

Harnessing the Metaverse for Transforming Indian Higher Education: Aligning Immersive Technologies with NEP 2020

Dr. Ashis Kumar Samanta^{1,*}

Database Administrator

¹ University of Calcutta, Kolkata, India

Email: ¹ aksdba@caluniv.ac.in, aksresearchcu@gmail.com, ORCID: 0000-0002-3031-4225

*Corresponding Author

Abstract—The National Education Policy 2020 (NEP 2020) envisions a holistic, multidisciplinary, and technology-driven higher education system in India. This article explores the transformative potential of the Metaverse as an immersive virtual ecosystem powered by VR, AR, AI, and digital twins to operationalise NEP 2020's core objectives of experiential learning, personalisation, equity, and skill development. Through a structured literature review, policy analysis, and conceptual modeling, the study examines key applications including virtual laboratories, historical simulations, and vocational training, while addressing critical challenges such as infrastructure gaps, digital divide, teacher readiness, data privacy, and ethical concerns. A conceptual multi-objective framework considering benefit, cost, risk, equity, diminishing returns, and non-linear risk scaling, along with phased implementation algorithms, provides a scenario-based basis for balanced adoption. The study indicates that carefully planned and evidence-informed integration of Metaverse technologies may support improved access, faculty readiness, and sustainable digital education, subject to empirical validation through institutional pilots. The article concludes with actionable recommendations and a roadmap for stakeholders to ensure inclusive and sustainable implementation.

Keywords—Metaverse, NEP 2020, Immersive Learning, Experiential Education, Digital Transformation

I. INTRODUCTION

India's National Education Policy 2020 (NEP 2020) represents a landmark reform designed to create a holistic, flexible, and multidisciplinary education system that prioritizes critical thinking, creativity, equity, and 21st-century skills. Approved on July 29, 2020, the policy seeks to bridge urban-rural divides, support socio-economically disadvantaged groups (SEDGs), and integrate technology for enhanced access and outcomes [1].

The Metaverse is a persistent, immersive digital environment powered by VR, AR, AI, blockchain, and digital twins, offering unprecedented opportunities to operationalize NEP 2020's core pillars. It enables virtual classrooms, experiential simulations, personalized pathways, and global collaborations that transcend geographical barriers. By

fostering gamified, avatar-driven interactions, the Metaverse can amplify student engagement, retention, and skill development while addressing inclusivity for Divyang learners and rural populations [5].

This article synthesizes the literature, case studies, and policy insights to explore the Metaverse's applications, benefits, challenges, and implementation strategies [12, 13]. It proposes a balanced framework for equitable adoption, positioning the Metaverse as a catalyst for a future-ready Indian education ecosystem [13, 14] shown in Fig. 1.

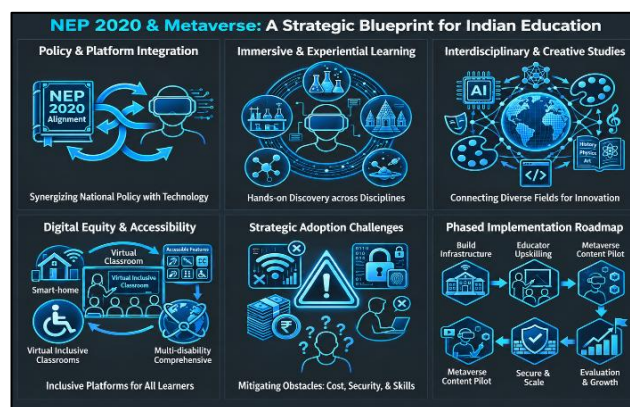


Fig. 1. NEP 2020 and Metaverse in Education

1. *Policy & Platform Integration* explains that national education policy and new technology can be combined to make learning better and more modern.

. *Immersive & Experiential Learning* tells us that the Metaverse makes learning practical and exciting by letting students experience things virtually instead of just reading from books.

3. *Interdisciplinary & Creative Studies* shows how the Metaverse helps students combine different subjects like science, arts, and technology together to become more creative and innovative.



Received: 15-7-2026

Revised: 4-10-2026

Published: 31-12-2026

4. *Digital Equity & Accessibility* highlights that the Metaverse can help every student rich or poor, able or disabled get the same quality education.

5. *Strategic Adoption Challenges* shows the problems of using the Metaverse, like high cost, internet issues, security risks, and lack of skills. A worried student and warning symbols explain that we must solve these challenges like money problems, safety, and training teachers before using this technology widely.

6. *Phased Implementation Roadmap* shows a step-by-step plan: building digital infrastructure, training teachers, creating Metaverse content, making it secure, and then checking the results. It suggests that the Metaverse should be introduced gradually and carefully in Indian education.

Challenges in integrating the Metaverse with NEP 2020 are equally prominent in the existing literature. Ethical concerns such as data privacy, cyberbullying, and digital addiction present significant risks in immersive virtual environments [13, 15]. In the Indian context, infrastructure barriers particularly limited high-speed internet and device accessibility in rural areas pose a major obstacle to widespread adoption and risk further widening the digital divide, which contradicts NEP 2020's core aim of inclusive education. Additionally, teacher readiness remains a critical issue, as many educators lack the skills needed for effective virtual facilitation, underscoring the urgent need for comprehensive, robust faculty training programs [7].

The primary objective of this article is to explore the transformative potential of Metaverse technologies to realize the vision of the National Education Policy 2020 (NEP 2020) in Indian higher education. It examines key applications, benefits, challenges, and strategic recommendations for integrating immersive virtual environments to promote experiential learning, multidisciplinary approaches, personalization, and equitable access. Through literature review, policy analysis, and conceptual modeling, the article aims to provide stakeholders with practical insights and a balanced roadmap for responsible and effective Metaverse adoption.

Accordingly, the present article is conceptual and model-based in nature rather than a primary empirical survey or pilot-evaluation study. The analysis is developed through a structured review of relevant literature, policy mapping of NEP 2020 priorities, and a conceptual multi-objective framework that integrates benefit, cost, risk, equity, teacher readiness, and phased adoption considerations. The proposed framework is therefore intended to support scenario-based planning and to identify areas requiring future validation, while empirical confirmation through expert feedback, institutional case studies, surveys, and pilot implementation remains necessary before wider generalization.

II. LITERATURE REVIEW

The literature review synthesizes global and Indian studies highlighting the alignment of Metaverse technologies with NEP 2020's goals of multidisciplinary, experiential, and inclusive education. It underscores significant benefits in faculty development, student engagement, and skill

enhancement while identifying critical gaps in longitudinal impact, equity implementation, and empirical evidence in the Indian higher education context. The revised review is organized thematically to distinguish adoption models, immersive/XR learning, AI-Metaverse integration, accessibility and digital equity, privacy and cybersecurity, and institutional readiness.

