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A Foresight Study of Metaverse Technology Adoption in Training and Development among Employees in Electrical and Electronics Industries

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Foresight, metaverse, training and development, electric, electronic, manufacturing industry

Abstract

Training and development were critical in human resource management for enhancing employee skills and competencies. This study was conducted to explore the potential of using Metaverse technology for employee training in the Electrical and Electronics Industries, focusing on the challenges, key drivers, and future applications. Traditional training methods often failed to meet the industry's evolving demands, necessitating innovative approaches. This research investigated the challenges, trends, and opportunities of adopting Metaverse technology in training programs. Using a mixed-methods approach, insights from HR professionals in Penang, Malaysia, were collected to understand the feasibility and effectiveness of Metaverse integration. The results identified the main drivers for adoption, which were assessing its impact on skill development and envisioning future applications in training programs. The significance of this study lies in its potential to enhance employee engagement, job satisfaction, and overall performance through immersive learning experiences. By addressing the benefits and challenges of Metaverse technology, this research aimed to provide practical insights for organisations to remain competitive and innovative, driving sustainable growth and global competitiveness in the manufacturing, electrical and electronics sector.

1. Introduction

Training and development are essential aspects of human resource management, aimed at enhancing employees' skills and knowledge. Training focuses on improving current job skills with specific, short-term goals (Adeleye, Adegbite, & Aderemi, 2014; Armstrong, 2003), while development aims at long-term personal and professional growth, preparing employees for future roles (Drummond, 2000; Armstrong, 2003). This can include formal education, job experiences, and evaluations of skills and abilities (WorkRamp, 2023). Training can be on-the-job (practical experience within the workplace) or off-the-job (learning through workshops and seminars) (Noe, 2010; Mehta and Bhatt, 2014).

The Metaverse, a virtual reality space from Neal Stephenson's "Snow Crash" (1992), offers innovative training opportunities. It provides immersive learning experiences, especially beneficial for industries like manufacturing, where hands-on practice is critical (Schlemmer and Backes, 2015; Dick, 2021). VR headsets allow trainees to safely gain practical experience.

Despite its advantages, theMetaverse presents challenges such as accessibility issues, technology addiction risks, privacy concerns, and the need for regulation. Balancing these factors is crucial to maximize its benefits for training and development (Dick, 2021). This study explores the Metaverse's potential in revolutionizing training in the manufacturing electrical and electronics industry, aiming to identify key drivers, challenges, and opportunities to help companies stay competitive and equip their workforce with necessary skills.

Traditional training methods in the manufacturing electrical and electronics sector have increasingly proven ineffective in meeting the industry's evolving demands for both technical and soft skills (Schulz, 2008; Dixon, Belnap, Albrecht, & Lee, 2010). Essential abilities such as communication, coordination, stress management, and problem-solving are often lacking in management, leading to potential systemic failures (Dixon *et al*., 2010). In the face of rapid technological advancements, these conventional approaches fall short in equipping employees with the skills necessary to keep pace with sector-specific requirements, including proficiency in assembly processes, adherence to quality control standards, and continuous technological innovation (Kirkpatrick and Kirkpatrick, 2016). As traditional methods falter, exploring innovative training solutions like the Metaverse has become critical (Shirmohammadi *et al*., 2022; Thite, 2022; Yarberry and Sims, 2021).

The Metaverse offers significant advantages, including enhanced engagement through immersive learning experiences, scalable training environments for large groups, and realistic simulations that facilitate practical skill acquisition (Kirkpatrick and Kirkpatrick, 2016; Thite, 2022; Yarberry and Sims, 2021). However, the adoption of Metaverse technology presents notable challenges, such as substantial technological infrastructure and setup costs, the necessity for bulky equipment and high-speed internet, and the requirement for users to possess higher technical proficiency (Mystakiddis, 2022; Jagatheesaperumal *et al*., 2022). Additionally, organizations must undergo cultural and operational adjustments to integrate these emerging technologies effectively (Upadhyay and Khandelwal, 2022). Understanding these advantages and disadvantages is crucial for developing impactful training programs that enhance workforce capabilities and contribute to sustained growth and competitiveness in the manufacturing electrical and electronics sector (Yilmaz *et al*., 2023).

Therefore, to achieve the research objectives, the issues, trends, and challenges of Metaverse technology adoption in training and development among employees in the Electrical and Electronics Industries are analyzed. Consequently, the key drivers of Metaverse technology adoption are identified and the future images of this adoption in training and development are studied.

2. Literature Review

2.1 Table with Issues, Challenges, and Trends

Table 1 shows key issues and challenges, with details elaborated in Tables 1 to 6, in Appendix A.

2.2 Table with Key Terms of Issues, Challenges, and Trends

Table 7 in Appendix C was tabulated by writing down the key term in accordance with the key issues found in Table 1. Table 7 presents a consolidated view of the drivers associated with the merged issues, challenges and trends.

2.3 Table of driver related to Merged Issues, Challenges, and Trends

Table 8 shows the drivers related to merged issues, challenges, and trends.

Table 8 *Table of drivers related to merged issues, challenges, and trends*

No	Issues, Challenges, and Trends	Drivers
1	1. Workplace cyberbullying and virtual representation harassment 2. Metaverse-induced dissociation and technological disconnection 3. AI-Driven inclusivity and global Metaverse adoption 4. Interpersonal communication skills and virtual team collaboration 5. Metaverse ethics and sustainable technological development	Social-Ethical Dynamics
2	1. AR-Metaverse cognitive overload 2. Metaverse-based training evaluation and the metaverse adoption gap in workplace training 3. Metaverse technology literacy barrier and metaverse technology adoption resistance 4. Metaverse accessibility barriers 5. Financial security threats in web3 Metaverse	Barriers to Metaverse Integration
3	1. Hight-cost barrier in creation and implementation	Economic Dynamics

