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Adapting the metaverse perception scale for Iranian nursing students: translation and psychometric assessment

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Abstract
The integration of metaverse technologies into healthcare education is expanding globally. However, there is a lack of culturally validated instruments to assess students' perceptions within the Iranian context. This study aimed to evaluate the psychometric properties of the Persian version of the Metaverse Perception Scale among Iranian nursing students. A cross-sectional psychometric study was conducted with 436 nursing students. The translated scale underwent Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). Internal consistency was assessed using Cronbach's alpha. Convergent and discriminant validity were evaluated through Composite Reliability (CR), Average Variance Extracted (AVE), inter-construct correlations, √AVE, MSV and ASV. Factor analysis revealed a four-factor structure—Education, Technology, Lifestyle, and Challenges—which explained 67.08% of the total variance. CFA results indicated that the refined 20-item version of the questionnaire had a good overall model fit ($\chi^2/df = 1.647$; $CFI = 0.958$; $RMSEA = 0.054$). All CR values and AVE values were above 0.70 and 0.50, respectively, supporting convergent validity. For all factors, √AVE values exceeded inter-construct correlations, and both MSV and ASV were lower than AVE, supporting discriminant validity. The scale demonstrated strong internal consistency (Cronbach's alpha = 0.917 − 0.822). The Persian version of the Metaverse Perception Scale (P-MPS) is a valid and reliable scale for assessing nursing students' perceptions of metaverse technologies in educational settings. This scale shows strong potential for application in both research and curriculum design within technology-enhanced nursing education.

Keywords Nursing students · Education · Nursing · Psychometrics · Technology · Perception

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1 Introduction

After the COVID-19 pandemic, the transition toward new paradigms of information technology-based education in nursing witnessed a remarkable acceleration (Fogg et al., 2020). This global crisis underscored the urgent need for innovative approaches to both theoretical and clinical nursing education (Cho et al., 2024). In response to the constraints imposed by the absence of face-to-face training, numerous educational and practical programs were introduced to replace the clinical experiences of nursing students (De Gagne et al., 2023). During this period, a significant portion of teaching and learning processes shifted from physical environments to virtual education infrastructures. Consequently, opportunities for in-person interaction among students, participation in group sessions, and engagement within academic settings were considerably limited (Kim, 2021). Understandably, the shift from traditional to digital education necessitates the development of new educational tools and strategies.

Within this context, the Metaverse has emerged as a novel and transformative platform in nursing education—one that has the potential to overcome many of the challenges associated with virtual learning, particularly the limited interactivity of videoconferencing tools. By offering an immersive and interactive environment, the Metaverse can create experiences that closely resemble real-world conditions (Kim & Kim, 2023). Although no universally accepted definition of the Metaverse exists, it is generally described as a three-dimensional virtual environment that provides a timeless and borderless immersive experience through virtual reality (VR) and augmented reality (AR) technologies—a metaphorical space where users can engage in social interactions, learning, practice, and even gaming, much like in real life (Diaz et al., 2020; Gao, 2023).

Previous research findings have shown that the Metaverse facilitates virtual social and emotional communication (Yang & Kang, 2022). Its application in nursing education enables students to practice safely, effectively, and comprehensively in a simulated environment (Cho et al., 2024). The avatar-based design of this platform aims to enhance interaction, immersion, and the protection of user privacy (Kim & Kim, 2023; Han & Noh, 2021). In recent years, clinical simulation has gained traction as a reliable and effective method in health care education, primarily due to its focus on problem-solving, skill performance, and decision-making (Yang & Kang, 2022). For instance, the study by Cho et al. (2024) confirmed that a Metaverse-based simulation program for patient handover—rooted in family-centered care and experiential learning theory—enhanced nursing students' self-efficacy in performing this procedure. By creating a realistic, patient-centered learning environment, the program contributed to students' preparedness for delivering safe and effective care in real clinical settings.