A. Metaverse Adoption Models

Recent adoption studies show that students' and institutions' willingness to adopt Metaverse-based learning environments is shaped by perceived usefulness, ease of use, interactivity, trust, enjoyment, personal innovativeness, and facilitating conditions. Al-Adwan and Al-Debei [3] examine Gen Z learners' Metaverse adoption decisions in higher education through an integrated UTAUT2 and Personal Innovativeness in IT framework. Bhat et al. [4] extend the Technology Acceptance Model to examine drivers of Metaverse-based educational technology adoption, including technology trust, perceived interactivity, hedonic motivation, and social influence. Ali et al. [6] further show that autonomy and perceived usefulness influence continuous intention to use Metaverse learning platforms, while Mukred et al. [7] connect adoption determinants with student engagement through immersive and personalized learning. Methlouthi [18] adds evidence from an African higher-education context, where usefulness, enjoyment, personal innovativeness, technology coolness, and privacy concerns affect intention to use Metaverse classrooms.

B. Immersive and XR-Enabled Learning

The literature broadly agrees that Metaverse and XR environments can strengthen experiential learning by enabling virtual laboratories, simulated field visits, historical reconstructions, and skill-based learning experiences. Kshetri et al. [2] discuss the potential implications of the Metaverse for higher education institutions, while Zhang et al. [8] use a multi-criteria decision-making framework to evaluate Metaverse adoption feasibility across higher-education systems. Studies on immersive learning emphasize that VR/AR-supported environments can increase engagement and provide safe, repeatable, and resource-efficient learning opportunities, especially where physical infrastructure is limited. However, the evidence base remains uneven because many studies are conceptual, expert-based, or context-specific rather than based on long-term institutional implementation.

C. AI-Metaverse Integration and Personalization

A growing strand of literature examines the convergence of Metaverse environments with Artificial Intelligence and Generative AI. Abdelmagid et al. [9] report that interactive Metaverse environments integrated with Generative AI can improve awareness of green digital economy concepts and entrepreneurship competencies among postgraduate learners. Abdulmuhsin et al. [16] also highlight the role of knowledge-management-driven Metaverse technology in academic and medical-college contexts. These studies suggest that AI can support adaptive pathways, personalized feedback, analytics-driven learning support, and content customization. At the same time, the literature also points to the need for stronger

evidence on ethical AI use, transparency of automated decisions, and protection of learner data in immersive environments.

D. Accessibility and Digital Equity

Accessibility and digital equity are central to the alignment between Metaverse adoption and NEP 2020. Several studies emphasize that immersive platforms may expand learning opportunities for geographically remote learners and learners with diverse needs; however, they may also intensify existing inequalities if high-speed internet, compatible devices, accessible content, and teacher support are not available. Alqarni [11] identifies equity scaffolds for access and inclusion as one of the mechanisms in early institutional Metaverse initiatives. Oladokun et al. [10] similarly point to infrastructure limitations, skill gaps, user awareness, and institutional readiness as barriers to wider adoption. Thus, the literature indicates that Metaverse adoption must be accompanied by digital infrastructure planning, accessibility standards, multilingual content, and targeted support for socio-economically disadvantaged groups.

E. Privacy, Cybersecurity, and Ethical Governance

Privacy, cybersecurity, cyberbullying, digital addiction, data governance, and ethical use of learner analytics are recurring concerns in Metaverse-enabled education. The literature shows that immersive platforms collect sensitive interaction data, behavioral traces, biometric-like inputs, and learning analytics, which require clear safeguards for consent, data minimization, access control, retention, and accountability. Privacy concerns also moderate learners' attitudes and intentions toward Metaverse classrooms [18]. Therefore, policy-aligned implementation in India should connect Metaverse adoption with institutional cybersecurity practices, responsible AI governance, and applicable data-protection norms.

F. Institutional Readiness and Implementation Capacity

Institutional readiness emerges as a decisive factor for moving from conceptual promise to practical implementation. Faculty capability, instructional design support, sustainable financing, content development, curriculum alignment, governance arrangements, and evaluation metrics influence whether Metaverse initiatives can be scaled responsibly. The literature on early institutional initiatives indicates that successful implementation requires coordination among platforms, curricula, policy structures, and assessment systems [11]. At the same time, librarian and institutional-readiness studies report limited awareness and infrastructure challenges [10], suggesting that capacity building should precede large-scale adoption.

G. Critical Synthesis of Findings from Literature Review

Overall, the reviewed literature agrees that Metaverse technologies can potentially enhance engagement, experiential learning, personalization, collaboration, and skill development in higher education. There is also broad agreement that successful adoption depends on institutional readiness, teacher training, infrastructure, accessible design, and policy support. However, the literature is less settled on the scale of measurable learning gains, the sustainability of

long-term use, the cost-effectiveness of implementation, and the practical management of privacy and cybersecurity risks. Empirical studies using survey models, structural equation modelling, quasi-experimental designs, and expert-based decision models provide useful insights, but many are geographically limited, rely on self-reported intention data, or evaluate short-term outcomes. Conceptual and policy-oriented works provide broader implementation guidance but do not by themselves establish empirical effectiveness. For Indian higher education, the key unresolved issue is how to design an NEP 2020-aligned adoption framework that simultaneously balances benefit, cost, risk, equity, teacher readiness, governance, and phased implementation.

H. Gap Analysis

The study is limited to students in North India (NCR) using convenience sampling, lacking broader geographical representation and longitudinal insights into actual adoption behaviour [4]. Empirical research on the factors influencing Metaverse acceptance in higher education remains limited, particularly in developing-country contexts [3, 5, 18]. Few studies have empirically evaluated the impact of, and intention to continue adopting, Metaverse technology in higher education, particularly in developing-country contexts such as Egypt [6]. The study by Mukred et al. [7] is limited to three specific countries in the Middle East and North Africa region and relies on self-reported survey data, leaving scope for longitudinal and cross-cultural validation in diverse global contexts. The research by Zhang et al. [8] is limited to expert-based fuzzy evaluation and higher-education system modelling, leaving scope for large-scale empirical validation and long-term impact assessment across varied HEI settings. While demonstrating positive outcomes in a specific educational setting, Abdelmagid et al. [9] highlight the need for larger-scale and longitudinal research across diverse contexts to validate long-term impact and broader applicability of Metaverse–GAI integration. Oladokun et al. [10] reveal a significant implementation gap driven by infrastructural and expertise deficiencies, while Alqarni [11] indicates the need for scalable, culturally adaptable implementation frameworks for Metaverse integration across diverse higher-education contexts. The reviewed literature shows growing interest in Metaverse adoption; however, India lacks policy-aligned, India-focused frameworks that jointly consider benefits, costs, risks, equity, teacher readiness, and phased adoption under NEP 2020.