	2. Emerging Metaverse technology and AI-driven Metaverse accessibility enhancement 3. Metaverse economic framework and market growth projection 4. Cost reduction benefits of remote working and global talent access 5. Metaverse-enabled virtual commerce revolution and digital economy	
4	1. Seamless experience-centric device design for the Metaverse 2. Energy-efficient and sustainable virtual environment development 3. Interactive 3D virtual world concept of the Metaverse 4. Metaverse and AI integration for real-time workplace safety monitoring 5. Metaverse-enabled industrial production enhancement	Technological Innovation
5	1. Avatar-based racist harassment 2. Data privacy and security regulations in the Metaverse 3. Policy support for Metaverse industry development and regulatory adaptation 4. Cybersecurity risk in the Metaverse	Governance in the Metaverse
6	1. Metaverse-based training evaluation and challenges in Metaverse adoption for workplace training 2. Impact of technology familiarity on Metaverse training participation and barriers to adoption 3. User experience enhancement and ethical frameworks for AI and Metaverse development 4. Practical applications and implementation factors of Metaverse in the workplace 5. Potential of Metaverse for creativity and social interaction and entrepreneurial opportunities	User Experience of Metaverse Technology

3. Research Methodology

3.1 Research Design

This study used both qualitative and quantitative data analysis to understand the adoption of Metaverse technology in training and development. Qualitative analysis focused on non-numerical data from interviews and surveys to explore concepts and experiences, while quantitative analysis used numerical data and statistical methods to identify patterns and trends. By integrating these approaches, the study provided a comprehensive view of Metaverse adoption in the manufacturing electrical and electronics sector, offering insights into its feasibility, benefits, challenges, and impacts on training effectiveness.

The foresight research focuses on a 5-year timeline, starting from 2026 to 2030. The study involved HR professionals from manufacturing electrical and electronics companies in Penang, chosen for their expertise in training strategies and new technologies like the Metaverse. Penang was selected due to its strong manufacturing performance, leading Malaysia with RM76.2 billion in investments in 2021 and RM13.7 billion in 2022, driven by growth in the electrical, electronics, scientific, and medical equipment industries.

3.2 Foresight Process

The foresight process involved gathering and interpreting data to enable innovative and diverse thinking about the future (Conways, 2014). This process comprised several key steps, beginning with horizon scanning to identify emerging trends and signals. The data were then analyzed using STEEPV analysis, which examines Social, Technological, Environmental, Economic, Political, and Values factors. This analysis helped identify the key drivers of change for the adoption of Metaverse technology in training and development.

3.2.1 Horizon Scanning

Horizon scanning was a method used to identify potential threats, risks, emerging issues, opportunities, and future developments by focusing on new technologies and their impacts. It helped analyze the future and spot emerging trends and developments that would shape future policies and practices (Government Office of Science & Cabinet Office, 2013). Horizon scanning aimed to help researchers identify constants, changes, unexpected problems, and trends through desk research. This research included sources such as internet resources, journal articles, books, and other relevant materials.

3.2.2 STEEPV Method

The STEEPV method was used to analyze factors affecting Metaverse technology adoption in training and development. It covered Social (cultural norms and behaviors), Technological (hardware and software advancements), Economic (financial implications and ROI), Environmental (sustainability and regulations), Political (policies and legal requirements), and Values (ethical standards and stakeholder perceptions). This comprehensive approach helped organizations make informed decisions and strategic plans, ensuring successful and responsible technology integration.

3.2.3 Drivers

Drivers were factors that would change, shape, or influence future development. The STEEPV method was used to identify these drivers. Various tools could assess or identify these drivers, such as impact-uncertainty analysis, the S-curve, and the future wheel. In this study, impact-uncertainty analysis was performed on the drivers or future factors that influenced and changed the issues, challenges, and trends of Metaverse technology adoption in training and development.

3.3 Research Flowchart

Fig. 1 represents a flowchart that depicted the sequence of activities within the research process. This visual representation provided the researcher with a clearer understanding of the procedures and operations at different levels, serving as a comprehensive framework. The flowchart also helped ensure that the study was conducted accurately and methodically.

