated that the minimum required sample size was 52. Consequently, a total of 59 teacher candidates from Burdur Mehmet Akif Ersoy University, Faculty of Sports Sciences participated in the study.

Ethical Consideration

This study was approved by the Ethics Committee of Burdur Mehmet Akif Ersoy University (Doc. Number: 2022/840). Before data collection, all participants were informed about the purpose, procedures, and voluntary nature of the research. Written informed consent was obtained from each participant in accordance with ethical guidelines. All data were collected anonymously and treated confidentially to protect the privacy and rights of the participants throughout the research process.

Research Design

The design of this study was informed by prior research utilizing a web-based learning approach. The study employed a quasi-experimental posttest-only control group design. The findings are reported in accordance with the criteria outlined in the Transparent Reporting of Evaluations with Nonrandomized Designs (TREND) checklist. Access to the study documents is available through the Open Science Framework (OSF) repository (https://osf.io/6h2rc/).

In this study, data collection was carried out within a 14-week physical education teacher education program, structured around Mosston and Ashworth's spectrum of teaching styles [28]. Both the experimental and control groups followed identical weekly content and objectives. While the control group received traditional face-to-face instruction, the experimental group was supported by a web-based learning platform (BESWEB). The education process began with six weeks of theoretical instruction, where prospective teachers were introduced to various teaching styles and pedagogical principles by an experienced academic. This phase concluded with a scholarly knowledge exam to assess their understanding of the course content.

The following eight weeks focused on practical training, where teacher candidates applied selected teaching styles in planning and delivering lessons in sports such as volleyball, basketball, and gymnastics. Teaching styles were randomly assigned, and students designed lesson plans accordingly. The experimental group used BESWEB throughout this process to access learning materials, submit assignments, and receive instructor feedback. Candidates also uploaded their lesson plans and instructional videos to the platform. The development of professional teaching competencies was evaluated using the Competency Form for Prospective Physical Education Teachers, and comprehensive feedback was provided at the end of the program. This blended approach aimed to integrate theoretical knowledge with practical experience, supported by interactive and accessible

digital tools. The overall experimental procedures and data collection process are illustrated in Figure 1.

Data Collection Tools

In this research, a web-based learning platform was developed specifically for physical education teacher candidates. The system was built using the Laravel framework with PHP for backend development and HTML, CSS, JavaScript, and Laravel Livewire for the frontend. MySQL was used for database management. The platform allows users to share educational materials, assign and collect homework, and monitor student engagement through activity reports. It was designed with a responsive layout to support mobile access and included security protocols such as HTTPS and encrypted passwords.

The development process lasted approximately three months. Version control was maintained via GitHub, and PHPStorm was used as the primary integrated development environment (IDE). After functional testing and feedback from teacher candidates, the final version of the platform was deployed. Performance optimization was achieved using Laravel's route and view caching features. The system was hosted on Turhost, and user access was managed manually by the development team through individual registration.

According to the teaching style spectrum developed by Mosston and Ashworth, the researchers prepared ten multiple-choice questions, four fill-in-the-blank questions, and four scenario-based writing questions. In developing these questions, they ensured alignment with the course learning outcomes and the distribution of teaching methods. The total score for the exam was set at 100 points, and it was administered in a classroom environment under controlled conditions, with a duration of 20 minutes. The wording of the questions in the academic knowledge exam was revised to meet the specified requirements, and a knowledge retention exam was conducted 12 months later.

The Competency Form for Prospective Physical Education Teachers was used to assess professional practice performance [29]. This form consists of four sub-dimensions designed to evaluate the teaching competencies of prospective teachers. These sub-dimensions include preparation, introduction, learning–teaching activities, and evaluation–end-of-course stages. A total of 25 items were used to measure these sub-dimensions, and the form was structured as a five-point Likert scale. The minimum possible score on the form was 25, and the maximum was 125. The reliability of the Competency Form for Prospective Physical Education Teachers was assessed using Cronbach's alpha coefficient, and the analysis indicated high internal consistency ($\alpha = 0.99$) [29].

Statistical Analysis

In this study, the data were analyzed using descriptive statistics. An intent-to-treat (ITT) approach was applied to handle missing data within the dataset. The randomness of missing data was assessed using the Missing Completely at Random (MCAR) test, and missing values were imputed with the hot deck imputation technique [30]. The normality of data distribution was evaluated through skewness and kurtosis values, with normality assumed for dependent variables exhibiting values between +2 and −2 [31].