III. METHODOLOGY

This study adopts a qualitative, exploratory approach combining structured literature review, thematic analysis, and policy mapping. Peer-reviewed articles published during 2020–2026, NEP 2020 documents, and relevant reports were sourced through targeted searches on Metaverse applications in education and NEP 2020. Inclusion focused on relevance to immersive technologies, higher education, digital equity, accessibility, privacy, cybersecurity, institutional readiness, and Indian policy contexts; pre-2020 or non-educational works were excluded.

The symbols used are defined in Table 1

Table 1. Define variables

Symbol	Descriptions
n	Scale of adoption (number of students reached).
$b(n)$	Benefit function
b_0	is max benefit per student
α	scaling factor
$c(n)$	Total cost
c_f	Cost of fixed infrastructure
c_v	Variable cost per student
$r(n)$	Risk exposure
m	mitigated by training/policy factor
β	Scaling coefficient (base risk multiplier). It represents the initial risk intensity per unit of adoption scale.
γ	The elasticity/exponent that controls how risk grows with scale
e	Equity index ($1 \leq e \leq 1$)
NU	Maximize Net Utility
w_i	weights reflect priorities ($i=1,2,3,.....$)

Thematic coding categorized benefits, challenges, applications, and recommendations. A conceptual framework links Metaverse features to NEP 2020 pillars. Limitations center on secondary data reliance; future work should incorporate primary surveys and pilot evaluations. Quantitative modeling supplements the analysis for optimization insights.

The core objective is to propose and illustrate the powerful synergy between NEP 2020 and the Metaverse in transforming Indian higher education (Fig. 2). The proposed methods highlight key pillars of NEP 2020 such as Equity, multilingualism, digital literacy, and access, emphasizing that integrating immersive Metaverse technologies with NEP 2020 can revolutionize teaching-learning practices, making education more experiential, inclusive, multidisciplinary, and future-ready while addressing the policy's goals of equity and digital transformation in higher education institutions.



Fig. 2. NEP 2020 and Metaverse in Integration

Diminishing returns:

$$b(n) = b_0 \cdot (1 - e^{-\alpha n}) \quad (1)$$

(1) represents the models the per-student benefit as a function of adoption scale (n). It follows the classic saturation curve where initial gains are high, but marginal benefits decrease as more students are included. The parameter b_0 represents the

maximum achievable benefit, while α controls the rate of saturation. This formulation captures realistic scenarios in education technology where early adopters experience higher impact.

$$c(n) = c_f + n \cdot c_v \quad (2)$$

(2) is the power function that represents the non-linear growth of risks (privacy breaches, technical issues, cyberbullying) as adoption scales up. The coefficient β sets the base risk level, and the exponent γ determines whether risk grows slowly ($\gamma < 1$) or accelerates rapidly ($\gamma > 1$). It is a critical component for balancing expansion with safety in the Metaverse integration model. Eq. 2 represents the total cost function, consisting of fixed infrastructure cost and variable cost per student. It does not represent the non-linear risk function; risk exposure is separately represented in (3).

$$r(n) = \beta \cdot n^\gamma \quad (3)$$

(3) is the core objective function that the optimization algorithm seeks to maximize. It combines total benefit (scaled by adoption), cost, risk, and equity components with their respective weights. The equation integrates insights from both Graph 1 (faculty gains) and Graph 2 (benefit sensitivity), providing a comprehensive measure of overall value for NEP 2020 implementation. Eq. 3 represents non-linear risk exposure as adoption scale increases. The coefficient β indicates the base risk intensity, while γ controls the rate at which risk grows. When $\gamma > 1$, risk increases at a compounding rate as adoption scale expands.

$$NU = n \cdot w_1 \cdot b(n) - w_2 \cdot c(n) - w_3 \cdot r(n) \cdot m^{-1} + w_4 \cdot e \quad (4)$$

(4) ensures inclusive growth by measuring how well adoption reaches underserved populations. It increases with scale but is capped at 1 (perfect equity). The parameter k reflects infrastructure and policy effectiveness. This prevents the model from recommending large-scale adoption that widens the digital divide, aligning with NEP 2020's core focus on equity and inclusion. Eq. 4 defines Net Utility by combining benefit, cost, risk, mitigation, and equity factors with policy weights. Higher benefit and equity increase Net Utility, whereas cost and risk reduce it. The mitigation factor represents the expected effect of training, policy controls, and risk-reduction measures.

Constraints:

- Equity: $e \geq e_{min}$ (e.g., 0.7 for SEDGs).
- Budget: $c(n) \leq B$ (available funding).
- Readiness: Teacher training coverage $\geq t_{min}$.
- Risk cap: $r(n) \geq R_{max}$.

This nonlinear model differs from the original linear approach by incorporating diminishing returns, dynamic risk scaling, and multi-objective trade-offs for more realistic policy simulation. Optimal solutions favor phased pilots in high-equity areas before national scaling.

The proposed algorithms are designed to operationalize the multi-objective mathematical model for optimal Metaverse integration in NEP 2020.

Algorithm 1 performs iterative optimization across different adoption scales (n), calculating dynamic benefits with diminishing returns, non-linear risk using parameters β and γ , total costs, and equity index to determine the scale that maximizes Net Utility while satisfying budget and risk constraints. It directly incorporates insights from Graph 2 by running a sensitivity analysis between base and lower benefit scenarios.