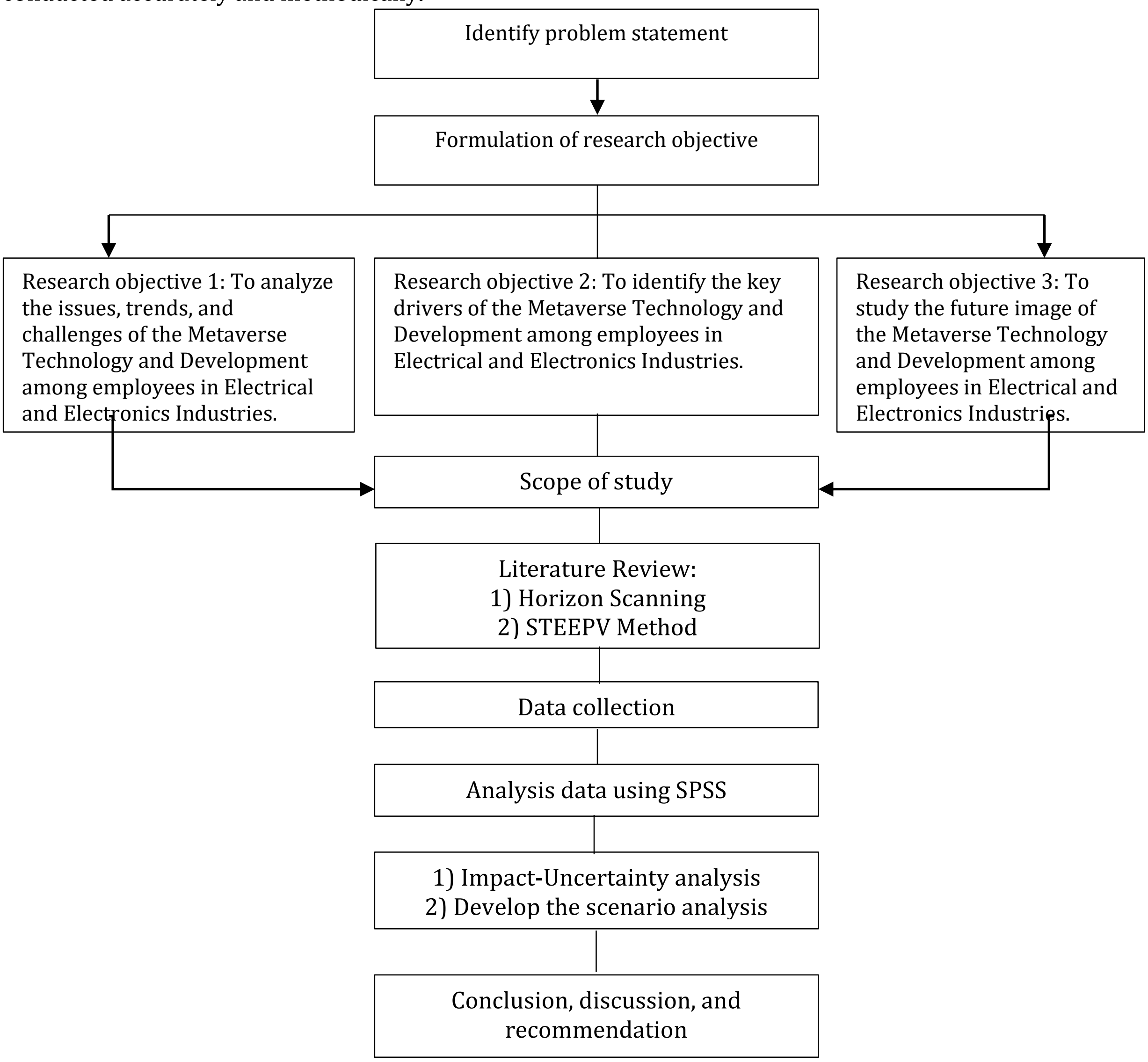

Fig. 1 *Research flowchart*

3.4 Population

This research focused on integrating Metaverse technology in training and development within the manufacturing, electrical, and electronics industry in Pulau Pinang. The target population comprised HR professionals from the training and development divisions of organisations within this sector. Based on Penang labour force statistics and the Institute of Labour Market Information, there were 60 companies in the electrical and electronics manufacturing sector in Pulau Pinang, with a total population of approximately 2400 professionals. The sample size was estimated using the Krejcie and Morgan table, which determined that a target of 331 respondents would ensure a statistically significant and generalizable sample size. Ultimately, 251 respondents participated and completed the questionnaire, providing valuable data for analysis.

3.4.1 Sampling Technique

The study used purposive sampling, a non-probability method, to focus on individuals actively involved in training and development within Pulau Pinang's manufacturing electrical and electronics industry. This method allowed the selection of participants with specific characteristics relevant to the research. Participants had to be based in Pulau Pinang and work in the manufacturing, electrical, and electronics sectors.

3.5 Research Instrument

This research employed a questionnaire as the primary research instrument because it allowed for efficient data collection and provided results that were straightforward and easy to understand.

3.5.1 Questionnaire

The questionnaire was designed to gather data on issues, challenges, and trends related to Metaverse technology adoption in training and development within the manufacturing, electrical and electronics industry in Pulau Pinang. It consisted of four parts: Part A collected demographic information; Part B ranked the importance of the drivers; Part C assessed their impact on Metaverse adoption; and Part D measured uncertainty levels.

3.6 Data Collection

Data collection included both primary and secondary methods. Primary data, collected firsthand through interviews and experiments, was specific to the study's needs, with questionnaires being a common tool. Secondary data, gathered from existing sources like journals, articles, and websites, provided context and supported the primary data. This research used secondary data to analyse Metaverse technology adoption in training and development, identifying related issues, challenges, and trends (Scribbr, 2020). Table 9 shows the reliability results for the pilot test, and Table 10 shows the results for the actual study. Response rate for this study is shown in Table 11.

Table 9 *Reliability of pilot test*

Factors	Cronbach's Alpha Value
Level of Importance	0.70
Level of Impact	0.79
Level of Uncertainty	0.80

Table 10 *Reliability for actual study*

Factors	Cronbach's Alpha Value
Level of Importance	0.85
Level of Impact	0.86
Level of Uncertainty	0.85

Table 11 *Response rate*

Questionnaire	Frequency *(f)*	Percentage (%)
The number of sets distributed	331	100
The number of sets returned	215	64.95
Number of sets not returned	116	35.05

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3.7 Analysis of Data

3.7.1 Descriptive Analysis

Descriptive analysis involved employing statistical methods to describe or summarise a set of data (Bush, 2020). In this study, data collected from the questionnaire were analysed using the Statistical Package for the Social Sciences (SPSS). SPSS assisted in generating statistical results in numerical form, allowing for a comprehensive examination of the collected data. Through SPSS, the data were presented in various statistical measures such as percentages, means, and standard deviations, providing insights into the distribution and characteristics of the data.

3.7.2 Impact-Uncertainty Analysis

The impact-uncertainty analysis ranked drivers by importance, impact, and uncertainty. The top two drivers with the highest impact and uncertainty were selected for scenario analysis. This helped explore how these factors might influence Metaverse technology adoption in training and development within the manufacturing, electrical, and electronics industries.

3.7.3 Development of Scenario Analysis

Figure 2, as in Appendix B, used a scenario matrix to explore potential developments in adopting Metaverse technology for training within the Electrical and Electronics industries. The matrix featured two primary drivers (Driver 1 on the vertical axis and Driver 2 on the horizontal axis) and created four scenarios based on their combinations: Scenario 1 (both drivers high), Scenario 2 (both drivers low), Scenario 3 (Driver 1 high, Driver 2 low), and Scenario 4 (driver 1 low, driver 2 high). This analysis helped stakeholders understand various future possibilities and devise strategies for effective Metaverse adoption.

4. Data Analysis and Findings

4.1 Demographic Analysis

Table 12, summarising the data, can be found in Appendix D. Among the 251 respondents, 127 (50.6%) were male and 124 (49.4%) were female. The age distribution showed that 86 respondents (34.3%) were aged 31 to 40 years, 74 respondents (29.5%) were aged 41 to 50 years, 52 respondents (20.7%) were aged 51 years and above, and 39 respondents (15.5%) were aged below 30 years. In terms of educational background, 88 respondents (35.1%) had a Master's degree, 87 respondents (34.7%) held a Bachelor's degree, 42 respondents (16.7%) had SPM/STPM/Diploma qualifications, and 34 respondents (13.5%) had a Ph.D. Regarding HR experience, 85 respondents (33.9%) had 1 to 5 years of experience, 80 respondents (31.9%) had 5 to 10 years of experience, 44 respondents (17.5%) had more than 10 years of experience, and 42 respondents (16.7%) had less than one year of experience. Job positions included 90 respondents (35.9%) as HR Specialists, 73 respondents (29.1%) as HR Managers, 48 respondents (19.1%) as HR Assistants, 39 respondents (15.5%) as HR Directors, and 1 respondent (0.4%) as an HR Admin Executive. In terms of company size, 78 respondents (31.1%) worked in companies with 51 to 199 employees, 63 respondents (25.1%) in companies with 500 to 999 employees, 55 respondents (21.9%) in companies with 200 to 499 employees, 28 respondents (11.2%) in companies with 1000 and more employees, and 27 respondents (10.8%) in companies with fewer than 50 employees. Regarding experience in Training and Development with technology, 83 respondents (33.1%) had limited experience, 82 respondents (32.7%) had moderate experience, 47 respondents (18.7%) had extensive experience, and 39 respondents (15.5%) had no experience. Familiarity with Metaverse Technology showed that 89 respondents (35.5%) were moderately familiar, 84 respondents (33.5%) were slightly familiar, 42 respondents (16.7%) were very familiar, and 36 respondents (14.3%) were not familiar at all. Lastly, for the use of technology for training and development, 74 respondents (29.5%) used cutting-edge technology, 67 respondents (26.7%) used basic tools, 53 respondents (21.1%) used advanced tools, 30 respondents (12.0%) did not use any technology, and 27 respondents (10.8%) used Metaverse-related technology.

