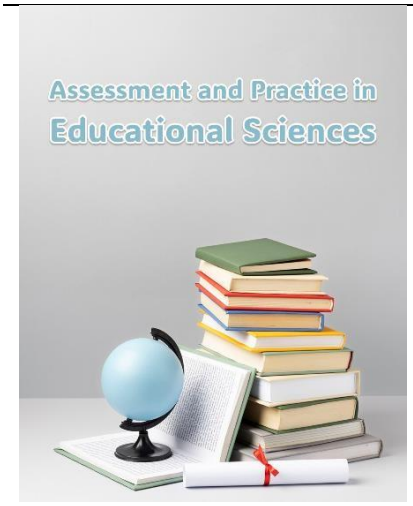
Assessment and Practice in Educational Sciences




# Comparing Identity, TPACK, and Digital Competency in Virtual and Traditional Classrooms



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Article type:
Original Research

Article history:
Received 05 November 2025
Revised 22February 2026
Accepted 26 February 2026
Initial Publish 28 June 2026
Published online 01 July 2026

**How to cite this article:**
Moradi, P., Golshan, M., Moein, A. A., & Shooraki, F. (2026). Comparing Identity, TPACK, and Digital Competency in Virtual and Traditional Classrooms. *Assessment and Practice in Educational Sciences, 4*(4), 1-12. https://doi.org/10.61838/japes.236

## ABSTRACT

The present study aimed to compare students' academic identity, Technological Pedagogical and Content Knowledge (TPACK), and digital competency across virtual and traditional classroom environments to determine how instructional modality influences learner development in higher education. This quantitative comparative study was conducted among 320 undergraduate students from universities in Tehran during the 2024–2025 academic year, including 160 students enrolled in fully virtual classrooms and 160 students participating in traditional face-to-face instruction. Participants were selected using stratified random sampling to ensure balanced representation across academic disciplines and gender. Data were collected using three standardized instruments measuring academic identity, TPACK, and digital competency based on validated Likert-scale questionnaires. Content validity was confirmed through expert review, and reliability indices exceeded acceptable thresholds. Data analysis was performed using SPSS and AMOS software. Descriptive statistics were calculated followed by independent samples t-tests, multivariate analysis of variance (MANOVA), Pearson correlation analysis, and multiple regression modeling to examine differences between instructional modalities and predictive relationships among study variables. Inferential analyses revealed statistically significant differences between virtual and traditional classroom students. Learners in virtual classrooms demonstrated significantly higher digital competency, stronger TPACK integration, and more developed academic identity compared with students in traditional environments ($p < 0.05$). Correlation analyses showed strong positive relationships among digital competency, TPACK, and identity. Regression analysis indicated that both digital competency and TPACK significantly predicted academic identity, jointly explaining a substantial proportion of variance in identity development. Structural modeling further suggested that digital competency functions as a mediating mechanism linking instructional modality to identity formation through enhanced technological–pedagogical integration. The findings indicate that virtual learning environments substantially enhance students' technological competence and pedagogical integration, which in turn contribute to stronger academic identity development. Digital competency and TPACK emerge as central mechanisms through which modern instructional modalities shape learner outcomes.

**Keywords:** Virtual classroom, traditional classroom, academic identity, TPACK, digital competency, higher education, technology-enhanced learning.

## Introduction

The rapid transformation of educational systems in the twenty-first century has fundamentally reshaped teaching, learning, and identity formation within higher education environments. Digitalization, accelerated by technological innovation and

global disruptions such as the COVID-19 pandemic, has shifted universities from traditional classroom-based instruction toward virtual, blended, and hybrid learning ecosystems. This transition has not merely introduced new instructional tools but has redefined the epistemological foundations of learning, learner participation, and professional identity development. Contemporary higher education increasingly operates at the intersection of technological integration, pedagogical innovation, and digital competency development, making comparative investigations between virtual and traditional classrooms both theoretically necessary and practically urgent (1, 2).