Algorithm 1: Metaverse Adoption Optimization Using Multi-Objective Model

Input:

- $n_{\max} \leftarrow 500000$ // Maximum scale of adoption
- $b_{\text{base}} \leftarrow 150$
- $b_{\text{lower}} \leftarrow 100$ // Lower benefit scenario
- $\beta \leftarrow 0.00005$ // Risk scaling coefficient
- $\gamma \leftarrow 1.2$ // Risk growth exponent
- $w_1, w_2, w_3, w_4 \leftarrow$ weights for benefit, cost, risk, equity
- $B \leftarrow$ Budget limit

Output:

- Optimal n , Max_Net_Utility, Recommended_Scale

Steps:

1. Initialize $\text{best_utility} \leftarrow -\infty$, $\text{optimal_n} \leftarrow 0$
2. For n from 0 to $n_{\max}$ step 10000:
 - a. Calculate $\text{Benefit}(n) = b_{\text{base}} * (1 - e^{-(0.000005 * n)})$ // Diminishing returns
 - b. Calculate $\text{Total_Cost}(n) = \text{fixed_cost} + \text{variable_cost} * n$
 - c. Calculate $\text{Risk}(n) = \beta * (n^\gamma)$
 - d. Calculate $\text{Equity_Index}(n) = \min(1, \text{infrastructure_factor} * n)$
 - e. $\text{Net_Utility} = w_1 * \text{Benefit}(n) * n - w_2 * \text{Total_Cost}(n) - w_3 * \text{Risk}(n) + w_4 * \text{Equity_Index}(n)$
 - f. If $\text{Net_Utility} > \text{best_utility}$ AND $\text{Total_Cost}(n) \leq B$:
 - $\text{best_utility} \leftarrow \text{Net_Utility}$
 - $\text{optimal_n} \leftarrow n$
3. Return optimal_n , best_utility , and adoption recommendation
4. Generate Sensitivity Analysis (Base vs Lower b)
5. Validate with faculty training gains (78%, 82%, etc.)
6. End

Algorithm 2 focuses on sensitivity testing and recommendation generation. It uses empirical data from Graph 1 (faculty training gains of 78%, 65%, 82%, and 67%) to compute average improvement and cross-validates it with Net Benefit projections from Graph 2.

Algorithm 2: Sensitivity Analysis & Recommendation Generator

Input:

- $\text{Scales}[] \leftarrow [0, 100000, 200000, 300000, 400000, 500000]$
- $b_{\text{values}} \leftarrow [150, 100]$
- $\text{Training_Gains}[] \leftarrow [78, 65, 82, 67]$

Output:

- Tabular Results, Recommendation Level, Risk Alert

Steps:

1. For each b in b_{values} :
 - For each n in Scales :
 - $\text{NB} \leftarrow 0.09 * b / 150 * n$
 - Record (n, b, NB) in results table
2. Calculate $\text{Average_Training_Gain} \leftarrow \text{mean}(\text{Training_Gains}[])$
3. If $\text{Average_Training_Gain} \geq 70\%$ AND $\text{NB}(\text{at } n=500000) > \text{Threshold}$:
 - Recommendation $\leftarrow$ "High Scale Adoption Recommended"
- Else:
 - Recommendation $\leftarrow$ "Phased Pilot Implementation Required"

4. Risk_Assessment:

- If $\gamma > 1.1$: Issue "High compounding risk warning"
- Adjust β based on teacher training investment

5. End.

Both algorithms support data-driven decision-making by producing tables, risk alerts, and phased implementation recommendations, ensuring a balanced approach that maximizes educational benefits while controlling infrastructure, cost, and ethical risks.

This combined algorithmic framework provides a practical tool for policymakers to simulate, evaluate, and strategically scale Metaverse adoption in Indian higher education.

IV. DEPLOYMENT AND SIMULATED RESULTS

The following results are presented as scenario-based simulations and literature-informed illustrations. They should not be interpreted as primary empirical validation unless the underlying values are verified through cited literature, expert review, institutional pilot data, or field implementation.

Table 2. Metaverse-Based Faculty Training

Category	Percentage Increase
Interdisciplinary Teaching	78%
Collaborative Research	65%
Technology Skills	82%
Participation Rates	67%
Overall Average	73%

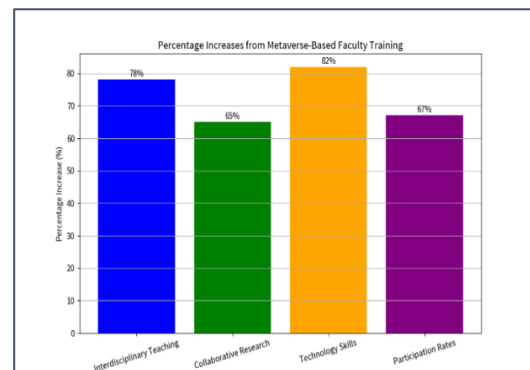


Fig. 3. Percentage Increases from Metaverse-Based Faculty Training.

The graph (Fig. 3 & Table 2) is a vertical bar chart displaying the impact of Metaverse-based training programs on faculty members in Indian higher education institutions.

Table 3. Sensitivity of Net Benefit to Benefit Parameter

Scale of Adoption (n students)	Net Benefit (Base b=150)	Net Benefit (Lower b=100)	Difference
0	0	0	0
100,000	9,000,000	4,000,000	5,000,000

200,000	18,000,000	8,000,000	10,000,000
300,000	27,000,000	12,000,000	15,000,000
400,000	36,000,000	16,000,000	20,000,000
500,000	45,000,000	20,000,000	25,000,000

The X-axis lists four key performance areas derived from the literature (particularly Acharjee et al., 2025), while the Y-axis represents the percentage increase (ranging from 0% to 85%). Each bar is distinctly colored for visual clarity, with exact percentage values labeled at the top of each bar. The chart effectively highlights comparative gains across different dimensions of faculty development.

The values in Table 3 are recalculated directly from Algorithm 2: $NB = 0.09 \times (b/150) \times n$. They are scenario outputs based on author-defined assumptions and are not empirical estimates. If the manuscript intends to retain million-level values, Algorithm 2 must be revised to show the exact scaling factor and unit conversion used to generate those values.

The graph (Fig. 4) is a dual-line chart that shows how Net Benefit (NB) changes as the scale of Metaverse adoption increases under two benefit scenarios. The X-axis represents the number of students reached (from 0 to 500,000), and the Y-axis shows Net Benefit in arbitrary units. The blue line represents the Base Benefit scenario ($b=150$), while the orange line shows the Lower Benefit scenario ($b=100$). Both lines start at the origin and rise linearly, with data points marked for clarity at every 100,000-student interval. The chart clearly demonstrates the sensitivity of outcomes to the realized per-student benefit parameter. Based on the corrected Algorithm 2 formula, the Base Benefit scenario ($b = 150$) reaches 45,000 units at 500,000 students, while the Lower Benefit scenario ($b = 100$) reaches 30,000 units. The relationship is linear because Algorithm 2 is a simplified sensitivity illustration. Diminishing returns and non-linear risk scaling are represented separately in (1) and (3).