The systematic review conducted by De Gagne et al. (2023) also indicates that Metaverse-based interventions lead to improvements in nursing students' knowledge, self-confidence, active engagement, satisfaction, and clinical performance, although some studies reported mixed and heterogeneous findings for certain learning outcomes. Additionally, Sharma and Sharma (2023) suggests that integrating the capabilities of the Metaverse with artificial intelligence, particularly ChatGPT, could enrich nursing students' learning experiences and better equip them for remote patient care—ultimately contributing to improved health care outcomes.

Nevertheless, some studies have raised concerns regarding the use of the Metaverse. For example, the study by Kuş (2021) revealed that participants had doubts about the physical and psychological effects of using the Metaverse. Other reports have pointed to symptoms such as nausea and eye strain resulting from VR use (Beder, 2022), while prolonged sedentary behavior and limited physical activity were also cited as potential health risks (Bayram, 2022). Moreover, concerns about data privacy and user information security have been highlighted (Beder, 2022; Choi et al., 2022). These issues underscore the need for further, more comprehensive research to better understand the positive and negative implications of using Metaverse technologies in health education.

Accordingly, assessing nursing students' perceptions and attitudes toward the Metaverse—as a key target group and primary users of this technology—is essential for effective planning in Metaverse-based education and clinical service delivery. Such an assessment requires a scientifically valid, reliable, and culturally adapted measurement tool. Considering the increasing adoption of advanced technologies in Iran's education system and the lack of a valid Persian-language instrument to evaluate nursing students' perceptions of the Metaverse, the present study was designed to translate and psychometrically validate the Metaverse Perception Scale for Nursing Students. Originally developed and validated by researchers in Turkey, this self-report instrument comprises 24 items across four dimensions, rated on a five-point Likert scale (from 1 = strongly disagree to 5 = strongly agree) (Yıldırım & Karaman, 2024). The primary objective of this study is to localize the scale for use among Iranian nursing students, thereby paving the way for future research and evidence-based decision-making in the domain of education and emerging technologies.

2 Methodology

2.1 Research design

A cross-sectional psychometric evaluation was conducted to assess the validity and reliability of the Persian version of the Metaverse Perception Scale among nursing students in Iran. A total of 436 nursing students were recruited through convenience sampling from various faculties across the country between May and June 2024. The sample size was determined based on established methodological recommendations. For the exploratory factor analysis (EFA), a minimum of 5 to 10 participants per item was considered appropriate (Plichta Kellar, 2012). In line with most experts' recommendations, a minimum of 200 participants needs to run a confirmatory factor analysis (CFA), especially if your model isn't too complex (Kline, 2015; Brown, 2015). Data were collected through an online survey hosted on the Persian platform Porsline (www.porsline.ir), which was distributed via messaging and available social media applications such as Telegram, WhatsApp, Bale, and Eitaa. Eligible participants included undergraduate students in their second semester or higher and postgraduate nursing students who voluntarily consented to participate.

2.2 Measurements

The survey instrument consisted of two parts:

Demographic Information: Participants provided data on age, gender, academic level, current semester, and answered three questions related to their familiarity with the metaverse, prior usage experience, and average daily internet usage.
Metaverse Perception Scale (Persian version): This 24-item instrument evaluates perceptions of four domains: Education (9 items), Technology (5 items), Lifestyle (5 items), and Challenges (5 items). Responses were rated on a five-point Likert scale, ranging from 1 (Strongly disagree) to 5 (Completely agree) (Yıldırım & Karaman, 2024).

2.3 Translation

The original Metaverse Perception Scale, developed by Yıldırım and Karaman (2024) in Turkish, was translated into Persian following the World Health Organization's forward–backward translation protocol. Two bilingual experts independently translated the scale into Persian. These versions were reconciled into a single form and then back-translated into Turkish by a different bilingual translator. The back-translated version was reviewed by the original scale developer to ensure semantic and conceptual equivalence. Revisions were made until full agreement was reached.

3 Validity assessment of the Persian version of the metaverse perception scale

3.1 Face validity

Ten nursing students were randomly selected and reviewed the translated scale for clarity and comprehensibility. Their feedback informed minor revisions to the wording of several items.