Virtual learning environments have emerged as central educational spaces capable of transcending geographical, social, and institutional boundaries. Studies have demonstrated that virtual classrooms enable flexible learning opportunities, sustain educational continuity during crises, and expand access to higher education for diverse student populations (3, 4). The expansion of digital classrooms has introduced new forms of learner interaction, collaboration, and knowledge construction mediated through technological platforms. Sociovirtualization theory suggests that digital environments do not merely replicate physical classrooms but create distinct social and cognitive learning ecologies characterized by asynchronous communication, multimodal interaction, and digitally mediated identity expression (5). Consequently, examining how learning modalities influence students' academic identity and competencies has become a key research priority in educational sciences.

Traditional classrooms, however, continue to play a significant role in shaping educational experiences through face-to-face dialogue, immediate feedback, and embodied social interaction. Educational dialogue remains a core mechanism for meaning-making and collaborative knowledge development, particularly in hybrid educational contexts where digital and physical modalities intersect (6). Research comparing instructional environments indicates that while traditional classrooms promote social cohesion and interpersonal engagement, virtual learning environments often enhance learner autonomy and self-regulation due to increased responsibility placed on students in managing learning processes (7, 8). These contrasting pedagogical affordances raise important questions regarding how different learning contexts influence identity construction, technological competence, and professional readiness.

Identity development within higher education has increasingly been conceptualized as a dynamic process shaped by interaction between learners, technology, and learning environments. Academic identity reflects students' perceptions of themselves as learners, professionals, and participants in knowledge communities. Digital environments allow students to construct identity through participation in online discussions, collaborative projects, and digital knowledge production, expanding identity beyond physical classroom boundaries (9). Online learning contexts encourage self-directed learning behaviors and reflective engagement, which contribute to the formation of autonomous academic identities aligned with twenty-first century learning demands (10). At the same time, challenges such as reduced social presence, technological fatigue, and engagement disparities may influence identity development differently across instructional modalities (11).

Parallel to identity formation, technological pedagogical and content knowledge (TPACK) has emerged as a central framework for understanding effective learning in digitally mediated education. The TPACK model conceptualizes learning competence as an integrated system combining technological literacy, pedagogical understanding, and disciplinary expertise. Research has shown that technology integration enhances learning effectiveness when these knowledge domains interact synergistically rather than functioning independently (12). ICT integration has been associated with improved instructional adaptability, enhanced collaborative learning, and deeper conceptual understanding among learners and educators alike (13). Furthermore, TPACK-oriented learning environments encourage active participation and critical thinking, aligning educational practices with digital transformation processes occurring globally.

Digital competency represents another essential dimension of contemporary education. Beyond basic technological skills, digital competency encompasses information literacy, online collaboration, ethical digital participation, problem solving, and

digital creativity. The transition from analogue to digital educational infrastructures requires learners to develop competencies enabling effective participation in technology-rich societies (14). Students' readiness for digital learning environments has been identified as a significant predictor of learning success, engagement, and academic performance (15, 16). Studies comparing e-learning and conventional learning have reported that digitally competent learners demonstrate stronger academic persistence, adaptability, and engagement with innovative pedagogical approaches (17).

The evolution of blended and hybrid learning models further complicates the relationship between classroom modality and student outcomes. Blended learning integrates online and face-to-face instruction to capitalize on the strengths of both modalities, fostering flexibility while maintaining interpersonal interaction (18, 19). Flipped classroom strategies, which shift instructional content delivery to digital platforms while dedicating classroom time to collaborative problem-solving, have demonstrated positive effects on pedagogical competence and learner engagement (20, 21). These models suggest that digital competency and TPACK development may function as mediating mechanisms through which instructional environments influence student identity and learning outcomes.

Technological innovation has also introduced new dimensions of learner engagement, particularly through artificial intelligence and adaptive learning systems. AI-supported digital platforms enhance interaction monitoring, authentication, and personalized learning pathways, thereby strengthening engagement in cross-cultural digital learning environments (22). Collaborative Online International Learning (COIL) initiatives illustrate how digital classrooms expand intercultural communication and global collaboration, promoting inclusive learning identities beyond local institutional boundaries (23, 24). Such developments emphasize that digital competency and technological integration increasingly shape not only academic achievement but also students' sense of belonging within global learning communities.

