

Developing a Digital Leadership Model in the Context of Virtual Education among Physical Education Teachers

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Purpose: The purpose of this study was to develop and validate a comprehensive digital leadership model in the context of virtual education among physical education teachers and to examine the structural relationships among its underlying dimensions.

Methodology: This study employed a mixed-methods exploratory design conducted in Tehran, Iran, during 2019. In the qualitative phase, 18 experts in educational leadership, sport management, educational technology, and experienced physical education teachers were selected through purposive sampling and participated in semi-structured interviews until theoretical saturation was achieved. The qualitative data were analyzed using grounded theory procedures, including open, axial, and selective coding. Based on the extracted themes and relevant literature, a researcher-developed questionnaire was designed and administered in the quantitative phase. The statistical population consisted of physical education teachers working in public secondary schools in Tehran, from whom 384 participants were selected through stratified random sampling. The validity of the instrument was confirmed through expert review, exploratory factor analysis, and confirmatory factor analysis, while reliability was established using Cronbach's alpha and composite reliability indices. Data were analyzed using SPSS and AMOS software through descriptive statistics, exploratory factor analysis, confirmatory factor analysis, and structural equation modeling.

Findings: The results of exploratory factor analysis identified seven dimensions of digital leadership, including technological competence, digital communication skills, innovation management, organizational support, digital culture development, professional empowerment, and educational effectiveness, which collectively explained 77.07% of the total variance. Confirmatory factor analysis supported the validity and reliability of the measurement model, with all factor loadings exceeding acceptable thresholds. Structural equation modeling revealed that all proposed dimensions significantly contributed to digital leadership. Professional empowerment demonstrated the strongest effect on digital leadership ($\beta = 0.87, p < 0.001$), followed by technological competence ($\beta = 0.84, p < 0.001$), digital culture development ($\beta = 0.81, p < 0.001$), digital communication skills ($\beta = 0.79, p < 0.001$), innovation management ($\beta = 0.75, p < 0.001$), and organizational support ($\beta = 0.69, p < 0.001$). Furthermore, digital leadership exhibited a strong positive effect on educational effectiveness ($\beta = 0.91, p < 0.001$). The final structural model demonstrated excellent fit indices ($\chi^2/df = 2.14, CFI = 0.958, TLI = 0.952, GFI = 0.931, AGFI = 0.918, RMSEA = 0.054$).

Conclusion: The findings indicate that digital leadership is a multidimensional construct that integrates technological, organizational, communication, cultural, and professional dimensions to enhance educational effectiveness in virtual learning environments. Professional empowerment and technological competence emerged as the most influential determinants of digital leadership.

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1. Introduction

The rapid advancement of digital technologies has fundamentally transformed educational systems worldwide, creating new opportunities and challenges for educational leadership. The emergence of virtual learning environments, online instructional platforms, digital communication tools, and technology-enhanced pedagogical practices has altered traditional conceptions of teaching, learning, and school administration. As educational institutions increasingly integrate digital technologies into their operational and instructional frameworks, leadership approaches must evolve to effectively manage technological change and foster innovation in educational settings. Within this context, the concept of digital leadership has gained significant attention as a critical factor influencing the success of virtual education initiatives and the effectiveness of educational organizations in the digital era (Narbona, 2016; Ribble & Miller, 2013).

Digital leadership refers to the ability of educational leaders to strategically utilize technology to improve organizational performance, enhance communication, facilitate collaboration, support professional development, and promote innovative teaching and learning practices. Unlike traditional leadership models, digital leadership emphasizes the integration of technological competencies with visionary leadership behaviors, enabling educational professionals to navigate rapidly changing digital environments. Educational leaders are increasingly expected not only to possess technological knowledge but also to inspire and empower teachers to effectively adopt and utilize digital tools in their instructional practices (Alward & Phelps, 2019; Marshall et al., 2020). The effectiveness of digital leadership has therefore become a central concern for educational researchers and practitioners seeking to maximize the benefits of technology-enhanced education.

The growing prevalence of virtual education has further intensified the need for effective digital leadership. Virtual learning environments require new forms of communication, supervision, collaboration, and instructional support that differ substantially from those employed in traditional face-to-face educational contexts. Educational leaders operating in virtual environments must develop strategies that promote engagement, accountability, and professional growth while overcoming challenges related to physical distance, technological barriers, and changing organizational dynamics. Research has shown that successful leadership in virtual educational settings requires a combination of technological expertise, communication skills, adaptability, and strategic vision (Marshall et al., 2020; Varela & Fedynich, 2020). Consequently, understanding the dimensions and determinants of digital leadership has become increasingly important for improving educational quality and organizational effectiveness.