3.2 Content validity

Ten academic experts in nursing, medical education, and health IT assessed each item's necessity and relevance. The Content Validity Ratio (CVR) was calculated using Lawshe's method, with a threshold of 0.62 for ten experts (Lawshe, 1975). The Content Validity Index (CVI) and modified kappa statistics were also computed, with acceptable kappa values set at ≥ 0.60 (Norouzinia et al., 2025).

3.3 Construct validity

IBM SPSS Statistics Version 26 (IBM Corp., Armonk, NY, USA) and AMOS 24 (Scientific Software International, Skokie, IL, USA) were used to assess the validity of the scale employed in this study. Prior to analysis, items within the Challenges dimension were reverse-coded to ensure a consistent scoring direction; the recoded variables were used in all subsequent analyses. The construct validity of the scale was evaluated using maximum likelihood Exploratory Factor Analysis (EFA) and Varimax rotation on the 216 nursing students' responses. The Kaiser–Meyer–Olkin (KMO) measure and Bartlett's test confirmed sample adequacy and the model. A KMO value of ≥ 0.70, a minimum eigenvalue of 1.0, item loadings ≥ 0.3, and factors explaining ≥ 5% of variance were criteria for factor extraction (Shrestha, 2021).

To evaluate the structural factors, a confirmatory factor analysis (CFA) using the maximum likelihood estimation method was conducted on a separate sample of 220 participants. The model fit was assessed using commonly reported goodness-of-fit indices, including the Chi-square test (χ^2), the normed chi-square (CMIN/DF), with values < 3 indicating acceptable fit, the Comparative Fit Index (CFI) > 0.90, the Incremental Fit Index (IFI) > 0.90, the Parsimonious Comparative Fit Index (PCFI) > 0.50, the Parsimonious Normed Fit Index (PNFI) > 0.50, the Tucker–Lewis Index (TLI) > 0.90, and the Root Mean Square Error of Approximation (RMSEA) < 0.08 (Norouzinia et al., 2024).

3.4 Convergent validity

The Fornell and Larcker methodology was employed to evaluate convergent and discriminant validity (Fornell & Larcker, 1981). In this method, the Average Variance Extracted (AVE) and Composite Reliability (CR) are computed for each construct. Convergent validity is considered to be established when the AVE exceeds 0.50, indicating that, on average, the construct explains more than half of the variance in its indicators. In addition, a CR value above 0.70 is required to demonstrate that the construct has acceptable internal consistency and reliability (Fornell & Larcker, 1981; Pahlevan Sharif & Sharif, 2020). According to the Fornell–Larcker approach, the square root of the Average Variance Extracted (√AVE) for each factor should be greater than its correlations with other factors, indicating that each factor shares more variance with its own indicators than with other factors. In addition, the Maximum Shared Variance (MSV) and Average Shared Variance (ASV) should be lower than the corresponding AVE values to support discriminant validity (Norouzinia et al., 2024; Karaman, 2023).

3.5 Reliability assessment

Internal consistency was assessed using Cronbach's alpha (α), while scale reliability was further evaluated through Composite Reliability (CR) and Maximum Reliability (Max H). For all three indices, values greater than 0.70 were considered indicative of acceptable reliability (Sharif Nia et al., 2019).

3.6 Ethical consideration

Ethical approval was obtained from the Ethics Committee of Alborz University of Medical Sciences (code: IR.ABZUMS.REC.1403.171). Participants were informed about the study's purpose, their right to withdraw, and the confidentiality of their data. Consent was implied through the voluntary completion of the online questionnaire.

4 Results

4.1 Participant characteristics

The questionnaire was viewed by 652 individuals, of whom 436 nursing students completed it, resulting in a response rate of 66.87%. The average age of respondents was 22.55 years (SD = 3.97), with 64.4% identifying as female. Most participants (84.6%) were enrolled in a bachelor's program, and 28.2% were in their fourth semester. A majority reported familiarity (66.7%) and prior experience (88.1%) with the metaverse, while 28.7% indicated using the internet for approximately four hours per day.