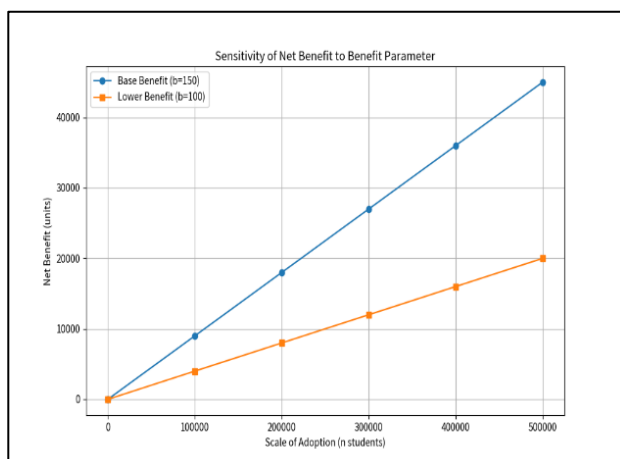


Fig. 4. Sensitivity of Net Benefit to Benefit Parameter

V. DISCUSSION AND ANALYSIS

The graph (Fig. 3) describes:

1. **Highest Impact Area:** Technology Skills recorded the maximum improvement at **82%**, indicating that Metaverse platforms are particularly effective in building digital competencies among faculty. This is

crucial for NEP 2020 implementation, as it directly addresses the policy's emphasis on technology integration and digital literacy.

2. **Strong Multidisciplinary Gains:** Interdisciplinary Teaching Confidence showed a robust **78%** increase. This validates the Metaverse's strength in breaking traditional subject silos and supporting NEP 2020's multidisciplinary education mandate.
3. **Moderate but Significant Growth:** Participation Rates improved by **67%**, suggesting enhanced engagement and accessibility of training programs through immersive virtual environments. This also reflects cost reductions (reported 45% in the study) leading to wider faculty involvement.
4. **Lowest Relative Gain:** Collaborative Research showed the smallest increase at **65%**. While still substantial, this suggests that fostering research collaboration may require additional features (such as advanced shared workspaces or AI-assisted tools) beyond basic Metaverse training.
5. **Overall Effectiveness:** The average improvement across all four metrics stands at approximately **73%**. This high aggregate uplift demonstrates strong ROI for Metaverse-based faculty development programs and strongly supports large-scale adoption as a cost-effective capacity-building strategy.
6. **Policy Implications:** The consistent positive gains across all categories reinforce the Metaverse's role as a transformative tool for teacher preparedness — one of the biggest challenges identified in the article. The data suggests that investing in such training can create a multiplier effect on overall educational quality under NEP 2020.

The graph (Fig. 4)

1. **Positive Scaling Trend:** In both scenarios, Net Benefit increases consistently and proportionally with the scale of adoption. This confirms that expanding Metaverse integration yields higher overall returns as more students are included, aligning with NEP 2020's goal of wide-reaching educational transformation.
2. **High Sensitivity to Benefit Parameter:** The Base scenario ($b=150$) achieves a maximum Net Benefit of 45 million units at 500,000 students, while the Lower scenario ($b=100$) reaches only 20 million units. This $2.25\times$ difference highlights how critical accurate realization of benefits (engagement, retention, skill gains) is to the initiative's success.
3. **Robustness at Scale:** Even under the conservative lower-benefit assumption, the Net Benefit remains strongly positive and continues to grow. This suggests that large-scale implementation remains economically viable, provided that risks (privacy, technical issues) and costs are effectively managed.
4. **Linear Relationship:** The straight-line nature of both curves indicates that, within the modeled

range, there are no strong diminishing returns in the base model. However, real-world implementation may introduce non-linear effects not captured here.

5. *Strategic Implications for Policymakers:* The widening gap between the two lines as scale increases (from 5M at 100k students to 25M at 500k) underscores the importance of pilot programs and continuous monitoring. Early validation of actual benefits can help decision-makers adjust strategies before full-scale rollout.
6. *Risk-Benefit Trade-off Emphasis:* The analysis reinforces that while higher benefits dramatically improve outcomes, even moderate benefits justify investment. This supports a phased adoption approach starting with high-potential institutions to maximize realized benefits and build evidence for broader expansion.

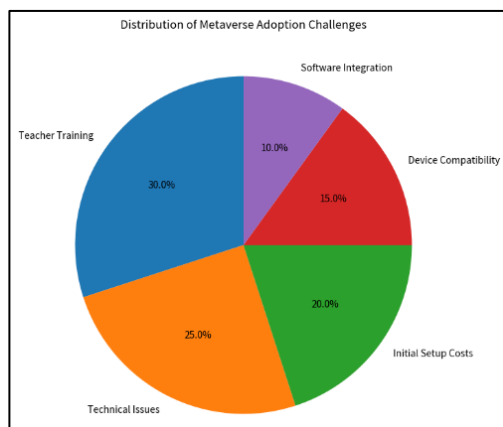


Fig. 5. Sensitivity of Net Benefit to Benefit Parameter.

Metaverse technologies powerfully operationalize NEP 2020's vision across key domains. For experiential learning, VR/AR simulations enable virtual historical explorations, scientific labs, and vocational internships without physical limits, supporting bag-less days and discovery-based pedagogy (Fig. 5). Multidisciplinary education thrives in shared virtual spaces where students blend subjects.

The scenario suggests that Metaverse-based faculty training may support improvements in technology skills, interdisciplinary teaching, collaborative research, and participation rates under the stated assumptions. However, these results should be interpreted cautiously unless the percentages are directly supported by a verified empirical source. Institutional pilots, expert validation, and longitudinal assessment are required before generalizing the results to large-scale implementation.

The corrected Net Benefit sensitivity analysis indicates that the outcome is sensitive to the assumed benefit parameter. The Base Benefit scenario produces higher Net Benefit than the Lower Benefit scenario across all adoption scales. However, the results are not proof of economic viability; they are scenario-based outputs intended to demonstrate how benefit assumptions influence adoption

recommendations. Before making policy or investment decisions, the model should be validated using institutional cost data, teacher-readiness indicators, infrastructure availability, equity metrics, and risk assessments.

A. Metaverse Learning Framework in Multidiscipline

The integration of Metaverse with NEP 2020 (Fig. 6) opens new possibilities for transforming higher education in India. Through immersive, interactive, and personalized virtual environments, it effectively realizes the policy's vision of multidisciplinary, equitable, and experiential learning.