A two-way repeated-measures ANOVA (3 time points × 2 groups) was conducted to compare the effects of web-based and traditional learning methods. The homogeneity of variances was tested using Levene's test, while Mauchly's test was employed to assess the sphericity assumption. When sphericity was violated, the Greenhouse–Geisser correction was applied. Effect sizes for the ANOVA were calculated using partial eta squared, with the following reference values [32]: 0.01 = small, 0.06 = moderate, and 0.14 = large.

Post hoc tests were conducted for pairwise comparisons if the main effect of time or the group

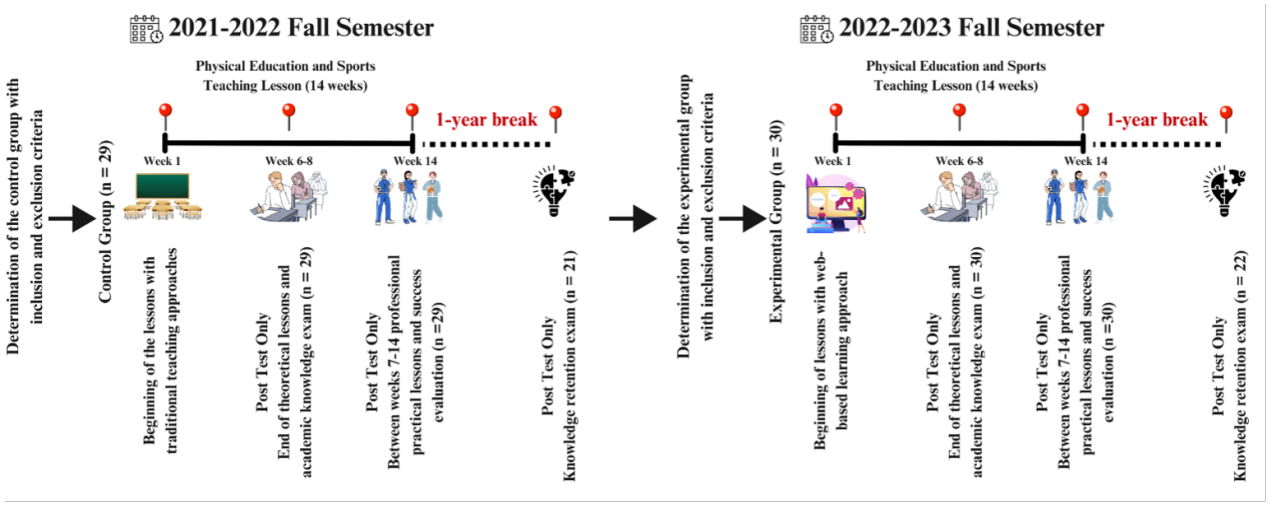

Figure 1. Experimental procedures and data collection process of the study.

× time interaction was statistically significant. Cohen's *d* was used to calculate effect sizes in the post hoc tests, interpreted as follows [32]: trivial (<0.20), small (0.20–0.59), moderate (0.60–1.19), large (1.20–1.99), and very large (⩾2.00).

In this study, in addition to frequentist statistics, a repeated-measures ANOVA was also conducted using Bayesian statistics. The Bayes factor for inclusion in the model comparison ($BF_{an}c_1$) was used to evaluate the contribution of variables to the model. A $BF_{an}c_1$ value equal to or greater than 1 was interpreted as supporting the alternative hypothesis (H_1), whereas values below 1 indicated evidence for the null hypothesis (H_0). The interpretation of $BF_{an}c_1$ followed these reference ranges: extreme evidence ($BF_{an}c_1$ > 100), very strong evidence (30–100), strong evidence (10–30), moderate evidence (3–10), anecdotal evidence (1–3), weak evidence (0.3–1), moderate evidence for H_0 (0.1–0.3), strong evidence for H_0 (0.03–0.1), very strong evidence for H_0 (0.001–0.03), and extreme evidence for H_0 (<0.001). All statistical analyses were performed using the JASP software program (version 0.19.1.1, Amsterdam, Netherlands), with the significance level for frequentist statistics set at $\alpha = 0.05$.

Results

The normality distribution analyses revealed that all three time-based dependent variables met the normality assumption. The results of the normality tests are presented in Table 1.