4.2 Content and face validity

All items demonstrated strong content validity, with CVR values ≥ 0.80 and I-CVI scores exceeding 0.80. The average S-CVI/Ave was 0.95, and modified kappa coefficients were all ≥ 0.79, indicating high agreement among experts.

4.3 Exploratory factor analysis

The KMO value was 0.87, and Bartlett's test was statistically significant (χ^2 = 3267.386, $p < 0.001$), confirming the adequacy of the data for factor analysis. EFA revealed a four-factor structure—Education, Technology, Lifestyle, and Challenges—consistent with the original scale. These factors accounted for 67.08% of the total variance. Item loadings ranged from 0.573 to 0.840, with all items exceeding the 0.50 threshold, indicating strong item-factor alignment.

(see Table 1).

4.4 Confirmatory factor analysis

The initial confirmatory factor analysis (CFA) of the 24-item version revealed suboptimal fit indices. Following the removal of four items (Education: items 4 and 8; Lifestyle: item 2; Challenges: item 5), the revised 20-item model demonstrated good fit. To further improve model fit, covariances were specified between certain item error terms: e1 and e2, and e2 and e6 within the Education factor, as well as e9 and e10 within the Technology factor. The final CFA model yielded the following fit indices: χ^2/df = 1.647, IFI = 0.958, TLI = 0.950, CFI = 0.958, and RMR = 0.051 — all indicating a good fit and confirming the robustness of the four-factor structure. Additional indices also met acceptable fit criteria: GFI = 0.891, AGFI = 0.858, NFI = 0.900, and RMSEA = 0.054. Reverse coding was applied when calculating the mean score for the Challenges factor (see Table 2; Fig. 1).

Table 1 Descriptive statistics, and factor loadings of the Persian metaverse perception scale items (N=216)

Item Code	M±SD	Skewness	Kurtosis	CTC*	CAD	Factor Loading	Eigenvalue	Explained Variance (%)
Education							**7,67**	**31.98**
E1	3.83±0.83	−0.532	−0.113	0.809	0.931	0.840		
E6	3.84±0.85	−0.539	−0.339	0.810	0.931	0.824		
E2	3.76±1.00	−0.463	−0.283	0.812	0.931	0.823		
E9	3.88±0.83	−0.632	0.054	0.779	0.933	0.803		
E4	3.66±0.88	−0.205	−0.703	0.791	0.932	0.791		
E5	3.57±0.90	−0.689	0.208	0.750	0.935	0.775		
E7	3.87±0.86	−0.162	−0.684	0.773	0.933	0.766		
E8	3.92±0.88	−0.152	−0.731	0.752	0.934	0.742		
E3	3.66±0.90	−0.456	−0.478	0.689	0.939	0.692		
Technology							**3.299**	**13.74**
TEC3	3.83±0.85	−0.494	−0.240	0.756	0.854	0.807		
TEC2	3.87±0.95	−0.418	−0.805	0.746	0.858	0.776		
TEC5	3.99±0.80	−0.408	−0.382	0.728	0.861	0.728		
TEC4	3.91±0.83	−0.596	0.221	0.723	0.862	0.725		
TEC1	4.11±0.81	−0.629	−0.151	0.681	0.872	0.696		
Lifestyle							**2.961**	**12.33**
LS4	4.03±0.76	0.688	−0.061	0.761	0.831	0.821		
LS1	3.89±0.84	0.281	−0.785	0.731	0.836	0.788		
LS5	3.91±0.89	0.682	−0.047	0.680	0.849	0.717		
LS2	3.98±0.76	0.423	−0.393	0.683	0.848	0.715		
LS3	3.78±0.94	0.391	−0.506	0.655	0.857	0.674		
Challenges							**2,164**	**9.01**
CH2	2.27±0.94	−0.283	−0.146	0.705	0.761	0.796		
CH4	2.06±0.91	−0.491	0.264	0.662	0.774	0.727		
CH1	2.46±1.02	−0.396	−0.445	0.624	0.786	0.717		
CH3	2.44±1.00	−0.428	−0.370	0.613	0.789	0.676		
CH5	1.90±0.82	−0.485	−0.314	0.482	0.822	0.573		