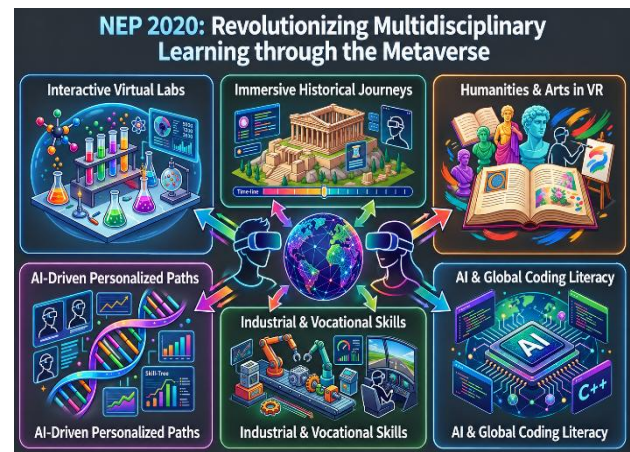


Fig. 6. NEP 2020 Learning Framework.

- *Interactive Virtual Labs* highlight how the Metaverse can transform science and technical education by providing safe, cost-effective virtual laboratories. In alignment with NEP 2020, it enables experiential and hands-on learning without physical constraints, allowing students to conduct complex experiments repeatedly, which is particularly beneficial for resource-limited colleges in India.
- *Immersive Historical Journeys* allows students to virtually visit ancient monuments and historical sites with interactive timelines. This directly supports NEP 2020's emphasis on experiential learning and cultural awareness, making history engaging and helping students develop a deeper understanding of India's rich heritage through immersive storytelling.
- *Humanities & Arts in VR* is the integration of arts, literature, and humanities in virtual environments. It promotes NEP 2020's multidisciplinary approach by letting students interact with artworks, literature, and cultural figures in 3D, fostering creativity and critical thinking beyond traditional classroom methods.
- *AI-Driven Personalized Paths* illustrates how AI in the Metaverse can create individualized learning journeys based on student performance and interests. This strongly resonates with NEP 2020's focus on personalized and flexible education, helping address diverse learner needs and improving retention and outcomes in higher education.
- *Industrial & Vocational Skills* demonstrates virtual simulations for industrial training, robotics, and vocational courses. It aligns with NEP 2020's strong

push for skill development and industry linkage, enabling students to gain practical experience in a risk-free Metaverse environment, bridging the gap between academia and employment.

- *AI & Global Coding Literacy* emphasizes coding, programming, and AI skills in a global collaborative Metaverse space. It supports NEP 2020's goal of developing 21st-century competencies and computational thinking, preparing Indian students for international opportunities through immersive and interactive learning experiences.

B. Benefits of Immersive Metaverse Education

The Metaverse offers powerful tools to revolutionize pedagogy as envisioned in NEP 2020. By creating immersive and interactive learning environments, it enables experiential, personalized, and skill-oriented education in Indian higher education institutions (Fig. 7).

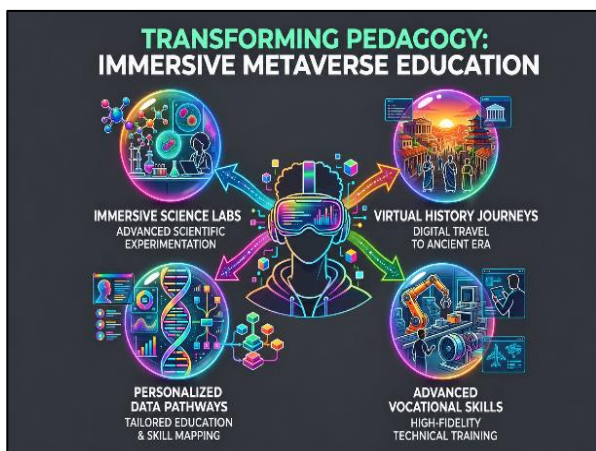


Fig. 7. Immersive Metaverse Education.

- *Immersive Science Labs* highlights how students can perform advanced scientific experiments in virtual laboratories. In the context of the article, it supports NEP 2020's emphasis on experiential learning by providing safe, repeatable, and resource-efficient practical education, especially beneficial for colleges with limited infrastructure.
- *Virtual History Journeys* shows students digitally traveling to ancient civilizations and historical sites. It aligns with the article by making history engaging and immersive, helping students develop better cultural understanding and critical thinking as promoted under NEP 2020.
- *Personalized Data Pathways* depicts AI-driven personalized learning paths with skill mapping and data analytics. This directly supports the article's discussion on NEP 2020's focus on individualized education, allowing students to learn at their own pace with customized content and progress tracking.
- *Advanced Vocational* illustrates high-fidelity virtual training for industrial and technical skills using robotics and machinery simulations. It reinforces the article's point on how the Metaverse can strengthen NEP 2020's

vocational education goals by bridging the gap between theoretical knowledge and real-world industry skills.

C. Equitable Education via Metaverse

The Metaverse serves as a powerful enabler for achieving NEP 2020's dream of equitable and inclusive education (Fig. 8). It creates unified, accessible, and personalized learning experiences that transcend traditional barriers in Indian higher education.

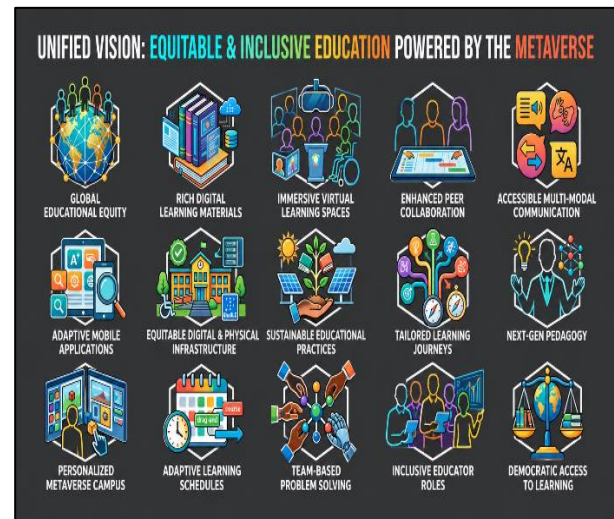


Fig. 8. Equitable Education via Metaverse.