4.2 Descriptive Analysis

4.2.1 Highest to The Lowest Mean Based on Its Importance

The mean value of the drivers based on their importance is shown in Table 13.

Table 13 *Descriptive analysis on importance level*

No	Drivers	Mean (μ)	Standard deviation (σ)
1	Social-Ethical Dynamics	3.66	1.16
2	Barriers to Metaverse Integration	3.70	1.18
3	Economics Dynamics	3.63	1.21
4	Technological Innovation	3.74	1.14
5	Governance in the Metaverse	3.71	1.15
6	User Experience of Metaverse Technology	3.67	1.24
7	Metaverse Technology Know-How	3.73	1.26
8	Technology Integration	3.72	1.14
9	Workplace Transformation	3.55	1.30
10	Regulations in the Metaverse	3.66	1.30

4.2.2 Highest to The Lowest Mean Based on Its Impact

The mean value of the drivers based on their impact is shown in Table 14.

Table 14 *Descriptive analysis on impact variables*

No	Drivers	Mean (μ)	Standard deviation (σ)
1	Social-Ethical Dynamics	3.62	1.23
2	Barriers to Metaverse Integration	3.64	1.20
3	Economics Dynamics	3.70	1.21
4	Technological Innovation	3.69	1.22
5	Governance in the Metaverse	3.65	1.25
6	User Experience of Metaverse Technology	3.71	1.22
7	Metaverse Technology Know-How	3.64	1.21
8	Technology Integration	3.65	1.24
9	Workplace Transformation	3.65	1.18
10	Regulations in the Metaverse	3.68	1.21

4.2.3 Highest to The Lowest Mean Based on Its Uncertainty

The mean value of the drivers based on their uncertainty is shown in Table 15.

Table 15 *Descriptive analysis of uncertainty variables*

No	Drivers	Mean (μ)	Standard deviation (σ)
1	Social-Ethical Dynamics	3.63	1.22
2	Barriers to Metaverse Integration	3.63	1.23
3	Economics Dynamics	3.76	1.18
4	Technological Innovation	3.57	1.26
5	Governance in the Metaverse	3.73	1.15
6	User Experience of Metaverse Technology	3.69	1.22
7	Metaverse Technology Know-How	3.65	1.20
8	Technology Integration	3.69	1.25
9	Workplace Transformation	3.65	1.27
10	Regulations in the Metaverse	3.67	1.18

4.3 Impact-Uncertainty Analysis

The mean values for impact-uncertainty were illustrated in Table 16. According to the graph in Fig. 2, D3 and D5 had the highest impact and uncertainty. D3 represented the economic dynamics, and D5 represented the governance in the Metaverse.

The researcher must arrange and evaluate the data gathered during the data collection phase in order to comprehend it. Data analysis is used to identify study findings and whether the research will fulfill its goals. Data will be gathered from primary sources through the distribution of questionnaires.

Table 16 *Mean of impact and uncertainty variables*

No	Drivers	Mean (μ)	
		Uncertainty	Impact
1	Social-Ethical Dynamics	3.63	3.62
2	Barriers to Metaverse Integration	3.63	3.64
3	Economics Dynamics	3.76	3.70
4	Technological Innovation	3.57	3.69
5	Governance in the Metaverse	3.73	3.65
6	User Experience of Metaverse Technology	3.69	3.71
7	Metaverse Technology Know-How	3.65	3.64
8	Technology Integration	3.69	3.65
9	Workplace Transformation	3.65	3.65
10	Regulations in the Metaverse	3.67	3.68

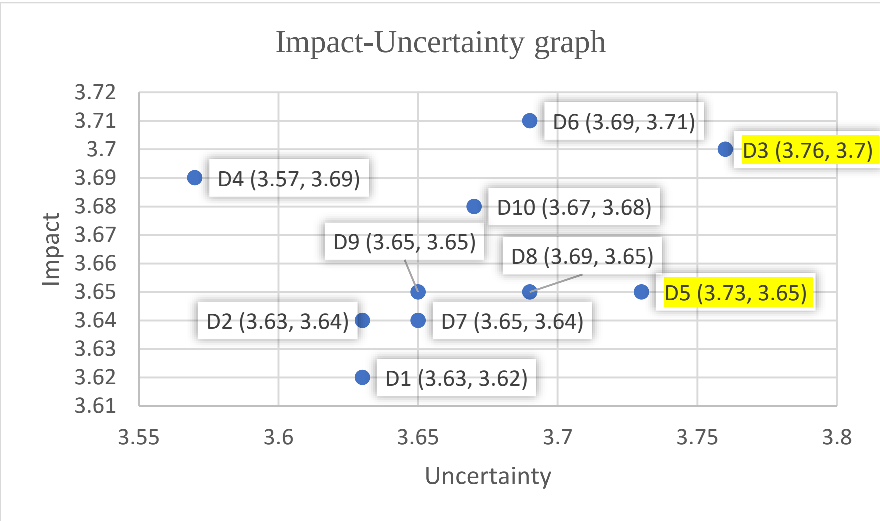

Fig. 2 *Impact-Uncertainty Graph*

5. Conclusion

In conclusion, this research explored Metaverse technology in E&E sector training, identifying four scenarios: Sustainable Innovation, Neglected Potential, Unregulated Prosperity, and Regulated Constraints. These scenarios illustrate the diverse impacts of economic dynamics and governance on tech integration. The chapter also addressed research limitations like respondent transparency, methodological challenges, and geographical constraints. Future research should focus on data verification, diverse participant engagement, ensuring survey anonymity, and expanding the geographical scope for more reliable studies.