*Note. *CTC* Corrected Item-Total Correlation, *CAD* Cronbach's Alpha if Item Deleted. Factor loadings are based on exploratory factor analysis with Varimax rotation. Items were retained based on loadings≥0.50. Eigenvalues>1 were used to extract factors

Table 2 Model fit indices for confirmatory factor analysis of the metaverse perception scale ($n = 220$)

Model Version	χ^2/df	CFI	TLI	IFI	NFI	GFI	AGFI	RMR	RMSEA (90% CI)
Original (24 items)	2.004	0.838	0.912	0.923	0.857	0.922	0.800	0.064	0.068 (0.059–0.076)
Revised (20 items)	1.647	0.958	0.950	0.958	0.900	0.891	0.858	0.051	0.054 (0.042–0.066)

*Note. *χ^2/df* chi-square/degree of freedom ratio, *CFI* Comparative Fit Index, *TLI* Tucker–Lewis Index, *IFI* Incremental Fit Index, *NFI* Normed Fit Index, *GFI* Goodness-of-Fit Index, *AGFI* Adjusted GFI, *RMR* Root Mean Square Residual, *RMSEA* Root Mean Square Error of Approximation. Acceptable fit: CFI/TLI/IFI > 0.90, RMSEA < 0.08, χ^2/df < 3