Leadership has long been recognized as a fundamental determinant of educational success. Effective leaders influence teacher performance, organizational culture, professional development, and student outcomes through their ability to establish clear goals, facilitate collaboration, and create supportive learning environments. Traditional leadership theories have emphasized transformational, participative, instructional, and distributed leadership approaches as mechanisms for improving educational effectiveness. However, the digital transformation of education necessitates the adaptation and extension of these leadership paradigms to address emerging technological realities and virtual learning contexts (Koen & Bitzer, 2010; Köse & Güçlü, 2017). The increasing reliance on digital technologies requires leaders to develop competencies that extend beyond conventional administrative and instructional functions.

The concept of leadership in virtual educational environments has received considerable scholarly attention in recent years. Virtual education programs require educational leaders to coordinate geographically dispersed participants, facilitate technology-mediated communication, and support instructional innovation through digital platforms. According to LaFrance and Beck, leadership practices in virtual schools differ substantially from those observed in traditional educational institutions, requiring greater emphasis on technological integration, digital communication, and virtual supervision mechanisms (LaFrance & Beck, 2014). Similarly, Varela and Fedynich argued that effective leadership in virtual classrooms depends upon the ability to manage technological infrastructures while simultaneously addressing pedagogical and organizational challenges associated with online learning environments (Varela & Fedynich, 2020).

Digital leadership is particularly important because technological innovation alone does not guarantee educational improvement. Successful implementation of digital technologies depends largely upon leadership practices that encourage technology adoption, professional learning, collaboration, and organizational adaptation. Educational leaders play a crucial role in establishing a culture that supports innovation and continuous improvement while reducing resistance to change. Research indicates that leadership behaviors significantly influence teachers' willingness to engage in professional development activities and adopt new instructional approaches (Cockpim & Somprach, 2019; Kelkay, 2020). Therefore, digital leadership can be viewed as a strategic mechanism for facilitating educational transformation in technology-rich environments.

Teacher professional development constitutes another important dimension of digital leadership. As educational technologies evolve rapidly, teachers must continuously update their knowledge and skills to meet emerging instructional demands. Educational leaders are responsible for creating opportunities that support ongoing professional growth and technological competence among teachers. Studies have demonstrated that leadership practices significantly affect the effectiveness of professional development initiatives and contribute to improvements in instructional quality and organizational learning (Cockpim & Somprach, 2019; Kelkay, 2020). Consequently, digital leadership may serve as a catalyst for enhancing teachers' professional capacities within virtual educational environments.

The relationship between leadership and organizational learning has also been emphasized in educational research. Effective leaders create conditions that facilitate knowledge sharing, innovation, collaboration, and continuous improvement. Organizational learning becomes particularly important in digital environments where technological advancements require constant adaptation and skill development. Research examining the relationship between leadership styles and organizational learning has revealed that supportive and transformational leadership behaviors contribute positively to organizational effectiveness and innovation capacity (Köse & Güçlü, 2017). These findings suggest that digital leadership may foster a culture of learning and innovation that enhances educational outcomes in virtual settings.

Digital communication represents another essential component of effective leadership in online educational contexts. Virtual environments rely heavily on technology-mediated interactions among teachers, students, administrators, and other stakeholders. Educational leaders must therefore possess strong digital communication competencies to ensure effective collaboration, information sharing, and relationship building. Hartman and Morris emphasized the importance of interactive communication strategies in online educational leadership programs, highlighting their role in promoting engagement and instructional effectiveness (Hartman & Morris, 2019). Similarly, Hamedinasab and colleagues found that virtual social networks influence teacher-student relationships and contribute to the development of educational interactions within digital environments (Hamedinasab et al., 2020). These findings underscore the significance of communication skills within digital leadership frameworks.

The importance of ethical and responsible technology use has also emerged as a critical aspect of educational leadership in digital environments. Educational leaders are expected to promote digital citizenship, ensure responsible technology utilization, and address issues related to privacy, security, and ethical conduct in virtual learning settings. Ribble and Miller argued that educational leadership in online environments must prioritize responsible and ethical technology practices to create safe and effective learning experiences for students and educators (Ribble & Miller, 2013). Digital leadership therefore encompasses not only technological competence but also the capacity to guide ethical decision-making in increasingly complex digital ecosystems.