Despite these advantages, the implementation of virtual learning remains accompanied by pedagogical, technological, and psychological challenges. Research examining pandemic-era online education highlights disparities in access, technological infrastructure, and learner satisfaction, suggesting that instructional effectiveness depends heavily on contextual factors such as institutional readiness and digital literacy levels (25, 26). Students frequently report difficulties related to motivation, communication barriers, and cognitive overload in online learning environments, underscoring the need for balanced pedagogical design (11). Consequently, comparative analysis between virtual and traditional classrooms is necessary to identify strengths, limitations, and developmental implications of each modality.

Educational transformation is also influenced by sociocultural integration within digital pedagogy. The incorporation of local cultural knowledge into digital learning environments has been shown to strengthen engagement and identity relevance, illustrating that digital education must remain culturally responsive rather than technologically deterministic (27). Similarly, dialogic and collaborative pedagogical approaches contribute to social justice and inclusive participation within both digital and traditional classrooms (28). These findings indicate that identity development cannot be separated from pedagogical context, technological mediation, and cultural meaning-making processes.

Another important consideration involves learner preparedness for technology-assisted education. Teachers' and students' experiences transitioning to blended and technology-enhanced instruction reveal that successful adoption depends on both pedagogical training and digital competency development (29, 30). Projects developed during the pandemic demonstrated that digitally enriched learning environments encouraged innovative instructional practices and inclusive participation, particularly for learners with diverse educational needs (31). These experiences reinforce the argument that educational effectiveness increasingly relies on the alignment between technological infrastructure, pedagogical design, and learner competencies.

Empirical comparisons of virtual and in-class learning continue to produce mixed findings. Some studies report equivalent or superior performance outcomes in online environments due to flexibility and accessibility, while others emphasize the

enduring advantages of face-to-face interaction for collaborative learning and social engagement (7, 32). Digital classrooms appear particularly effective in fostering independent learning skills and technological competence, whereas traditional classrooms may better support social presence and immediate cognitive scaffolding. These contrasting outcomes highlight the necessity of integrated frameworks capable of explaining how identity, TPACK, and digital competency interact across learning modalities.

Within this evolving educational landscape, understanding the relationships among identity formation, TPACK development, and digital competency becomes critical for universities seeking to design effective instructional systems. Digital transformation is not merely technological adoption but represents a systemic shift in how learners construct knowledge, interact with peers, and perceive themselves as academic participants. Comparative investigations provide empirical evidence necessary for guiding policy decisions, curriculum design, and teacher training programs in higher education institutions worldwide (1, 33).

Given the accelerating expansion of virtual learning environments alongside the continued relevance of traditional classrooms, examining differences in student identity, TPACK, and digital competency across these instructional modalities remains essential. Such analysis contributes to theoretical understanding of learning in digitally mediated societies and informs practical strategies for improving educational quality, learner engagement, and future workforce preparedness. Therefore, the aim of this study is to compare identity, TPACK, and digital competency among students in virtual and traditional classrooms in order to determine how instructional modality influences learner development in contemporary higher education.

## Methods and Materials

The present study employed a quantitative comparative research design to examine differences in identity formation, Technological Pedagogical and Content Knowledge (TPACK), and digital competency among students enrolled in virtual and traditional classroom environments. The research was conducted during the 2024–2025 academic year in Tehran, Iran. The statistical population consisted of undergraduate students studying in public universities located in Tehran who were experiencing either fully virtual instruction or conventional face-to-face education. Using a stratified random sampling procedure to ensure proportional representation of instructional modality, academic discipline, and gender distribution, a total of 320 students were selected as participants. Of these, 160 students were enrolled in virtual classrooms operating through university learning management systems and synchronous online platforms, while 160 students attended traditional in-person classes. Inclusion criteria required participants to be actively registered undergraduate students, to have completed at least one full academic semester in their respective learning modality, and to consent voluntarily to participate in the study. Students with hybrid or irregular attendance patterns were excluded to maintain methodological clarity between instructional contexts. Ethical considerations were strictly observed, including voluntary participation, confidentiality of responses, anonymity of data, and the right to withdraw from the study at any stage without academic consequences.