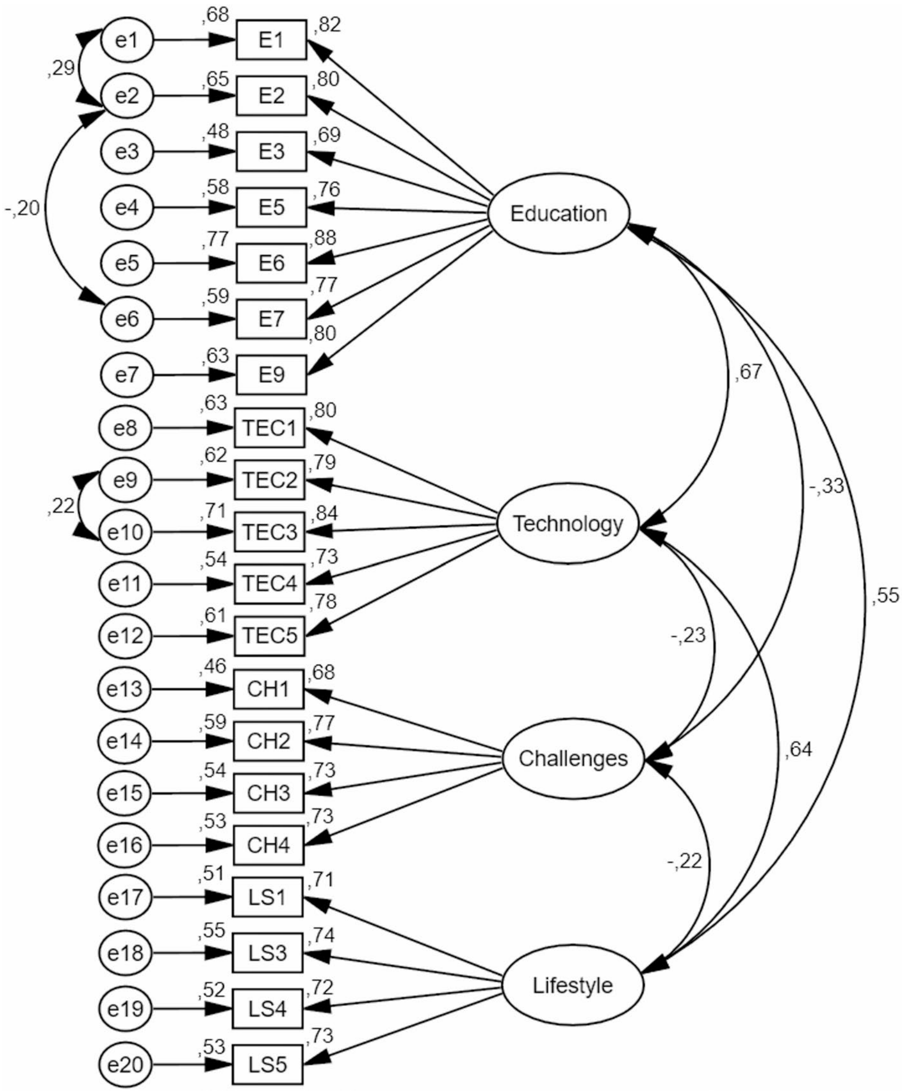

Fig. 1 The CFA structure the metaverse perception scale for nursing students ($N = 220$)

Table 3 Reliability indices, convergent and discriminant validity of the metaverse perception scale dimensions

	Reliability Indices		Convergent Validity		Discriminant Validity		
Factor	α	MaxR(H)	AVE	CR	√AVE	MSV	ASV
Education	0.917	0.946	0.624	0.920	0.790	0.454	0.289
Technology	0.890	0.904	0.621	0.891	0.788	0.454	0.305
Lifestyle	0.830	0.890	0.526	0.816	0.725	0.407	0.254
Challenges	0.822	0.899	0.529	0.818	0.727	0.106	0.069

*Note. *α* Cronbach's alpha, *CR* Composite Reliability, *AVE* Average Variance Extracted, *√AVE* square root of AVE, *MaxR(H)* Maximum Reliability, *MSV* Maximum Shared Variance, *ASV* Average Shared Variance. Convergent validity is supported if AVE > 0.50 and CR > 0.70. Discriminant validity is met when √AVE > inter-factor correlations

4.5 Convergent and discriminant validity

All factors demonstrated acceptable convergent validity, with Average Variance Extracted (AVE) values > 0.50 and Composite Reliability (CR) values > 0.70. As shown in Table 3, for all factors, √AVE values exceeded inter-construct correlations, and both MSV and ASV were lower than AVE, supporting discriminant validity.

4.6 Internal consistency and reliability

The Cronbach's alpha was between 0.917 and 0.822. Composite Reliability (CR) and Max H values across all dimensions exceeded 0.80, indicating strong internal consistency and structural reliability (see Table 3).

5 Discussion

Studies have shown that the metaverse has played a significant role in the fields of health and education, particularly in medical and nursing education. As a virtual, three-dimensional, and interactive environment, the metaverse—utilizing technologies such as Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR)—provides learners with a safe, controlled, and repeatable space for practicing clinical skills, simulating real-life scenarios, and engaging in interactive learning (De Gagne et al., 2023; Popov et al., 2024; Lewis et al., 2024). Common applications of the metaverse in healthcare include anatomy education using AR, advanced clinical simulations, physical and mental rehabilitation, remote surgery, and psychological care (De Gagne et al., 2023; Bansal et al., 2022). This technology not only enhances interaction and spatial understanding but also boosts learners' confidence and offers a more hands-on learning experience compared to traditional methods (De Gagne et al., 2023; Henssen et al., 2020).

Research has further indicated that metaverse environments, through realistic simulations, can liberate the learning process from temporal and spatial constraints, shorten the learning curve, and enhance educational effectiveness over time (Ghaempanah et al., 2024). For instance, in an experimental study, nursing students who practiced clinical skills—such as nasogastric tube insertion or catheterization—using VR demonstrated superior performance compared to the control group (Yoon et al., 2024). Additionally, virtual patient simulations within the metaverse provide opportunities for practicing communication skills; findings from systematic reviews also confirm that virtual reality positively impacts the improvement of nursing students' communication abilities (Cho et al., 2024).

Despite these advantages, several challenges hinder the widespread adoption of this technology. Issues such as concerns over data privacy, the lack of unified standards, relatively high costs, and the need for advanced technological infrastructure pose significant barriers (Gao et al., 2023; Bansal et al., 2022). Moreover, some studies have pointed to theoretical and interdisciplinary gaps in this area, emphasizing the need to develop conceptual frameworks, consider the psychological consequences of metaverse use, and formulate ethical policies for this environment (Gao et al., 2023; Narin, 2021).