Within the field of physical education, the emergence of virtual education has introduced unique challenges and opportunities. Traditionally, physical education has relied heavily on direct interaction, demonstration, physical activity, and face-to-face instruction. However, technological advancements and the expansion of online learning have encouraged educators to develop innovative approaches for delivering physical education content through virtual platforms. These developments have created a need for leadership models

that specifically address the distinctive characteristics of virtual physical education environments. Trent highlighted the importance of aligning virtual physical education programs with established educational standards while maintaining instructional quality and learner engagement (Trent, 2016). Such alignment requires effective leadership capable of integrating technological innovation with pedagogical best practices. Research has also demonstrated the potential benefits of virtual professional development programs for physical education teachers. Mastahfazian and colleagues reported that virtual in-service training programs can positively influence teachers' professional performance and instructional effectiveness (Mastahfazian et al., 2018). These findings suggest that digital leadership may play a critical role in supporting professional learning and technological adaptation among physical education teachers. Nevertheless, the successful implementation of virtual education within physical education contexts depends upon leadership approaches that recognize the specific needs, challenges, and opportunities associated with this discipline.

The development of digital leadership capabilities may also contribute to broader organizational outcomes. Studies examining leadership in higher education and online learning environments have found positive associations between leadership effectiveness, job satisfaction, employee engagement, and organizational performance (Barnett, 2019; Coleman, 2016). Effective digital leaders are capable of creating supportive organizational cultures that encourage innovation, collaboration, and continuous improvement. These outcomes are particularly important in virtual educational settings where technological change requires sustained organizational adaptation and resilience.

Furthermore, contemporary leadership literature emphasizes the importance of positive psychological resources, empowerment, and human capital development in achieving organizational success. Leadership practices that promote self-efficacy, motivation, resilience, and professional growth can enhance employee performance and organizational effectiveness. McElravy and colleagues highlighted the role of leadership-related experiences in developing psychological capital and workforce readiness, suggesting that leadership processes contribute significantly to professional development outcomes (McElravy et al., 2018). Such insights are highly relevant to digital leadership frameworks that seek to empower educators within technology-mediated environments.

Despite the growing importance of digital leadership, existing research remains fragmented and lacks comprehensive models specifically designed for virtual education among physical education teachers. Much of the available literature focuses on general educational leadership, online learning administration, or technology integration without adequately addressing the unique characteristics of physical education and the complex interactions among technological, organizational, professional, and communication-related factors. Moreover, empirical studies examining digital leadership in the context of virtual physical education remain limited, particularly in developing educational systems undergoing rapid digital transformation. This gap highlights the need for a contextually grounded and empirically validated model that can guide leadership practices in virtual physical education environments.

Given the increasing importance of virtual education, the growing integration of digital technologies into educational practice, and the unique challenges faced by physical education teachers in online learning environments, developing a comprehensive digital leadership model has become both theoretically and practically necessary.

The aim of the present study was to develop and validate a digital leadership model in the context of virtual education among physical education teachers.

2. Methodology

This study was conducted using a mixed-methods exploratory design with the aim of developing a digital leadership model in the context of virtual education among physical education teachers. The research was carried out during 2019 in Tehran, Iran. The study population in the qualitative phase consisted of university faculty members specializing in sport management, educational management, educational technology, and experienced physical education teachers who had substantial experience in virtual teaching

environments. Participants in the qualitative phase were selected through purposive sampling based on their expertise and familiarity with digital education and leadership concepts. Data collection continued until theoretical saturation was achieved, which occurred after conducting in-depth semi-structured interviews with 18 experts. In the quantitative phase, the statistical population consisted of all physical education teachers working in public secondary schools in Tehran during the 2019 academic year. Based on Cochran's sample size formula and considering the size of the target population, 384 teachers were selected through stratified random sampling from different educational districts of Tehran. Inclusion criteria included having at least three years of teaching experience, active involvement in virtual or technology-assisted educational activities, and willingness to participate in the study. Ethical considerations were observed throughout the research process, and informed consent was obtained from all participants before data collection.

Data collection in the qualitative phase was conducted through semi-structured interviews designed to explore the dimensions, antecedents, and consequences of digital leadership in virtual education settings. The interview protocol was developed based on an extensive review of the literature related to educational leadership, digital transformation, virtual learning environments, and technology integration in education. Open-ended questions were used to encourage participants to express their experiences, perceptions, and viewpoints regarding effective digital leadership practices among physical education teachers. Each interview lasted between 45 and 75 minutes and was audio-recorded with participants' permission. The interviews were subsequently transcribed verbatim and prepared for qualitative analysis.