The first objective of this research was to identify issues, challenges, and trends related to adopting Metaverse technology in training and development within the Electrical and Electronics industries, derived through STEEPV analysis. Previous research was categorized into six areas: Social, Technological, Economic, Environmental, Political, and Values. The analysis of these categories resulted in numerous findings on the adoption and impact of Metaverse technology (Almeida et. al., 2023).

The second research objective was to identify key drivers for adopting Metaverse technology in training and development within the Electrical and Electronics industries. Through STEEPV analysis, ten drivers were identified, including social-ethical dynamics, barriers to Metaverse integration, economic dynamics, technological innovation, governance in the Metaverse, user experience, Metaverse technology know-how, technology integration, workplace transformation, and regulations. The top 60% of these drivers were selected based on importance, impact, and uncertainty. The top two drivers, identified through impact-uncertainty analysis, were economic dynamics and governance in the Metaverse, as they had the most significant impact and uncertainty according to respondents in the E&E sector (Loveridge, 2002). This section explored how the economic dynamics and governance in the Metaverse could impact and create uncertainty in the future adoption of Metaverse technology in training and development among employees in the Electrical and Electronics industries. The subsequent section delves into a more detailed discussion of these top two drivers. Economic dynamics was identified as the highest driver for uncertainty in adopting Metaverse technology in training and development for the E&E sector. This uncertainty stems from fluctuating market conditions and economic factors, which impact the future of Metaverse integration (Mystakidis, 2022). Economic trends can lead to rapid adoption or hesitation in implementing Metaverse technologies (Guo *et al*., 2022). For example, economic downturns may limit budgets for new technologies, whereas economic booms can encourage investments in innovative solutions. Additionally, the cost implications of adopting Metaverse technologies, such as initial setup and maintenance, add to the economic uncertainty (International *et al*., 2023). Global economic stability also affects the availability of funds for training and development, making long-term strategic decisions challenging for stakeholders. Governance in the Metaverse was identified as a significant driver due to its high levels of impact and uncertainty on training and development in the Manufacturing E&E sector. The results showed a mean score of 3.73 in uncertainty and 3.65 in impact. This driver encompasses regulations, policies, and standards necessary to guide the use of Metaverse technologies (Askr, 2023). The lack of clear governance frameworks introduces significant unpredictability, as varying regulations across regions and industries can influence the pace and manner of Metaverse adoption. Respondents highlighted the need for robust governance to address privacy, security, and ethical concerns, which are paramount in immersive virtual environments. Effective governance ensures Metaverse technology is integrated in compliance with existing laws and standards (Notice of State Council, 2022). However, the evolving nature of both the technology and regulatory landscape adds layers of complexity, contributing to the high uncertainty score. Stakeholders are concerned about the potential for regulatory lag, where laws and policies struggle to keep pace with technological advancements, potentially hindering innovation or causing legal and operational challenges.

The third objective was to explore the future landscape of Metaverse technology adoption in training and development within the manufacturing E&E industries and to identify key forces influencing this adoption. Four distinct scenarios, based on the top two drivers from the impact-uncertainty analysis, represent potential outcomes from 2031 to 2037. These scenarios, depicted in Fig. 3, include sustainable innovation, neglected potential, unregulated prosperity, and regulated constraints, discussing both favourable and unfavourable future forecasts.

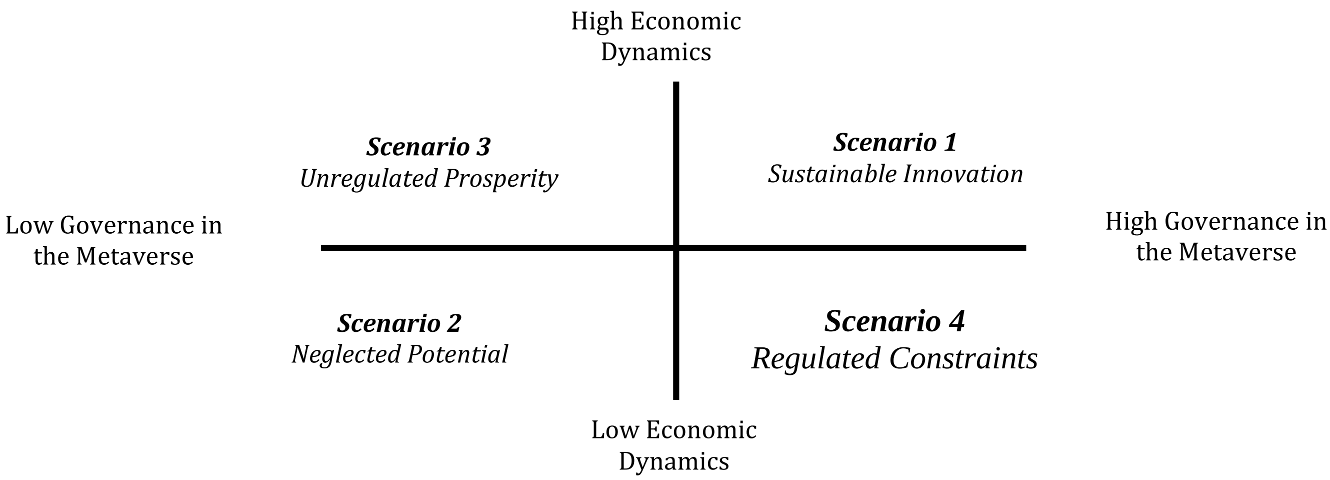

Fig. 3 *Development of four scenario analysis*

The first scenario (sustainable innovation) arises when both economic dynamics and governance within the Metaverse are at high levels, leading to the successful integration of Metaverse technologies in training and development. Sustainable Innovation balances technological progression with ethical, regulated practices, fostering long-term growth and inclusivity. The Metaverse becomes a well-regulated and economically robust platform, revolutionizing training in the electrical and electronics industries, ensuring employee safety, data privacy, and adherence to ethical standards, while allowing significant investments in advanced technologies like VR and AR (Bland, 2021). To achieve this, the government must actively promote Metaverse technology through subsidies or tax incentives, particularly for SMEs, and establish rigorous standards for ethical use focusing on data protection, workplace safety, and quality assurance (Chui, Manyika, & Miremadi, 2016). Investments in R&D and public-private partnerships are crucial for developing accessible training programs, benefiting even resource-limited organizations (Catnip Infotech Private Limited, 2023). This approach will make the Metaverse an integral component of workforce training. Additionally, educational institutions and vocational training centers need to update curricula to include Metaverse-related skills and knowledge. This focus on continuous learning and innovation ensures employees remain competitive and capable of leveraging Metaverse technologies (McKinsey & Company, 2013). A holistic approach drives Metaverse adoption while ensuring its sustainable and beneficial implementation for all stakeholders.