In summary, the metaverse—as an emerging technology—is redefining methods of education and healthcare delivery and holds substantial potential for improving the quality of learning in medical and nursing sciences (De Gagne et al., 2023; Gao et al., 2023; Bansal et al., 2022). However, its effective and sustainable use requires the development of reliable tools to assess users' experience and perception. In this context, the present study aimed to validate the Metaverse Perception Scale for Nursing Students and to evaluation its psychometric properties.

Demographic findings indicated that most nursing students were familiar with the metaverse and had experience using it. They were also frequent internet users. This suggests a high level of digital readiness in this group, highlighting the practical significance and applicability of exploring their perceptions of the metaverse.

Exploratory factor analysis confirmed the initial four-factor structure of the scale—education, technology, lifestyle, and challenges—which together explained over 68% of the total variance. In the original study by Yıldırım and Karaman (2024), who developed the scale, these four factors accounted for 77.28% of the total variance.

In the confirmatory factor analysis (CFA), the model fit indices were not satisfactory when retaining all items. However, after removing four items (E4, E8, LS2, and CH5), the four-factor model was confirmed. The revised model showed acceptable to good fit indices, indicating that the proposed factor structure aligned well with the data. The factor loadings exceeded the recommended minimum thresholds, demonstrating strong correlations between items and their corresponding factors. The scale also exhibited high internal consistency; Cronbach's alpha coefficients for the four factors indicated excellent reliability.

Convergent and discriminant validity were also confirmed. A noteworthy finding was the negative correlation between the "Challenges" factor and the other three factors (Education, Technology, and Lifestyle), suggesting that students who perceived more challenges had less favorable attitudes toward the educational and technological benefits of the metaverse. This has implications for educational planning, as reducing perceived challenges could enhance students' acceptance and engagement in metaverse-based learning environments.

During the psychometric evaluation of the scale assessing nursing students' perceptions of Metaverse applications in medical education in Iran, two items from the education dimension—"Metaverse applications strengthen professional skills/competencies such as professionalism and autonomy" and " Metaverse strengthens clinical decision-making"—were removed during CFA. This may reflect differing cultural and educational interpretations of abstract concepts such as "professionalism" or "clinical decision-making," especially considering that many Iranian students had limited practical experience with technology-based environments. It is also possible that a more profound experiential foundation or direct instruction through the metaverse is needed for better conceptual understanding. This finding suggests the need for newly designed items that align more closely with the lived experiences and educational expectations of students in Iranian learning contexts.

In the Technology dimension of the scale, all five designed items were retained in the final model. These items covered concepts such as the integration of physical and virtual worlds, immersive experiences, and the innovative solutions offered by the metaverse, all of which are consistent with the technological nature of this platform. The validation of these items indicates that students predominantly perceive the metaverse as an emerging and transformative technology with the potential to bring about fundamental changes in education and professional lifestyle. Moreover, this accurate and positive perception of metaverse features among respondents could promote its wider acceptance in future educational settings. Thus, the technology dimension demonstrated not only statistical reliability but also conceptual alignment with expectations and realities of digital transformation in education.

In the Challenges dimension, four items reflecting the negative consequences of this technology were validated, while the item—"The lack of necessary infrastructure and equipment for Metaverse limits accessibility"— was removed during CFA. This may suggest that from the students' perspective, concerns about physical and mental health, privacy, and social impacts of the metaverse are more pressing than technical or infrastructural barriers. The removal of the infrastructure-related item might also reflect the specific context of the respondents, who may not have directly experienced equipment shortages or may not view them as significant obstacles. Conversely, the retention of items addressing issues such as privacy threats, negative health impacts, and social isolation indicates students' awareness of the potential risks of the metaverse, which should be considered in the design of educational interventions based on this technology. Therefore, the challenges dimension effectively captured critical concerns regarding metaverse use, although further exploration of technological barriers remains recommended.