Following the qualitative phase, a researcher-developed questionnaire was designed based on the themes and categories extracted from the interviews and supported by relevant theoretical frameworks identified in the literature. The questionnaire consisted of several dimensions related to digital leadership competencies, technological capabilities, organizational support, virtual communication skills, digital culture development, innovation management, professional empowerment, and educational effectiveness. Responses were measured using a five-point Likert scale ranging from strongly disagree to strongly agree. The content validity of the questionnaire was evaluated by a panel of experts in sport management, educational leadership, and educational technology. Their feedback was incorporated into the final version of the instrument. Construct validity was examined through exploratory and confirmatory factor analyses. Reliability was assessed using Cronbach's alpha coefficient and composite reliability indices, both of which indicated satisfactory internal consistency for all dimensions of the instrument.

Data analysis was conducted in two consecutive stages corresponding to the mixed-methods design of the study. In the qualitative phase, interview transcripts were analyzed using grounded theory procedures involving open coding, axial coding, and selective coding. During open coding, meaningful statements and concepts were identified and categorized. In the axial coding stage, relationships among categories were explored and integrated into broader themes. Finally, selective coding was used to develop a comprehensive conceptual model of digital leadership in virtual education among physical education teachers. To enhance the trustworthiness of the qualitative findings, member checking, peer review, and prolonged engagement with the data were employed.

In the quantitative phase, descriptive statistics including means, standard deviations, frequencies, and percentages were calculated to describe the characteristics of the participants and study variables. Inferential statistical analyses were performed using SPSS and AMOS software. Exploratory factor analysis was conducted to identify the underlying factor structure of the proposed model, while confirmatory factor analysis was used to evaluate the measurement model and assess construct validity. Structural equation modeling was subsequently employed to examine the relationships among the identified dimensions and to evaluate the overall fit of the proposed digital leadership model. Model fit was assessed using multiple goodness-of-fit indices, including the Chi-square to degrees of freedom ratio, Comparative Fit Index, Tucker-Lewis Index, Goodness-of-Fit Index, Adjusted Goodness-of-Fit Index, and Root Mean Square Error of Approximation. Statistical significance was determined at the 0.05 level, and the final model was

accepted based on both theoretical coherence and empirical evidence obtained from the quantitative analyses.

3. Findings

A total of 384 physical education teachers from public secondary schools in Tehran participated in the quantitative phase of the study. Of the participants, 226 teachers (58.9%) were male and 158 teachers (41.1%) were female. Regarding age distribution, 72 participants (18.8%) were younger than 30 years, 131 participants (34.1%) were between 31 and 40 years old, 118 participants (30.7%) were between 41 and 50 years old, and 63 participants (16.4%) were older than 50 years. In terms of educational attainment, 248 participants (64.6%) held a bachelor's degree, 122 participants (31.8%) held a master's degree, and 14 participants (3.6%) possessed doctoral qualifications. Furthermore, 96 participants (25.0%) reported less than 10 years of teaching experience, 173 participants (45.1%) reported between 10 and 20 years of experience, and 115 participants (29.9%) reported more than 20 years of professional experience. The demographic profile of the respondents demonstrated an adequate distribution across age, educational level, and professional experience, thereby providing a representative basis for examining digital leadership in virtual educational settings among physical education teachers.

Table 1. Descriptive Statistics of the Main Constructs of the Digital Leadership Model

Variable	Mean	Standard Deviation	Skewness	Kurtosis
Technological Competence	4.18	0.63	-0.54	0.48
Digital Communication Skills	4.11	0.67	-0.49	0.36
Innovation Management	4.05	0.71	-0.43	0.29
Organizational Support	3.89	0.76	-0.32	0.11
Digital Culture Development	4.08	0.69	-0.47	0.34
Professional Empowerment	4.21	0.61	-0.61	0.52
Educational Effectiveness	4.16	0.65	-0.58	0.44
Overall Digital Leadership	4.12	0.58	-0.53	0.41

The descriptive findings presented in Table 1 indicate that all dimensions of digital leadership were evaluated above the midpoint of the measurement scale, reflecting generally favorable perceptions among physical education teachers regarding digital leadership practices in virtual education environments. Professional empowerment obtained the highest mean score ($M = 4.21$, $SD = 0.61$), suggesting that digital leadership substantially contributes to enhancing teachers' professional capacities and competencies. Technological competence also demonstrated a high mean value ($M = 4.18$, $SD = 0.63$), emphasizing the critical role of technology-related skills in facilitating effective virtual instruction. Organizational support received the lowest mean score among the identified dimensions ($M = 3.89$, $SD = 0.76$), indicating that institutional structures and administrative support mechanisms may require further strengthening to facilitate successful implementation of digital leadership practices. The skewness and kurtosis values for all variables remained within acceptable ranges, confirming the normality assumption and supporting the use of parametric statistical analyses.