The results of the frequentist repeated-measures ANOVA indicated that the assumption of sphericity was violated. Based on the Greenhouse–Geisser correction, the main effect of time was statistically significant ($F = 27.50$, $df = 2$, $p = 0.001$, $\eta^2p = 0.325$). Moreover, the group × time interaction was also statistically significant ($F = 27.50$, $df = 2$, $p = 0.04$, $\eta^2p = 0.05$). These findings indicate that, in addition to the effect of time, the learning approach used influenced students' learning levels. The results of the Bayesian repeated-measures ANOVA also supported these outcomes. The $BF_{an}c_1$ for the main effect of time provided extreme evidence in favor of the alternative hypothesis ($BF_{an}c_1 = 1.339 \times 10^8$). In addition, the $BF_{an}c_1$ for the group × time interaction showed moderate evidence in favor of the alternative hypothesis ($BF_{an}c_1 = 6.799$).

Post hoc pairwise comparisons revealed that the experimental group had a statistically significantly higher academic knowledge exam score than the control group (mean difference = 18.26, $t = 4.53$, $p = 0.01$, ES = 1.08). However, there were no statistically significant differences between the experimental and control groups in application success (mean difference = 10.41, $t = 2.56$, $p = 0.07$, ES = 0.61) or in the knowledge retention exam (mean difference = 4.12, $t = 0.82$, $p = 1.00$, ES = 0.24).

In intragroup comparisons, a statistically significant difference was found between the academic knowledge exam and the knowledge retention exam in the experimental group (mean difference = 19.86, $t = 5.38$, $p = 0.01$, ES = 1.17). In contrast, there was no statistically significant difference between these exams in the control group (mean difference = 5.72, $t = 1.52$, $p = 0.53$, ES = 0.34). Details of the analysis are presented in Tables 2 and 3.

Table 1. Results of normality assumption for dependent variables.

Normality assumption	Academic knowledge exam		Knowledge retention exam		Professional practice score	
	EG	CG	EG	CG	EG	CG
Skewness	-0.456	0.184	-0.230	-0.118	-0.578	-1.472
Kurtosis	-0.162	-0.558	-0.459	-1.263	-0.145	1.987

Note. EG: Experimental group; CG: Control group; ES: Effect size of Cohen'd.

Table 2. Descriptive statistics for the dependent variables of the study.

Variables /Groups	Descriptive statistics		Frequentist RM-ANOVA		Bayesian RM-ANOVA	
	Experimental Group (n = 30)	Control Group (n= 29)	Main effect *p*-value (ES)	Group x time interaction *p*-value (ES)	Main effect (BFincl)	Group x time interaction (Bfincl)
	Mean±SD	Mean±SD				
Academic knowledge exam	75.33 ± 12.72	57.06 ± 17.88	0.001 (0.325)	0.04 (0.059)	**1.339×10^8**	6.799
Professional practice score	78.00 ± 13.03	67.58 ± 17.81				
Knowledge retention exam	55.46 ± 16.42	51.34 ± 21.77				

Note. ES: Effect size; RM: Repeated measures

Table 3. Post-hoc analysis groups based on dependent variables.

Group	Dependent variables	Group	Dependent variables	Mean Difference	t	*p*-value	ES
EG	Academic knowledge exam	CG	Academic knowledge exam	18.26	4.53	0.01	1.08
EG	Academic knowledge exam	EG	Knowledge retention exam	19.86	5.38	0.01	1.17
CG	Academic knowledge exam	CG	Knowledge retention exam	5.72	1.52	0.53	0.34
EG	Professional practice score	CG	Professional practice score	10.41	2.56	0.07	0.61
EG	Knowledge retention exam	CG	Knowledge retention exam	4.12	0.82	1.00	0.24

Note. EG: Experimental group; CG: Control group; ES: Effect size of Cohen'd.

Discussion

This study aimed to evaluate the effects of a web-based learning approach on the academic knowledge levels, professional practice success, and knowledge retention of physical education teacher candidates compared with traditional learning methods. The findings demonstrated that both time and the interaction between group and time had statistically significant effects on the dependent variables ($F = 27.50$, $df = 2$, $p = 0.001$, $\eta^2p = 0.325$; $F = 27.50$, $df = 2$, $p = 0.04$, $\eta^2p = 0.05$). These results suggest that learning outcomes varied not only over time but also according to the type of instructional approach applied. The web-based learning group showed higher academic achievement compared to the traditional group, while differences in professional practice success and knowledge retention were less pronounced. Overall, the findings indicate that integrating web-based learning into physical education teacher education can enhance academic knowledge acquisition but may have limited influence on practical skill development and long-term retention.