The second scenario (neglected potential) represents a worst-case scenario for adopting Metaverse technology in training and development within the manufacturing E&E sector. In this scenario, the Metaverse's potential remains unrealized due to weak economic growth and lack of governance, resulting in minimal technological and workforce advancement. Outdated technologies and limited innovation prevail due to a lack of investment in Metaverse infrastructure and regulations, diminishing trust and discouraging adoption (Morgan & Horgan, 2022; Dubey & Gunasekaran, 2020). Organizations continue to rely on traditional methods, like classroom-based learning, which fail to meet the demands of a technologically advancing workforce. Challenges of integrating new technologies during periods of low economic growth are well-documented, further exacerbating the situation (Teece, 2018; Park & Shin, 2017). To avoid this outcome, governments need to address economic and governance challenges, creating a national strategy that prioritizes the Metaverse as a key workforce development tool. Attracting international investments can improve economic conditions, while a comprehensive governance framework ensures ethical and safe use of Metaverse technologies. This includes protecting user data, enforcing workplace safety regulations, and addressing ethical concerns. Investments in digital infrastructure are necessary to enable widespread Metaverse use. Additionally, creating incentives for innovation and adopting forward-thinking policies can stimulate economic growth and encourage technological adoption. Collaborations between government, academia, and industry can drive research and development, leading to advancements in Metaverse technologies. This approach supports innovation and ensures the Metaverse becomes a viable platform for training and development in the E&E sector, mitigating risks associated with low economic dynamics and governance, and unlocking its full potential.

The third scenario, unregulated prosperity, occurs when economic growth is strong but Metaverse governance is weak. This leads to rapid adoption of Metaverse technologies in the electrical and electronics industries due to economic benefits like cost savings and increased training efficiency (Alsebai *et al*., 2022; Gonzales, 2023). Employees gain access to advanced tools such as VR simulations, but the lack of regulation results in issues like data breaches and inconsistent training quality, eroding trust in the technology (Vergara Cobos & Maláquez, 2023). To address these risks, governments need to establish governance frameworks, including licensing for training providers, data security regulations, and public awareness campaigns. These measures ensure quality standards, protect data, and promote fair access to Metaverse tools (Teece, 2018; Dubey & Gunasekaran, 2020). Without them, long-term instability may overshadow initial economic gains.

In the fourth (Regulated Constraints), strong governance ensures Metaverse safety and ethics, but low economic dynamics hinder widespread adoption. Large corporations can implement training programs, but SMEs struggle (Dubey & Gunasekaran, 2020; Park & Shin, 2017). Governments should provide financial support, like low-interest loans and subsidies, to help SMEs invest in Metaverse training tools. Collaborations and cost-sharing models can also reduce adoption costs (Vergara Cobos & Maláquez, 2023). Governance ensures a secure Metaverse, but economic support is essential for its full potential in training (Alsebai *et al*., 2022; Gonzales, 2023).

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Aida Farhana Azahar, Shazaitul Azreen Rodzalan;* ***data collection:*** *Aida Farhana Azahar;* ***analysis and interpretation of results:*** *Aida Farhana Azahar;* ***draft manuscript preparation:*** *Aida Farhana Azahar, Shazaitul Azreen Rodzalan. All authors reviewed the results and approved the final version of the manuscript.*

Appendix A

Table 1 *Key Issues, Challenges, and Trends (Social)*

No	Drivers and Trends	Key Terms
1.	Employees may face greater risks of bullying, harassment, and/or cyberaggression (Di Pietro and Cresci, 2021; Purdy,2022).	Workplace Cyberbullying
2.	Employees may be subject to racist harassment because of their avatar's representation (Tawakley, 2022).	Virtual Representation Harassment
3.	Employees immersed in the metaverse may experience a dissociation disorder and a lower sense of presence in objective reality (Ardema *et al*., 2010; slate *et al*., 2020).	Metaverse-Induced Dissociation
4.	The Metaverse is one of the most significant rising technologies right now (Guo *et al*, 2022).	Emerging Technology
5.	AI is likely to play a vital role in the inclusivity and accessibility of the Metaverse, making it more functional and user-friendly (Guo *et al*., 2022).	AI-Driven Inclusivity
6.	The meta-universe concept has been thrust into the limelight and has received widespread attention, with domestic and international companies beginning to lay out their transformations (Wu *et al*., 2023).	Global Metaverse Adoption
7.	Meanwhile, the metaverse industry will gradually move into our society in the future, (e.g., mobile phones and computers are popularly used), both in the B-side market and C-side market, the prospect and potential are especially huge (Wu *et al*., 2023).	Metaverse Market Integration
8.	The ability to interact with people both familiar and unfamiliar is probably one of the most important skills to learn for many situations (Ritterfeld *et al*., 2006).	Interpersonal Communication Skills
9.	The integration of AI and the metaverse is expected to improve people's lives in various ways, as well as many industries and working processes, such as operations in fashion, management, marketing, and education (Rathore &Bharati, 2023).	AI-Metaverse Synergy
10.	The metaverse is ready to emerge as a new digital platform for business relationships (Wei & Zhang, 2022).	Metaverse Business Platform
11.	More and more organizations now want to explore the possibilities that avatars and holograms offer in VR for greater engagement, collaboration and inclusion of employees engaged in remote work for greater productivity and learning (Upadhyay, Ashwani Kumar *et al*., 2022).	VR-Enhanced Remote Work
12.	The COVID-19 pandemic has intensified the need to incorporate digital technologies (DTs) into the workplace (Davison, 2020; Newman & Ford, 2020; Selimović *et al*., 2021).	Digital Workplace Transformation
13.	Remote workers are often joined into virtual teams, who collaborate through ICTs and rarely meet face-to-face (Aldag & Kuzuhara, 2015).	Virtual Team Collaboration
14.	The Metaverse can be understood as an extension of virtual reality (VR) and augmented reality (AR) technologies (Mahmoudi *et al*, n.d.).	Extended Reality (XR)
15.	The emergence of the Metaverse also raises important ethical and philosophical questions (Mäyrä, 2020).	Metaverse Ethics
16.	Working together with coworkers who are in the same location has a significant impact on collaboration (Hussain *et al*., 2023).	Co-located Collaboration
17.	Many are using the increased ability to gather information from various sources within a short span of time through AI to learn new skills, research ideas and even produce certain outputs (International *et al*., 2023).	AI-Enabled Information Gathering
18.	The immersive nature of some technologies may leave people feeling out of touch with reality and unable to interact in the real world (International *et al*., 2023).	Technological Disconnection