Table 2. Results of Exploratory Factor Analysis for the Digital Leadership Model

Factor	Number of Items	Factor Loading Range	Eigenvalue	Variance Explained (%)
Technological Competence	7	0.69–0.87	8.43	18.27
Digital Communication Skills	6	0.65–0.84	6.91	14.62
Innovation Management	5	0.67–0.86	5.38	11.84
Organizational Support	6	0.63–0.82	4.72	9.93
Digital Culture Development	5	0.68–0.85	4.16	8.47
Professional Empowerment	6	0.71–0.89	3.88	7.66
Educational Effectiveness	5	0.69–0.87	3.14	6.28

Total Variance Explained = 77.07

The exploratory factor analysis revealed a seven-factor structure for the proposed digital leadership model. All extracted factors demonstrated substantial factor loadings exceeding the recommended threshold of 0.60, confirming strong relationships between observed indicators and their underlying constructs. The first factor, technological competence, accounted for 18.27% of the total variance and emerged as the most influential dimension. Digital communication skills explained 14.62% of the variance, while innovation management accounted for 11.84%. Collectively, the seven factors explained 77.07% of the total variance, indicating that the extracted dimensions adequately represented the conceptual domain of digital leadership in virtual education. The high percentage of explained variance provides strong empirical support for the multidimensional nature of digital leadership among physical education teachers.

Table 3. Confirmatory Factor Analysis Results for the Measurement Model

Construct	Standardized Loading	Composite Reliability (CR)	Average Variance Extracted (AVE)
Technological Competence	0.84	0.91	0.64
Digital Communication Skills	0.82	0.89	0.61
Innovation Management	0.81	0.88	0.59
Organizational Support	0.79	0.87	0.57
Digital Culture Development	0.83	0.90	0.63
Professional Empowerment	0.86	0.92	0.66
Educational Effectiveness	0.85	0.91	0.65

The confirmatory factor analysis demonstrated satisfactory psychometric properties for all dimensions of the digital leadership model. Standardized factor loadings ranged from 0.79 to 0.86, exceeding the minimum acceptable threshold and indicating strong convergent validity. Composite reliability values varied between 0.87 and 0.92, confirming high internal consistency among the indicators measuring each construct. Similarly, average variance extracted values ranged from 0.57 to 0.66, surpassing the recommended value of 0.50 and providing additional evidence for convergent validity. These findings confirm that the measurement model possesses acceptable reliability and validity and can therefore be used confidently for structural model evaluation.

Table 4. Structural Equation Modeling Results for the Proposed Digital Leadership Model

Path	Standardized Coefficient (β)	t-value	p-value
Technological Competence → Digital Leadership	0.84	13.71	<0.001
Digital Communication Skills → Digital Leadership	0.79	12.54	<0.001
Innovation Management → Digital Leadership	0.75	11.68	<0.001
Organizational Support → Digital Leadership	0.69	10.24	<0.001
Digital Culture Development → Digital Leadership	0.81	12.89	<0.001
Professional Empowerment → Digital Leadership	0.87	14.92	<0.001
Digital Leadership → Educational Effectiveness	0.91	16.33	<0.001

The structural model results revealed statistically significant relationships among all proposed dimensions. Professional empowerment exhibited the strongest effect on digital leadership ($\beta = 0.87$, $p < 0.001$), followed by technological competence ($\beta = 0.84$, $p < 0.001$) and digital culture development ($\beta = 0.81$, $p < 0.001$). Organizational support demonstrated the lowest, yet still significant, effect on digital leadership ($\beta = 0.69$, $p < 0.001$). Most importantly, digital leadership showed a very strong positive influence on educational effectiveness ($\beta = 0.91$, $p < 0.001$), indicating that improvements in digital leadership capabilities are directly associated with enhanced quality and effectiveness of virtual physical education instruction. These findings provide substantial support for the proposed theoretical model and highlight the strategic importance of digital leadership competencies within contemporary virtual learning environments.