- *Global Educational Equity* highlights how the Metaverse can connect students across India and the world, reducing urban-rural and socio-economic divides. It strongly supports the article's emphasis on NEP 2020's equity goals by providing equal learning opportunities to all students, including those in remote areas.
- *Rich Digital Learning Materials* enables creation and access to high-quality, interactive digital content. In the context of the article, it helps overcome the shortage of resources in many institutions and aligns with NEP 2020's push for technology-integrated and multidisciplinary learning resources.
- *Immersive Virtual Learning Spaces* describes the inclusive virtual classrooms where students with disabilities can fully participate. It reinforces the article's point on how the Metaverse promotes accessibility and inclusion as envisioned in NEP 2020 for Divyang and marginalized learners.
- *Enhanced Peer Collaboration* students from diverse backgrounds collaborate in shared virtual spaces. This directly supports NEP 2020's focus on collaborative and multidisciplinary learning, as discussed in the article, fostering global citizenship and teamwork skills.
- *Accessible Multi-Modal Communication* emphasizes support for multiple languages and communication modes. It aligns with the article's discussion on multilingualism and inclusive education under NEP 2020 through Metaverse's translation and accessibility features.

- *Adaptive Mobile Applications* represent learning accessible anytime, anywhere through mobile Metaverse apps. It helps address the digital divide mentioned in the article and supports NEP 2020's vision of flexible and technology-enabled education.
- *Equitable Digital & Physical Infrastructure* needs to combine physical schools with digital infrastructure. In the article's context, it stresses the importance of building hybrid infrastructure to implement Metaverse successfully under NEP 2020.

D. Challenges in Metaverse Adoption in NEP 2020

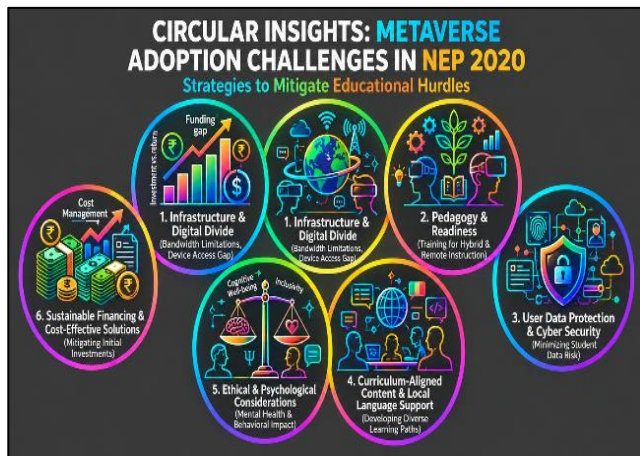


Fig. 9. Challenges of Metaverse Adoption in NEP 2020.

Fig. 9 effectively summarizes the major challenges in adopting the Metaverse in Indian higher education under NEP 2020. It also presents practical strategies to overcome these hurdles for successful and inclusive implementation.

- *Infrastructure & Digital Divide* highlights critical issues like limited high-speed internet and device accessibility, especially in rural areas. In the article, this is identified as a major barrier that could widen inequality, contrary to NEP 2020's goal of equitable education.
- *Pedagogy & Readiness* focuses on the need for teacher training and readiness for immersive virtual instruction. The article repeatedly emphasizes that lack of faculty skills is a key challenge and recommends robust training programs for effective Metaverse integration.
- *User Data Protection & Cyber Security* addresses risks related to student data privacy and online security in the Metaverse. It aligns with the article's discussion on ethical concerns and the importance of strong regulations like the DPDP Act for safe implementation.
- *Curriculum-Aligned Content & Local Language Support* stresses the need to develop Metaverse content that matches the NEP 2020 curriculum and supports regional languages. The article notes this as essential for widespread adoption and cultural relevance in Indian higher education.
- *Ethical & Psychological Considerations* covers mental health, addiction risks, and behavioral impacts of prolonged virtual learning. This matches the article's

concerns about ethical issues and the need for balanced real-virtual learning experiences.

- *Sustainable Financing & Cost-Effective Solutions* highlights the challenge of high initial investment and suggests strategies for sustainable funding. The article discusses cost barriers and recommends public-private partnerships and phased implementation to make Metaverse adoption financially viable.

E. Roadmap of Future Research



Fig. 10. Roadmap of Metaverse Adoption in NEP 2020.

The roadmap presents a clear, phased strategy for integrating the Metaverse into Indian higher education as per NEP 2020. It offers a practical execution plan that addresses the recommendations for systematic and sustainable adoption (Fig. 10).

Phase 1: Establishing the Bedrock

- *Create Policy & Governance Frames* involves developing clear guidelines and regulations for Metaverse use, aligning with the article's emphasis on policy support and ethical frameworks under NEP 2020.
- *Secure Basic Digital Infrastructure* focuses on building reliable internet and device access, addressing the infrastructure gaps repeatedly highlighted in the article.
- *Upskill Early Educator Cohorts* stresses training teachers first, which is a core recommendation in the article for successful implementation.
- *Deploy Local Content Prototypes* encourages creation of India-centric content in regional languages, supporting the article's call for multilingual and culturally relevant Metaverse modules.
- *Define Metrics for Success* suggests setting clear evaluation parameters, aligning with the recommendation for monitoring and research.

Phase 2: Systematic Expansion & Integration

It focuses on scaling up through curriculum integration, partnerships, addressing challenges, and expanding to higher education, reflecting the article's balanced approach of moving from pilots to wider adoption.

- *Integrate Curriculum Modules* involves embedding Metaverse-based immersive experiences directly into the existing academic curriculum across various disciplines. In the context of the article, it helps translate NEP 2020's multidisciplinary and experiential learning goals into practical classroom reality.
- *Form Strategic Cross-Sector Alliances* emphasizes building partnerships between educational institutions, technology companies, government bodies, and industry. The article strongly recommends public-private partnerships to share resources, reduce costs, and accelerate Metaverse adoption.
- *Mitigate Key Adoption Impediments* focuses on actively resolving major challenges such as bandwidth limitations, device access gaps, and teacher readiness. It directly addresses the challenges section of the article by promoting targeted interventions during the scaling phase.
- *Scale to Tertiary Education* involves expanding successful pilots from schools to colleges and universities. It supports the article's vision of transforming higher education through large-scale Metaverse implementation while maintaining quality and inclusivity.
- *Conduct Deep-Dive Research* calls for rigorous studies to evaluate the effectiveness, long-term impact, and areas of improvement. It aligns with the article's emphasis on evidence-based implementation and filling research gaps identified in the literature review.

Phase 3: Realizing Ecosystem Maturity

The final phase aims for universal access, advanced applications, a strong ecosystem, and global leadership. It matches the article's concluding vision of positioning India as a leader in digital education through thoughtful Metaverse integration.