19.	The Metaverse can therefore, be used as a tool in industrial companies learning and development strategy, which is needed, since DT in industrial organizations is transforming industry, and therefore, new skills and abilities are required in order to respond to the changes (Li, 2022).	Metaverse-Driven Learning and Development.
20.	As such, there is a strong call in both Industry 5.0 and Society 5.0 to balance Industry 4.0, responsible economic development and resolution of social problems (Potocan *et al*., 2021; Zengin *et al*., 2021; Carayannis *et al*., 2021).	Sustainable Technological Development
21.	The social system integrates humans with the physical devices and the cyber world, human-related data is collected and spread easily (Wu *et al*., 2014).	Cyber-Physical-Social Integration
22.	Conversely, the open innovation, community sharing, makers, prosumers and open sources become part of manufacturing systems to facilitate product innovation for mass personalization (Yao *et al*., 2024).	Open Manufacturing Ecosystem
23.	Social interaction and communication are faced with fear and worry about exposure to the COVID-19 virus, so that people are more likely to choose digital interaction and communication compared to physical communication (Heruatmadja & Ramadhan, 2023).	Digital Preference Amidst Pandemic
24.	The metaverse refers to a three-dimensional virtual world where avatars engage in political, economic, social and cultural activities (Park & Kim, 2022).	Virtual Social Environment
25.	Metaverse is a network of 3D virtual worlds focused on social connection (Casey, 2021).	Socially-oriented 3D Virtual Network.
26.	Metaverse combines different technologies to make a digital universe where users interact with each other socially (Mehta & Joshi, 2023).	Integrated Digital Social Environment
27.	The early adopters of the metaverse were the gaming, entertainment, and more recently, the social media industries (Amaizu *et al*., 2024).	Metaverse Pioneering Sectors
28.	Members of a team can join a meeting from anywhere, real-time translations allow people from diverse cultures to collaborate in real-time (Amaizu *et al*., 2024).	Global Collaboration with Real-Time Translation.

Table 2 *Key Issues, Challenges, and Trends (Technological)*

No	Drivers and Trends	Key Terms
1.	Employees experience higher cognitive load when processing information through AR-based metaverse (Buchner, 2022; Jeffri and Awang Rambli, 2021; Xi *et al*, 2022).	AR-Metaverse Cognitive Overload.
2.	To assess the effectiveness of training, the metaverse offers advanced evaluation methods that can be incorporated into the program during training (Danylec *et al*., 2022).	Metaverse-Based Training Evaluation.
3.	However, despite the potential benefits, the metaverse has not yet been fully implemented in a workplace training setting (Kirkpatrick & Kirkpatrick, 2016).	Metaverse Adoption Gap in Workplace Training
4.	The lack of familiarity that participants may have with metaverse technologies, particularly VR, may hinder their ability to effectively participate in metaverse training (Hsu *et al*., 2013).	Metaverse Technology Literacy Barrier
5.	Many individuals may be hesitant to adopt this technology, especially if they are not familiar with it, which can hinder their ability to effectively participate in metaverse training (Hsu *et al*., 2013).	Metaverse Technology Adoption Resistance
6.	Since most of these are not lightweight, portable, or affordable, metaverse cannot have a wide-scale adoption (Kohli *et al*., 2022).	Metaverse Accessibility Barriers
7.	Ultimately, without AI, it will be difficult to create an engaging, authentic, and scalable metaverse experience (Askr *et al*., 2023).	Smart Metaverse Optimization
8.	The rapid development of the metaverse industry cannot be achieved without the support of relevant policies (Notice of the State Council, 2022).	Metaverse Policy Framework
9.	The valuation study of the metaverse industry is an issue that cannot be ignored in this historical context of rapid high-tech development and the opportunity of the advent of the metaverse boom (Wu *et al*., 2023).	Metaverse Industry Valuation Analysis
10.	The metaverse is an interactive 3D virtual world, in which users can engage as avatars with others and digital entities (Davis *et al*., 2009).	Avatar-based Interactive 3D Environment
11.	The metaverse had already made advancements to e-retail, which itself is an evolution to traditional retail, by providing 'experience-oriented' or novelty-	3D Experience Retailing in the Metaverse