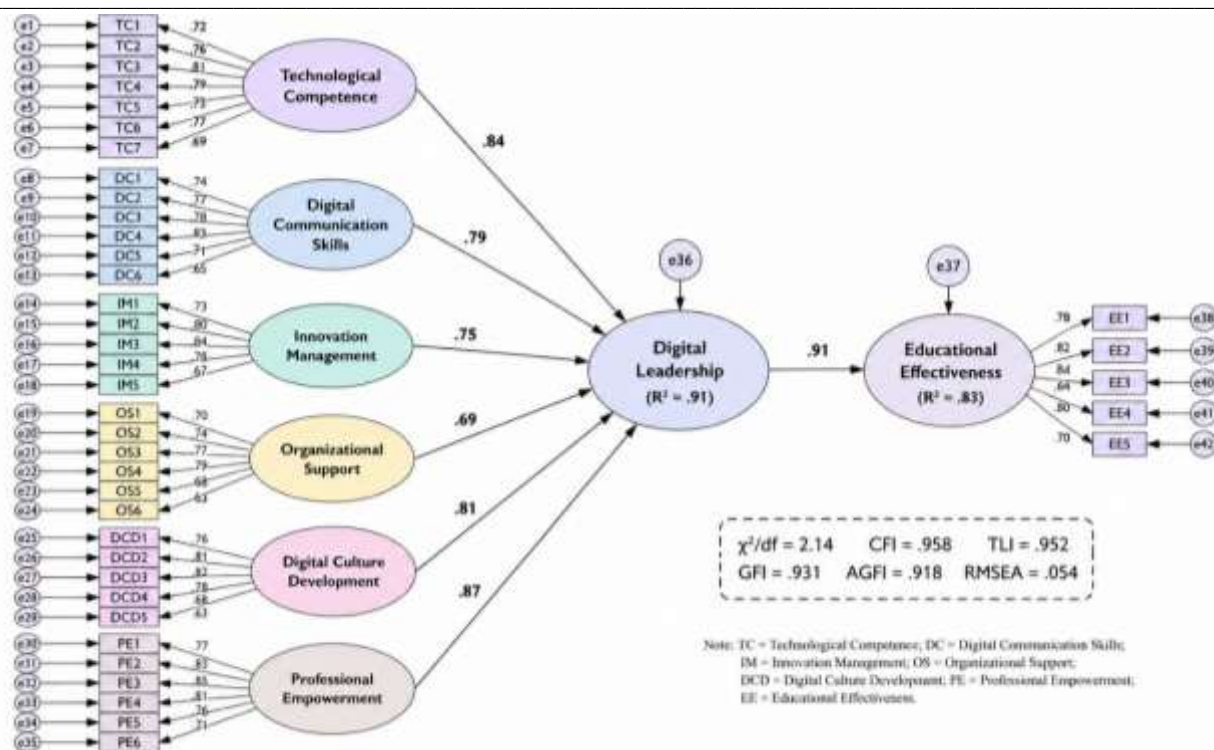


Figure 1. Final Structural Model of Digital Leadership in Virtual Education among Physical Education Teachers

The final structural model demonstrated an excellent level of fit to the observed data. The model fit indices were highly satisfactory, with $\chi^2/df = 2.14$, $CFI = 0.958$, $TLI = 0.952$, $GFI = 0.931$, $AGFI = 0.918$, and $RMSEA = 0.054$. All fit indices exceeded the recommended thresholds reported in the literature, indicating that the proposed model adequately represented the empirical relationships among the study variables. The figure illustrates the interconnections among technological competence, digital communication skills, innovation management, organizational support, digital culture development, professional empowerment, and educational effectiveness within the broader framework of digital leadership. The model confirms that digital leadership is a multidimensional construct that emerges through the interaction of individual, technological, organizational, and cultural factors and ultimately contributes to improving the effectiveness of virtual education among physical education teachers.

4. Discussion

The purpose of the present study was to develop and validate a digital leadership model in the context of virtual education among physical education teachers. The findings revealed that digital leadership is a multidimensional construct composed of technological competence, digital communication skills, innovation management, organizational support, digital culture development, professional empowerment, and educational effectiveness. The results further demonstrated that all identified dimensions significantly contributed to the formation of digital leadership and that digital leadership itself exerted a strong positive influence on educational effectiveness within virtual learning environments. The final structural model exhibited excellent goodness-of-fit indices, indicating that the proposed conceptual framework adequately explained the relationships among the study variables and provided a comprehensive representation of digital leadership in virtual education.

One of the most important findings of the study was the identification of technological competence as a fundamental component of digital leadership. The results indicated that technological competence had a strong and significant effect on the development of digital leadership among physical education teachers.

This finding is consistent with the growing body of literature emphasizing that educational leaders must possess advanced technological knowledge and digital skills to effectively guide educational institutions through periods of technological transformation. Digital leadership requires not only familiarity with technological tools but also the ability to strategically integrate technology into instructional and organizational processes. This finding aligns with the work of Narbona (Narbona, 2016), who emphasized that digital leadership emerges from the effective combination of leadership capabilities and technological expertise. Similarly, Ribble and Miller (Ribble & Miller, 2013) argued that educational leaders in online environments must develop strong technological competencies to ensure responsible, effective, and ethical use of digital technologies. The significant role of technological competence observed in the present study may be explained by the increasing dependence of virtual education on digital platforms, learning management systems, communication technologies, and online instructional resources.