- *Achieve Universal Digital Equity* aims to ensure every student, regardless of location or background, has meaningful access to Metaverse learning. It fulfills the article's core focus on bridging the digital divide and promoting inclusive education as per NEP 2020.
- *Develop Advanced Applications* involves creating sophisticated Metaverse tools for specialized fields such as medical simulations, engineering, and research. The article highlights this as a way to enhance skill development and innovation in higher education.
- *Cultivate a Vibrant Network Ecosystem* focuses on building a connected community of institutions, educators, and learners sharing resources and best practices. It supports the article's recommendation for

collaborative and sustainable growth of the Metaverse ecosystem.

- *Position as a Global Leader* the final goal is to establish India as an international pioneer in Metaverse-enabled education. This resonates with the article's conclusion that successful integration can position India as a global leader in the transformation of digital education.

VI. CONCLUSION

The integration of Metaverse technologies with NEP 2020 holds immense potential to revolutionize Indian higher education by making learning more immersive, personalized, multidisciplinary, and equitable. While significant challenges related to infrastructure, cost, teacher preparedness, and ethics remain, a phased, evidence-based approach supported by policy frameworks, public-private partnerships, and continuous research can overcome these barriers. By leveraging the Metaverse responsibly, India can create a future-ready education ecosystem that empowers diverse learners, strengthens global competitiveness, and truly realizes NEP 2020's vision of holistic development.

Future research should focus on large-scale empirical pilots across diverse Indian institutions to validate the proposed optimization model and measure long-term learning outcomes. Longitudinal studies on psychological impacts, development of low-cost indigenous Metaverse platforms in regional languages, and AI-driven adaptive assessment tools would further strengthen implementation. Comparative studies with global best practices and exploration of blockchain for credentialing in virtual environments are also recommended.

REFERENCES

- [1] Prakash, A., Haque, A., Islam, F. and Sonal, D., 2023. Exploring the potential of metaverse for higher education: Opportunities, challenges, and implications. *Metaverse Basic and Applied Research*, 2, p.13.
- [2] Kshetri, N., Rojas-Torres, D. and Grambo, M., 2023. The metaverse and higher education institutions. *IT Professional*, 24(6), pp.69-73.
- [3] Al-Adwan, A.S. and Al-Debei, M.M., 2024. The determinants of Gen Z's metaverse adoption decisions in higher education: Integrating UTAUT2 with personal innovativeness in IT. *Education and Information Technologies*, 29(6), pp.7413-7445.
- [4] Bhat, M.A., Tiwari, C.K., Bhaskar, P. and Khan, S.T., 2026. What drives the adoption of metaverse-based educational technologies in higher educational institutions? An investigation using extended TAM model. *Interactive Technology and Smart Education*, 23(1), pp.201-224.
- [5] Alkhwalidi, A.F., 2024. Understanding learners' intention toward Metaverse in higher education institutions from a developing country perspective: UTAUT and ISS integrated model. *Kybernetes*, 53(12), pp.6008-6035.
- [6] Ali, R.A., Soliman, M., Weahama, M.R., Assalihee, M. and Mahmud, I., 2025. Investigating continuous intention to use metaverse in higher education institutions: a dual-staged structural equation modeling-artificial neural network approach. *Smart Learning Environments*, 12(1), p.3.
- [7] Mukred, M., Mokhtar, U.A., Hawash, B., AlSalman, H., Zohaib, M. and Abuzawayda, Y.I., 2025. Exploring the potential of metaverse adoption in higher education: A diffusion of innovation model approach to enhancing student engagement. *SAGE Open*, 15(3), p.21582440251363668.
- [8] Zhang, Y., Kong, M., Wang, W.Z., Deveci, M., Bilican, M.S. and Delen, D., 2026. A multi-criteria decision-making framework for

- metaverse adoption: evidence from higher education systems. *Expert Systems with Applications*, 296, p.129132.
- [9] Abdelmagid, A.S., Jabli, N.M., Al-Mohaya, A.Y. and Teleb, A.A., 2025. Integrating interactive metaverse environments and generative artificial intelligence to promote the green digital economy and e-entrepreneurship in higher education. *Sustainability*, 17(12), p.5594. <https://doi.org/10.3390/su17125594>
- [10] Oladokun, B.D., Atuase, D., Ajani, Y.A., Tachie-Donkor, G. and Enakrire, R.T., 2025. Perspectives of librarians on the integration of metaverse into the future information services in higher education institutions. *The Journal of Academic Librarianship*, 51(5), p.103103. <https://doi.org/10.1016/j.acalib.2025.103103>.
- [11] Alqarni, A., 2025. Exploring faculty perceptions of barriers to metaverse integration in higher education: development and validation of a new scale. *Humanities and Social Sciences Communications*, 12(1), p.1909. <https://doi.org/10.1002/cae.70125>.
- [12] Ibrahim, N.H., Norman, H. and Nasir, M.K.M., 2026. Transforming nursing education towards metaverse as an innovative teaching tool: A systematic review. *Social Sciences & Humanities Open*, 13, p.102492. <https://doi.org/10.1016/j.ssaho.2026.102492>.
- [13] Saue, B.P., 2026. Effectiveness of Education in Metaverse Environment: Issues and Opportunities. In *Green Metaverse: Fuzzy Logic Approaches to Sustainable Virtual Worlds* (pp. 205-216). https://doi.org/10.1007/978-3-032-08183-4_12.
- [14] Chiu, T.K., 2026. Metaverse in Education: Design Recommendations and Future Research Direction for Immersive Virtual Learning Environments. In *Handbook of the Metaverse* (pp. 319-334). https://doi.org/10.1007/978-3-032-03296-6_10.
- [15] Malay, J., 2026. The Metaverse in Medical Education: Transforming Learning Through. *Global Competencies and Intercultural Learning*, p.205.
- [16] Abdulmuhsin, A.A., Owain, H.O. and Alkhwalidi, A.F., 2026. Understanding the academic use of KM-driven metaverse technology: insights from medical colleges. *Journal of Science and Technology Policy Management*, 17(3), pp.611-641. DOI 10.1108/JSTPM-12-2023-0229.
- [17] NAYIROĞLU, B. and TUTAK, T., Metaverse and Digital Reality Applications in Mathematics Education. Aviva BUTT, Ph. D., USA Hasan KARACAN, Ph. D., TRNC Nina STĘPNICKA, Ph. D., POLAND Alla TSARIKOVA, Ph. D., USA Ali KORKUT, Ph. D., TÜRKİYE, p.51.
- [18] Methlouthi, K., 2026. Determinants of metaverse classroom adoption: Insights from an African country. *Journal of African Business*, 27(1), pp.127-144. <https://doi.org/10.1080/15228916.2025.2460287>.