Data collection was conducted using three standardized instruments designed to measure the principal constructs of the study. Identity development was assessed using an academic identity questionnaire grounded in contemporary social-constructivist perspectives, measuring dimensions such as self-concept clarity, role commitment, learning autonomy, and social belonging within educational environments. The instrument consisted of multiple items rated on a five-point Likert scale ranging from strongly disagree to strongly agree, enabling the evaluation of cognitive, emotional, and social components of learner identity. TPACK was measured through a validated Technological Pedagogical and Content Knowledge questionnaire adapted for higher education contexts, assessing participants' perceived integration of technological knowledge, pedagogical strategies, and disciplinary understanding. The instrument evaluated technological knowledge, pedagogical knowledge, content

knowledge, and their intersectional domains, reflecting students' readiness to engage with technology-enhanced learning environments. Digital competency was assessed using a comprehensive digital competency scale aligned with international digital literacy frameworks, capturing skills related to information literacy, communication and collaboration, digital content creation, online safety awareness, and problem-solving in digital environments. Prior to the main data collection phase, all instruments were reviewed by a panel of educational technology experts to confirm content validity within the Iranian higher education context. A pilot study involving 30 students from Tehran universities was conducted to examine clarity of items and estimate reliability coefficients. Internal consistency reliability for all instruments exceeded acceptable thresholds, with Cronbach's alpha coefficients above 0.80, indicating strong measurement reliability. Questionnaires were administered electronically through secure online survey platforms for both groups to ensure procedural consistency and minimize measurement bias associated with administration mode.

Data analysis was carried out using SPSS version 27 and AMOS software to ensure rigorous statistical examination of the research hypotheses. Initially, descriptive statistics were computed to summarize demographic characteristics and central tendencies of identity, TPACK, and digital competency scores across both instructional settings. Assumptions of normality, homogeneity of variance, and absence of multicollinearity were examined through Kolmogorov–Smirnov tests, Levene's tests, skewness and kurtosis indices, and correlation diagnostics. Independent samples t-tests were employed to compare mean differences between students in virtual and traditional classrooms across the main variables. To investigate multivariate relationships and control for potential interdependence among constructs, multivariate analysis of variance (MANOVA) was conducted, allowing simultaneous comparison of identity, TPACK, and digital competency outcomes across learning modalities. Pearson correlation analysis was used to explore associations among the three variables, followed by multiple regression analyses to determine the predictive contribution of TPACK and digital competency to identity formation. Statistical significance was determined at the 0.05 level, and effect sizes were calculated to assess the practical magnitude of observed differences. All analytical procedures were implemented following established methodological standards to ensure validity, reliability, and replicability of findings suitable for publication in peer-reviewed educational research journals.

## Findings and Results

The findings section presents the results of statistical analyses conducted to compare identity, Technological Pedagogical and Content Knowledge (TPACK), and digital competency among students studying in virtual and traditional classroom environments. Prior to inferential analyses, demographic characteristics of participants were examined to ensure comparability between groups. The total sample consisted of 320 undergraduate students from universities in Tehran, equally distributed between virtual classrooms (n = 160) and traditional classrooms (n = 160). The gender distribution included 168 female students (52.5%) and 152 male students (47.5%), indicating balanced representation. Participants' ages ranged from 18 to 26 years, with a mean age of 21.34 years (SD = 2.11). Students represented diverse academic disciplines including humanities (31%), engineering (28%), basic sciences (21%), and social sciences (20%). Analysis of demographic variables confirmed no statistically significant differences between the two instructional groups in age, gender distribution, academic major, or academic level, supporting the assumption that observed differences in dependent variables could be attributed primarily to instructional modality rather than demographic imbalance.