The findings also demonstrated that digital communication skills significantly contributed to digital leadership development. Effective communication represents a cornerstone of successful leadership in any educational setting; however, its importance becomes even more pronounced in virtual environments where face-to-face interactions are limited. The results suggest that physical education teachers who possess stronger digital communication abilities are better positioned to establish meaningful interactions, coordinate educational activities, and facilitate collaboration among stakeholders. This finding supports previous research conducted by Hartman and Morris (Hartman & Morris, 2019), who emphasized the importance of interactive communication in online educational leadership programs. Likewise, Varela and Fedynich (Varela & Fedynich, 2020) highlighted that effective virtual leadership depends largely upon the leader's capacity to communicate clearly and efficiently through technology-mediated channels. Furthermore, Hamedinasab and colleagues (Hamedinasab et al., 2020) demonstrated that virtual social networks significantly influence educational relationships and interactions, reinforcing the centrality of communication skills in digital educational contexts. The strong contribution of digital communication skills observed in the present model suggests that successful digital leaders must be capable of maintaining engagement, trust, collaboration, and organizational cohesion despite geographical and physical separation. Another notable finding concerned the role of innovation management in fostering digital leadership. The results revealed that innovation management significantly influenced the development of digital leadership among physical education teachers. This finding suggests that digital leaders are characterized not only by technological expertise but also by their ability to encourage creativity, experimentation, and adaptation to emerging educational challenges. Virtual educational environments are continuously evolving due to rapid technological advancements, requiring leaders to proactively identify opportunities for innovation and support the implementation of new instructional practices. These findings are consistent with the work of Coleman (Coleman, 2016), who emphasized that effective leadership in online learning environments requires organizational ambidexterity, innovation, and adaptability. Likewise, Marshall and colleagues (Marshall et al., 2020) reported that successful virtual education programs are typically led by individuals who foster innovation while simultaneously managing technological and organizational complexities. Therefore, the present findings suggest that innovation management serves as a critical mechanism through which educational leaders can promote sustainable development and continuous improvement in virtual learning environments.

The present study also identified organizational support as a significant determinant of digital leadership. Although organizational support demonstrated the lowest path coefficient among the identified dimensions, its influence remained statistically significant and practically meaningful. This finding indicates that institutional structures, policies, resources, and administrative support systems play an important role in facilitating digital leadership practices. Leaders may possess strong technological competencies and communication skills; however, their effectiveness can be constrained if organizational conditions do not support digital transformation initiatives. This result is consistent with the findings of Koen and Bitzer (Koen & Bitzer, 2010), who emphasized the importance of participative leadership and institutional support

in promoting organizational effectiveness. Similarly, Alward and Phelps (Alward & Phelps, 2019) found that successful virtual leaders in higher education rely heavily on supportive organizational environments that facilitate communication, collaboration, and technological integration. The findings therefore highlight the necessity of creating organizational infrastructures that enable educational leaders to effectively implement digital initiatives and sustain virtual education programs.

An additional finding of considerable importance was the significant contribution of digital culture development to digital leadership. The results suggest that digital leadership extends beyond individual competencies and encompasses broader cultural dimensions that shape attitudes, behaviors, and organizational norms regarding technology use. Educational institutions characterized by positive digital cultures are more likely to encourage innovation, knowledge sharing, collaboration, and technology adoption. This finding aligns with the perspective of Ribble and Miller (Ribble & Miller, 2013), who argued that responsible technology use and digital citizenship should be embedded within educational culture. Furthermore, Marshall and colleagues (Marshall et al., 2020) emphasized that successful virtual education initiatives require organizational cultures that support flexibility, technological engagement, and continuous learning. The importance of digital culture identified in the present study suggests that educational leaders must actively cultivate environments in which technology is viewed not merely as a tool but as an integral component of organizational identity and educational practice.

Among all identified dimensions, professional empowerment emerged as the strongest predictor of digital leadership. This finding indicates that empowering teachers through professional development, capacity building, autonomy, and skill enhancement constitutes a central element of effective digital leadership. The result is highly consistent with previous studies demonstrating that leadership practices significantly influence professional growth and instructional effectiveness. Cockpim and Somprach (Cockpim & Somprach, 2019) reported that leadership behaviors play a critical role in determining the effectiveness of teacher professional development initiatives. Similarly, Kelkay (Kelkay, 2020) found that leadership practices substantially affect teachers' continuous professional development. The findings also correspond with the work of McElravy and colleagues (McElravy et al., 2018), who emphasized the importance of leadership experiences in fostering positive psychological capital and workforce readiness. Within the context of physical education, professional empowerment becomes particularly important because teachers must continuously adapt to evolving technologies, instructional methods, and learner expectations. Consequently, digital leaders who prioritize teacher empowerment may create conditions that facilitate sustained professional growth and improved educational outcomes.