Post hoc analyses revealed that the academic knowledge levels of the experimental group students who received instruction through the web-based learning approach were statistically significantly higher than those of the control group. This finding can be explained by the fact that web-based learning provides a more individualized learning environment and encourages active student participation. Researchers have reported that web-based learning environments enhance academic achievement through interactive communication and access to diverse resources [33]. A qualitative study also showed that technology-based approaches in physical education teacher education promote academic learning [14].

Furthermore, web-based learning may have positively influenced preservice teachers' attitudes toward the course, thereby contributing to their academic knowledge levels. Previous studies have indicated that web-based learning environments increase student satisfaction and foster positive attitudes toward learning, which, in turn, enhance academic competence [34]. As teacher candidates' pedagogical knowledge develops, they better recognize the role of technology in learning environments and are more capable of integrating it effectively into educational processes [35]. Overall, the present results are consistent with existing research demonstrating that web-based learning improves academic knowledge levels among teacher candidates [18, 36].

Although the web-based learning approach improved students' academic knowledge levels, post hoc analyses showed no statistically significant differences between the experimental and control groups in professional practice success. While web-based learning can positively influence academic performance through instant feedback and individualized learning environments [2], it may not have the same impact on practical professional activities. This limitation can be attributed to the absence of real-time feedback, reduced motivation, and insufficient support for the development of practical skills in digital learning environments. Previous research has reported that poor system configuration and technical issues in online settings can negatively affect students' motivation [37].

Studies have shown that real-time feedback in face-to-face learning environments plays a crucial role in the learning process, and direct educator–student interaction, especially in professional practice contexts, enhances the effectiveness of skill acquisition [38]. Additionally, feedback provided in digital settings is often perceived as less accessible or more difficult to interpret by students [39]. Researchers have also emphasized that structured and immediate feedback in traditional classroom settings has a stronger influence on student engagement and the development of practical application skills [40]. Similarly, online learning

platforms have been found to limit the development of hands-on skills due to the absence of instant feedback [41]. Therefore, several studies have suggested that interactive feedback mechanisms should be further developed to enhance the effectiveness of digital learning platforms in improving professional practice success [41, 42].

The present findings are consistent with evidence from other disciplines, indicating that web-supported learning approaches may be less effective for practical skill development [43]. Overall, the literature suggests that to increase the effectiveness of web-based learning environments, they should focus not only on academic knowledge transfer but also on building systems that foster student interaction and provide timely, structured feedback.

Post hoc analyses revealed no statistically significant differences in knowledge retention levels between the experimental and control groups. This outcome may be related to the frequency with which students revisited the material. A previous study reported that repeated online training can sustain knowledge retention for up to two years [45]. The absence of follow-up or repetition of the acquired knowledge after the experimental phase may have adversely affected retention. Researchers have emphasized that reviewing information at regular and frequent intervals improves memory performance and long-term knowledge retention [45].

Taken together, the findings of this study provide valuable insight into how web-based learning contributes to teacher education by strengthening cognitive outcomes while revealing its limitations in fostering practical and long-term learning. The results highlight the multifaceted nature of teaching competencies, which depend not only on technological resources but also on interaction, feedback quality, and sustained engagement. These observations underline the need for balanced instructional models that combine digital flexibility with experiential and feedback-driven components to support the holistic professional growth of future physical education teachers.

Limitations of the Study

This study has several limitations. First, assessing the cognitive levels of teacher candidates solely through academic knowledge and knowledge retention tests restricted the scope of the evaluation. In addition, professional practice success was measured only through a structured evaluation form. Finally, the study focused exclusively on physical education and sports teacher candidates, which limits the generalizability of the findings to other disciplines.

Future research could employ a wider variety of assessment tools to examine cognitive skills in greater depth. To obtain a more comprehensive understanding, these findings should be complemented by qualitative data. Moreover, conducting similar research with teacher candidates from different academic fields would help enhance the generalizability and applicability of the results.

Conclusions

The web-supported learning approach, when integrated into traditional education and training processes, may significantly enhance students' academic knowledge levels. However, this approach appears to produce outcomes comparable to traditional teaching methods in terms of professional practice success and knowledge retention. Future research could focus on strengthening professional practice skills by incorporating interactive simulations, virtual classrooms, and augmented reality applications into web-based learning environments. The impact of web-supported learning on knowledge retention could also be examined over shorter timeframes (e.g., 1–6 months). The reliability of the current findings may be confirmed across different disciplines by replicating the study protocol, while exploring the perspectives of prospective teachers could provide valuable qualitative insights.

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Conflict of Interest

The authors declare no conflict of interest related to this study.

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