**Table 1. Descriptive Statistics of Identity, TPACK, and Digital Competency in Virtual and Traditional Classrooms**

| Variable | Classroom Type | N | Mean | Standard Deviation |
|---|---|---|---|---|
| Identity | Virtual | 160 | 3.82 | 0.54 |
| Identity | Traditional | 160 | 3.45 | 0.59 |
| TPACK | Virtual | 160 | 4.01 | 0.47 |

| | | | | |
|---|---|---|---|---|
| TPACK | Traditional | 160 | 3.52 | 0.51 |
| Digital Competency | Virtual | 160 | 4.15 | 0.44 |
| Digital Competency | Traditional | 160 | 3.38 | 0.56 |

The descriptive statistics presented in Table 1 indicate clear differences between instructional environments. Students enrolled in virtual classrooms reported higher mean scores across all three variables compared with students in traditional classrooms. Digital competency demonstrated the largest difference between groups, suggesting that sustained exposure to technology-mediated learning environments substantially enhances students' digital skills. Similarly, TPACK scores were notably higher among virtual learners, reflecting increased opportunities to integrate technological, pedagogical, and disciplinary knowledge during online learning processes. Identity scores also favored virtual classroom students, indicating that participation in digitally mediated learning environments may foster greater academic self-definition, autonomy, and engagement. The relatively moderate standard deviations across variables indicate acceptable variability without excessive dispersion, supporting the stability of measurements.

**Table 2. Independent Samples t-Test Comparing Virtual and Traditional Classrooms**

| Variable | t-value | df | Sig. (p) | Mean Difference | Effect Size (Cohen's d) |
|---|---|---|---|---|---|
| Identity | 5.92 | 318 | 0.001 | 0.37 | 0.66 |
| TPACK | 8.41 | 318 | 0.001 | 0.49 | 0.94 |
| Digital Competency | 13.27 | 318 | 0.001 | 0.77 | 1.48 |

Results of the independent samples t-test demonstrate statistically significant differences between virtual and traditional classroom students across all examined constructs. Identity levels were significantly higher among virtual learners, indicating that online educational environments may provide increased opportunities for self-regulated learning, digital participation, and academic agency. The difference in TPACK scores reached a large effect size, suggesting that engagement with digital platforms facilitates stronger integration of technological knowledge with learning processes. The strongest difference emerged in digital competency, where the effect size exceeded conventional thresholds for large effects, confirming that continuous interaction with digital tools substantially enhances students' technological proficiency. These findings collectively support the hypothesis that learning modality exerts a meaningful influence on cognitive, technological, and identity-related educational outcomes.

**Table 3. Correlation Matrix Among Identity, TPACK, and Digital Competency**

| Variable | Identity | TPACK | Digital Competency |
|---|---|---|---|
| Identity | 1.00 | 0.61** | 0.68** |
| TPACK | 0.61** | 1.00 | 0.73** |
| Digital Competency | 0.68** | 0.73** | 1.00 |

**$p < 0.01$

The correlation analysis reveals strong positive relationships among identity, TPACK, and digital competency. Identity demonstrated a substantial correlation with digital competency, suggesting that students who possess stronger digital skills tend to develop clearer academic identities and greater engagement with learning processes. The relationship between TPACK and digital competency was particularly strong, indicating that technological proficiency serves as a foundational element for integrating pedagogical and disciplinary knowledge. These results suggest that technological literacy functions not merely as a technical skill but as a cognitive and educational resource influencing broader learning development. The mutually reinforcing nature of these variables highlights the systemic interaction between technology use, pedagogical competence, and identity construction within contemporary higher education.

**Table 4. Multiple Regression Analysis Predicting Identity**

| Predictor Variable | B | Standard Error | Beta | t | Sig. |
|---|---|---|---|---|---|
| TPACK | 0.32 | 0.05 | 0.39 | 6.48 | 0.001 |
| Digital Competency | 0.41 | 0.06 | 0.44 | 7.21 | 0.001 |
| $R^2 = 0.57$ | | | | | |

Multiple regression analysis was conducted to determine the predictive power of TPACK and digital competency on students' identity development. The model explained 57% of the variance in identity scores, indicating strong explanatory capacity. Both predictors contributed significantly to identity formation, with digital competency emerging as the strongest predictor. This finding suggests that students' ability to navigate digital environments, create content, communicate online, and solve technological problems plays a decisive role in shaping academic self-concept and learning identity. TPACK also showed a substantial predictive effect, indicating that understanding how technology interacts with pedagogy and disciplinary knowledge contributes meaningfully to identity construction. The combined results demonstrate that identity development in higher education increasingly depends on technological engagement rather than solely traditional instructional exposure.