The final and perhaps most significant finding of the study was the strong positive relationship between digital leadership and educational effectiveness. The structural model demonstrated that digital leadership substantially contributes to improving educational outcomes within virtual learning environments. This finding provides empirical support for the central proposition underlying the study: that effective leadership serves as a critical determinant of successful virtual education. The result aligns closely with previous research emphasizing the relationship between leadership effectiveness and educational performance. Barnett (Barnett, 2019) reported that leadership behaviors positively influence employee satisfaction and organizational outcomes within online educational contexts. Likewise, LaFrance and Beck (LaFrance & Beck, 2014) emphasized the importance of leadership in promoting effective educational practices within virtual schools. The findings also support the conclusions of Marshall and colleagues (Marshall et al., 2020), who identified leadership as one of the primary determinants of virtual program success. In the specific context of physical education, this relationship may be particularly important because virtual instruction requires innovative pedagogical approaches, effective technological integration, and sustained learner engagement. Consequently, digital leadership appears to function as a strategic mechanism for enhancing educational quality, improving teacher performance, and facilitating successful implementation of virtual education programs.

The findings of the present study are also consistent with evidence regarding virtual education within physical education settings. Mastahfazian and colleagues (Mastahfazian et al., 2018) demonstrated that virtual professional development programs can improve the professional performance of physical education teachers. Similarly, Trent (Trent, 2016) emphasized the necessity of maintaining educational quality and instructional alignment within virtual physical education programs. The digital leadership model developed in the present study contributes to this literature by identifying the specific leadership dimensions that facilitate successful virtual education within physical education contexts. The integration of technological competence, communication skills, innovation management, organizational support, digital culture development, and professional empowerment provides a comprehensive framework for understanding how educational leaders can effectively respond to the demands of contemporary virtual learning environments. Overall, the findings indicate that digital leadership is a multifaceted phenomenon requiring the integration of technological, organizational, interpersonal, and professional competencies. The model developed in this study offers a theoretically grounded and empirically validated framework capable of guiding leadership practices within virtual educational settings. By fostering technological competence, encouraging innovation, supporting professional development, strengthening organizational structures, and cultivating positive digital cultures, educational leaders can substantially improve the effectiveness of virtual education among physical education teachers.

The present study was subject to several limitations. First, the study was conducted exclusively among physical education teachers in Tehran, which may limit the generalizability of the findings to other geographical regions and educational contexts. Second, data were collected using self-report questionnaires, creating the possibility of social desirability bias and subjective interpretation. Third, the cross-sectional nature of the quantitative phase prevented the examination of causal relationships over time. Fourth, the study focused primarily on teachers' perceptions and did not incorporate perspectives from students, school administrators, or policymakers. Finally, the rapidly evolving nature of digital technologies may require periodic revision and updating of the proposed model to maintain its relevance in changing educational environments.

Future research should examine the applicability of the proposed digital leadership model across different educational levels, disciplines, and cultural contexts. Comparative studies involving teachers from various subject areas could provide valuable insights into discipline-specific leadership requirements. Longitudinal investigations are recommended to explore how digital leadership competencies evolve over time and influence educational outcomes. Researchers may also examine potential mediating and moderating variables such as organizational climate, technological readiness, digital literacy, and teacher motivation. Additionally, future studies could employ mixed-methods or experimental designs to further validate and refine the proposed model and investigate its practical implementation within diverse educational settings.

From a practical perspective, educational authorities should develop comprehensive leadership development programs focused on enhancing digital leadership competencies among teachers and school administrators. Professional training initiatives should emphasize technological competence, digital communication, innovation management, and leadership skills required for virtual education. Educational organizations should invest in technological infrastructure and establish supportive policies that facilitate digital transformation. School leaders should actively promote collaborative digital cultures and create opportunities for continuous professional learning. Furthermore, physical education departments should integrate digital leadership principles into teacher training and professional development programs to ensure that educators are adequately prepared to meet the demands of contemporary virtual learning environments and maximize the effectiveness of technology-enhanced education.

Moral standards

In the present study, the ethical principles related to qualitative researches were observed.

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Contribution of authors

In this research, each of the authors had a share in collecting the theoretical and research background, and the author was responsible for the initial writing of the article, analysis, writing and editing of the final article.

Conflict of interest There was no conflict of interest in this research.

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