In the Lifestyle dimension, four of the five designed items were confirmed. The only item removed was —"Metaverse allows for presence in a new virtual world through avatars"—. This removal may reflect students' limited familiarity with personalized and digital embodiment aspects of the metaverse, which typically require hands-on experience and direct interaction with advanced platforms. In contrast, the remaining items—focusing on elimination of time and space constraints, facilitation of social interactions, and participation in diverse events—indicate that students perceive the metaverse as an effective tool for enhancing digital lifestyle, particularly in areas of education, work, and social engagement. This finding suggests that students view the metaverse as having the capacity to transform daily routines and provide new opportunities for individual and collective activities; however, a more accurate understanding of abstract concepts such as digital embodiment may require additional training and exposure.

During confirmatory factor analysis, modification indices suggested residual covariation between a small number of item pairs (e1–e2, e2–e6 within the Education factor, and e9–e10 within the Technology factor). We allowed these covariances on substantive grounds (not solely data-driven), since the paired items share closely related wording and conceptual content. These limited adjustments yielded a clear improvement in global fit while leaving standardized factor loadings and reliability estimates essentially unchanged, indicating that the latent factor structure remained robust. We therefore retained the conservative modifications; future studies may reassess these items and consider minor rewording if similar residual covariation recurs.

Overall, the results demonstrated that the scale possesses a robust factor structure, high reliability, and satisfactory levels of convergent and discriminant validity, supporting its use as a valid and reliable instrument for assessing nursing students' perceptions of the metaverse.

As the instrument has not yet been translated and psychometrically evaluated in other languages, comparisons with other studies were not possible.

6 Conclusion

Overall, the Metaverse Perception Scale used in this study demonstrated satisfactory psychometric properties and can serve as a comprehensive and reliable tool for assessing nursing students' attitudes toward the metaverse in educational settings. With the rapid advancement of virtual and augmented reality technologies, instruments such as this scale can play a significant role in evaluating and guiding the effective integration of these technologies in nursing education.

6.1 Practical implications

Baseline needs assessment The P-MPS can be used to gauge students' readiness, perceived educational benefits, and key concerns such as privacy or health risks. This allows curriculum design to be informed by actual student needs rather than assumptions.

Evaluation of pilot modules By administering the scale before and after metaverse-based learning experiences, institutions can measure changes in student attitudes and compare the effectiveness of different instructional approaches.

Targeted training and support Subscale results can guide faculty development and student orientation. For example, low scores in the "Technology" domain may indicate a need for technical training, while high scores in "Challenges" may highlight the importance of addressing privacy or ergonomic issues.

Resource planning and policy development Aggregated data from the P-MPS can support decisions about hardware investment, technical support, and the creation of data protection and acceptable-use policies.

Monitoring equity and quality Disaggregating results by region or institution type can help identify disparities in readiness. Incorporating the P-MPS into program evaluations or accreditation processes enables ongoing monitoring of metaverse integration across diverse contexts.

Study limitations This study had several limitations. First, the sample consisted exclusively of nursing students, which may restrict the generalizability of the findings to other academic disciplines. Second, the cross-sectional design did not allow for the examination of changes in perception over time. Third, the instrument relied solely on self-report data, which may be subject to response biases such as social desirability or recall error. Finally, concurrent validity testing was not conducted, limiting the ability to compare the scale's performance against other established measures. Therefore, future research is recommended to validate the scale among students from diverse academic backgrounds, explore longitudinal trends in metaverse-related perceptions, and assess the impact of actual metaverse use on learning outcomes across different student populations.

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Data availability The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Compliance with ethical standards The research procedures comply with ethical principles for research with human participants consistent with the 1964 Helsinki Declaration and its later amendments and comparable ethical standards. Ethical approval for this study was obtained from the Ethics Committee of Alborz University of Medical Sciences (code: IR.ABZUMS.REC.1403.171) before the data collection took place. All participants voluntarily participated in the study with the assurance of confidentiality and anonymity of responses. Participants were informed about the study's purpose, their right to withdraw, and the confidentiality of their data. Consent was implied through the voluntary completion of the online questionnaire.

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