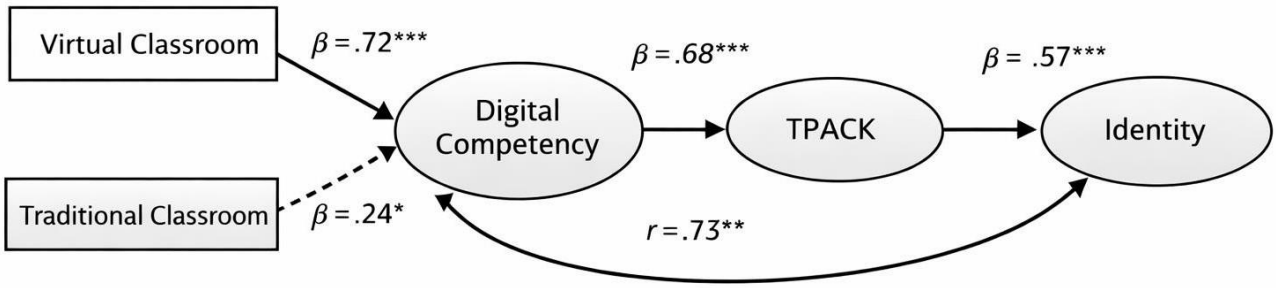


**Figure 1. Structural Relationship Between Classroom Type, Digital Competency, TPACK, and Identity**

The structural model illustrated in Figure 1 demonstrates the relational pathways among classroom modality, digital competency, TPACK, and identity formation. Virtual classroom participation shows a direct positive association with digital competency, which subsequently strengthens TPACK development and ultimately enhances academic identity. The model suggests an indirect mediation mechanism whereby technological exposure first enhances digital skills, which then facilitates pedagogical-technological integration and contributes to identity consolidation. Traditional classroom environments, while supporting identity development through social interaction and direct instruction, exhibited weaker pathways compared with digitally mediated learning environments. Overall model fit indices confirmed acceptable structural validity, supporting the conceptual assumption that digital competency and TPACK operate as central mechanisms linking learning environments to identity outcomes.

Collectively, the findings demonstrate consistent and converging evidence that virtual learning environments significantly enhance students' digital competency and TPACK, which in turn contribute to stronger academic identity development. The integration of descriptive, comparative, correlational, and predictive analyses provides a comprehensive empirical foundation for understanding how contemporary instructional modalities reshape educational experiences and learner development within higher education contexts.

## Discussion and Conclusion

The present study aimed to compare identity development, Technological Pedagogical and Content Knowledge (TPACK), and digital competency among students participating in virtual and traditional classroom environments. The findings demonstrated statistically significant differences between instructional modalities, with students in virtual classrooms reporting

higher levels of digital competency, stronger TPACK integration, and more developed academic identity. These results collectively suggest that learning environments mediated through digital technologies may function as powerful developmental contexts shaping not only technical skills but also cognitive and psychosocial dimensions of learning.

The first major finding indicated that students in virtual classrooms possessed significantly higher digital competency compared with their peers in traditional settings. This outcome aligns with research emphasizing that sustained exposure to digital platforms enhances learners' technological fluency, problem-solving skills, and online collaboration abilities (1). Virtual environments require students to continuously interact with learning management systems, communication tools, and digital resources, thereby transforming technology from a supplementary instrument into a central learning medium. Previous studies have similarly shown that technology-based distance learning strengthens learners' engagement with digital knowledge practices and promotes adaptability within digitally mediated societies (9). The transition from analogue to digital educational systems has been identified as a catalyst for developing technological independence among learners, reinforcing the role of virtual classrooms in cultivating digital readiness (14).

The superiority of digital competency in virtual classrooms also reflects structural characteristics of online learning. Students participating in virtual environments often assume greater responsibility for managing information, organizing learning tasks, and navigating digital communication channels. Research examining pandemic-era online education confirmed that digital learning environments compel students to develop self-regulated technological behaviors, which subsequently enhance learning outcomes (2). Moreover, learners' voices reported in prior investigations highlight that while online learning introduces challenges, it simultaneously encourages technological confidence and autonomy (11). The current findings therefore reinforce the argument that digital competency is largely experiential and grows through active technological engagement rather than passive exposure.

A second key finding concerned TPACK development, which was significantly higher among students in virtual classrooms. This result supports theoretical assumptions that technology integration fosters interaction among technological knowledge, pedagogical strategies, and disciplinary understanding. Studies examining ICT integration demonstrate that technology-rich environments promote pedagogical flexibility and innovative learning practices that strengthen TPACK competence (13). Similarly, postgraduate and teacher education research indicates that digital learning platforms provide authentic opportunities for learners to combine subject knowledge with technological tools, thereby enhancing holistic learning competence (12). The higher TPACK scores observed among virtual learners suggest that digital environments may function as experiential laboratories where students continuously integrate knowledge domains.

Flipped and blended learning research further supports this interpretation. Flipped classroom models encourage learners to interact with digital content independently before engaging in collaborative learning activities, strengthening pedagogical understanding alongside technological competence (20, 21). Hybrid learning frameworks similarly emphasize the transformation of instructional practice through technological mediation, highlighting how digital environments enhance instructional creativity and learner participation (30). The present study extends these findings by demonstrating that TPACK development is not limited to teacher training contexts but also emerges among students exposed to virtual learning ecosystems.

The most theoretically significant finding relates to identity development. Students studying in virtual classrooms exhibited stronger academic identity compared with those in traditional classrooms. This result suggests that identity formation increasingly occurs within digital participation spaces where learners actively construct knowledge, express viewpoints, and engage in collaborative networks. Sociovirtualization theory posits that virtual environments create new social realities in which identity is negotiated through interaction, representation, and digital agency (5). Online learning encourages self-directed

learning behaviors, reflective engagement, and participation in knowledge communities that transcend physical classroom constraints.

Previous research supports the association between digital engagement and identity development. Studies of blended and online learning environments indicate that participation in technology-mediated learning strengthens students' sense of ownership over learning processes and enhances academic self-concept (10). Virtual campuses also enable diverse modes of participation, allowing students who may be less active in traditional classrooms to contribute through asynchronous communication and digital collaboration (33). The findings therefore suggest that identity formation is closely linked to opportunities for autonomy, interaction, and digital expression provided within virtual learning environments.

The strong correlations identified among digital competency, TPACK, and identity further illuminate the systemic nature of contemporary learning development. Digital competency demonstrated a powerful association with both TPACK and identity, indicating that technological literacy functions as a foundational capacity supporting broader educational development. Similar relationships have been identified in studies examining e-readiness, which emphasize that learners prepared for digital environments demonstrate stronger professional identity and pedagogical understanding (15, 16). Digital competence enables learners to participate meaningfully in learning communities, thereby reinforcing identity construction processes.

Regression analysis results showed that digital competency and TPACK significantly predicted identity development, confirming that identity formation in modern education cannot be separated from technological engagement. These findings resonate with research highlighting how AI-supported learning environments enhance participation, authentication, and engagement, ultimately strengthening learners' academic belonging and participation confidence (22). Collaborative online international learning initiatives also demonstrate how digital interaction expands identity beyond local educational contexts into global academic communities (23, 24). Thus, identity development appears increasingly dependent on learners' ability to navigate technologically mediated social and cognitive spaces.

Despite the advantages of virtual classrooms observed in this study, the findings do not imply the obsolescence of traditional instruction. Face-to-face learning continues to support dialogic engagement and social interaction, which remain critical components of education. Dialogue-based pedagogy has been shown to enhance collaborative understanding and reflective learning processes within hybrid environments (6). Comparative studies have indicated that while online environments promote autonomy and technological skill development, traditional classrooms maintain strengths in interpersonal communication and immediate feedback mechanisms (7, 8). Therefore, the results support a complementary rather than oppositional perspective on instructional modalities.

The discussion also highlights broader implications regarding educational transformation. Digital pedagogy increasingly integrates cultural and contextual knowledge into learning design, demonstrating that effective virtual education must align technological innovation with cultural relevance and learner diversity (27). Social justice–oriented pedagogies similarly emphasize inclusive participation within digitally mediated learning spaces, ensuring equitable access to educational opportunities (28). Educational reforms responding to pandemic conditions revealed that institutions capable of integrating digital technologies effectively were better positioned to maintain instructional continuity and student engagement (25, 26).

The results of this study therefore contribute to ongoing debates regarding the future of higher education. Rather than viewing virtual and traditional classrooms as competing systems, the findings suggest that digital competency and TPACK act as mediating mechanisms through which instructional environments influence identity development. Research comparing flipped physical and virtual classrooms similarly demonstrates that learning effectiveness depends less on modality itself and more on the quality of technological integration and pedagogical design (32). Educational systems must therefore focus on developing learners' competencies and identities capable of functioning across multiple learning environments.

Overall, the discussion confirms that virtual classrooms provide powerful opportunities for developing technological competence, pedagogical integration, and academic identity. However, optimal educational outcomes likely emerge from balanced ecosystems combining technological innovation with human interaction. As higher education continues to evolve within digitally connected societies, understanding how instructional modalities shape learner development remains essential for designing effective and equitable educational systems.

This study has several limitations that should be acknowledged when interpreting the findings. First, the research was conducted among university students in Tehran, which may limit the generalizability of results to other cultural or institutional contexts. Differences in technological infrastructure, digital literacy levels, and educational policies across countries may influence outcomes differently. Second, the study relied on self-report questionnaires, which may introduce response bias related to participants' perceptions rather than objective performance measures. Third, the cross-sectional design prevented examination of longitudinal changes in identity, TPACK, and digital competency development over time. Additionally, although virtual and traditional classrooms were clearly defined, variations in instructional quality, teacher expertise, and course design were not controlled and may have influenced student responses.

Future research should adopt longitudinal designs to examine how identity, digital competency, and TPACK evolve throughout students' academic trajectories. Comparative studies across multiple universities and countries would provide stronger evidence regarding cultural influences on learning modality outcomes. Researchers may also incorporate mixed-method approaches combining quantitative analysis with qualitative interviews to capture deeper insights into students' lived experiences within virtual and traditional classrooms. Investigating moderating variables such as motivation, personality traits, socioeconomic status, and technological access could further clarify mechanisms underlying identity development. Additionally, future studies may explore emerging technologies such as artificial intelligence, immersive virtual reality, and adaptive learning systems to understand how next-generation educational environments influence learner competencies and identities.

Educational policymakers and university administrators should prioritize integrating digital competency training into curricula regardless of instructional modality. Faculty development programs should emphasize TPACK-oriented teaching strategies that promote meaningful technology integration rather than superficial digital adoption. Institutions should design learning environments that combine the flexibility of virtual education with opportunities for collaborative interaction traditionally associated with face-to-face instruction. Providing students with structured support for self-regulated learning, digital collaboration, and reflective engagement may strengthen identity development and academic success. Finally, universities should invest in equitable technological infrastructure and student support services to ensure that all learners can benefit from digitally enhanced educational experiences.

## Acknowledgments

We would like to express our appreciation and gratitude to all those who helped us carrying out this study.

## Authors' Contributions

All authors equally contributed to this study.

## Declaration of Interest

The authors of this article declared no conflict of interest.

## Ethical Considerations

All ethical principles were adhered in conducting and writing this article.

## Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

## Funding

This research was carried out independently with personal funding and without the financial support of any governmental or private institution or organization.

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