	craving customers with a unique 3D experience (Bourlakis, Papagiannidis, & Li, 2009).	
12.	The third web-empowered metaverse ecosystem has witnessed various financial crimes, and it is critical to summarize and classify the financial security threats on the Web3-empowered metaverse to maintain the long-term healthy development of its ecology (Wu *et al*., 2023).	Financial Security Threats in Web3 Metaverse.
13.	VR as technology for training has been used for many years in various scenarios successfully like in retail, firefighting, aviation, police, military, oil and natural gas, chemical, travel, tourism, gaming, sports, etc. (Upadhyay, Ashwani Kumar *et al*., 2022)	VR Training Applications Across Industries.
14.	The emergence of digital technologies has significantly transformed the workplace by enhancing productivity and improving employee wellbeing (Šímová *et al*., 2024).	Digital Work Environment Upgrade
15.	One of the latest technological advancements in the workplace is the metaverse (Šímová *et al*., 2024).	Metaverse Integration in the Workplace.
16.	DT also brings new elements into the work environment, such as extended reality (XR), augmented reality (AR), mixed reality (MR) and virtual reality (VR) (Kaplan *et al*., 2021; Milgram & Kishino, 1994; Morimoto *et al*., 2022; Mystakidis, 2022; Zhang *et al*., 2022).	Immersive Technologies in the Workplace
17.	The Metaverse is based on a combination of different technologies, including virtual reality, augmented reality, blockchain, and artificial intelligence (Mahmoudi *et al*, n.d).	Multifaceted Technological Integration in the Metaverse
18.	Virtual worlds are the backbone of the metaverse, and they are created using a variety of technologies, including game engines, 3D modeling software, and virtual reality platforms (Bravo & Donoso, 2016).	Virtual World Infrastructure in the Metaverse
19.	Virtual worlds have developed for years through computer simulation, resulting in incredibly lifelike images and melding with reality (Park & Kim, 2022).	Hyper realistic Virtual Environments
20.	The integration of complicated applications of automated information into businesses has been made possible by using I4.0 through virtualization technologies like simulation and VR (Roldán *et al*., 2019).	Industry 4.0-enabled Virtualization.
21.	It has not been long since organizations started using technology to improve remote working conditions and have greater access to information than ever before (International *et al*., 2023).	Technology-Enabled Remote Work Transformation
22.	Options such as AI and the metaverse are even being used by individuals in a variety of ways (International *et al*., 2023).	Individual Utilization of AI and Metaverse Technologies
23.	Organizations can use this technology to provide more realistic scenarios where their workforce can work through different solutions and discover their effectiveness (International *et al*., 2023).	Immersive Training Simulations
24.	To create those environments, extended reality (XR) platforms are used, which is an umbrella term for three immersive technologies that are used based on the level of reality the user strives for – these technologies are augmented-, mixed- and virtual reality (Pimentel *et al*., 2022).	XR-based Immersive Environments
25.	The Metaverse presents promising potential as a tool that can be used for workforce training (Dwivedi *et al*., 2022; Feng *et al*., 2022).	Metaverse-enabled Workforce Training
26.	To meet such challenges, we regard Industry 5.0 as a socio-technical revolution based on the socio-cyber-physical system (SCPS), and propose a socio-technically enhanced wisdom manufacturing architecture and framework beyond CPS-based Industry 4.0/smart manufacturing (Yao *et al*., 2024).	Socio-Technical Wisdom Manufacturing Framework
27.	Finally, we address the roadmap to blockchainzed value-added SCPS-based Industrial Metaverse for Industry/Society 5.0 (Yao *et al*., 2024).	Blockchain-Enabled Industrial Metaverse Roadmap
28.	Currently several industries are starting to try to apply metaverse in various possible implementations, such as manufacturing, health, business, education and training, architecture, and entertainment (Heruatmadja & Ramadhan, 2023).	Cross-Industry Metaverse Adoption.

29.	For business in a smaller context, metaverse can be used to interact with other users in virtual meetings and predicted to be able to replace the current concept of online communication using video conferencing (Heruatmadja & Ramadhan, 2023).	Metaverse-enabled Virtual Meetings
30.	Metaverse, also known as 'the world that is everything', is a blockchain-based decentralized platform (Mehta & Joshi, 2023).	Blockchain-powered Decentralized Metaverse
31.	Metaverse is a virtual environment with 3D avatars that can be accessed using web browsers (Mehta & Joshi, 2023).	Browser-based 3D Avatar Metaverse.
32.	The advancements in artificial intelligence and immersive technologies have made the metaverse a trending topic in various industries, including manufacturing (Amaizu *et al*., 2024).	AI-Driven Immersive Metaverse Trends
33.	Advancements in virtual reality (VR), augmented reality (AR), mixed reality (MR), extended reality (XR), artificial intelligence (AI), Blockchain, non-fungible tokens (NFTs), and digital twins (DT) are of essential importance to the acceleration and realization of the metaverse (Park & Kim, 2022).	Key Technologies Shaping the Metaverse

Table 3 *Key Issues, Challenges, and Trends (Economic)*

No	Drivers and Trends	Key Terms
1.	Organizations face excessive cost of creation, development, and implementation (Mystakidis, 2022).	High-cost Barrier in Creation and Implementation
2.	The Metaverse is one of the most significant rising technologies right now (Guo *et al*, 2022).	Emerging Metaverse Technology
3.	AI is likely to play a vital role in the inclusivity and accessibility of the Metaverse, making it more functional and user-friendly (Guo *et al*, 2022).	AI-driven Metaverse Accessibility Enhancement
4.	The meta-universe concept has been thrust into the limelight and has received widespread attention, with domestic and international companies beginning to lay out their transformations (Wu *et al*., 2023).	Meta-Universe Transformation Initiatives
5.	In the metaverse, its economic system is constructed with the following four aspects, i.e., Digital Creation, Digital Assets, Digital Markets and Digital Currencies (Wu *et al*., 2023).	Metaverse Economic Framework.
6.	The metaverse had already made advancements to e-retail, which itself is an evolution to traditional retail, by providing 'experience-oriented' or novelty-craving customers with a unique 3D experience (Bourlakis, Papagiannidis, & Li, 2009).	3D Experience E-Retailing in the Metaverse
7.	The potential benefits of I6.0 metaverse integration, such as the ability to deliver customized products and services, enhance productivity, and reduce costs (Wierenga, 2021).	I6.0 Metaverse Integration Advantages
8.	The market for Metaverse applications is expected to grow from $47.69bn in 2020 to $828.95bn in 2028, as per the analysts at Emergen Research (Emergen Research, 2021).	Metaverse Application Market Growth Projection.
9.	In teleworking, employees are asked to perform some of their duties at an official workplace (e.g., an office).In cases where the employee works permanently from home, we talk about remote working. Remote working brings several benefits to organizations and employees. Specifically, it reduces the costs (Bjørn &Ngwenyama, 2009; Thompson, 2018).	Cost Reduction Benefits of Remote Working
10.	Remote working also improves the performance of the organizations by the possibility to access talented people worldwide (Aldag & Kuzuhara, 2015; Marques *et al*., 2021).	Global Talent Access and Organizational Performance Enhancement through Remote Working
11.	The Metaverse has the potential to transform the gaming industry by offering new opportunities for engagement and commerce (Mahmoudi *et al*, 2024).	Metaverse-driven Gaming Industry Transformation.
12.	In the commerce industry, the Metaverse can create new opportunities for virtual commerce (Mahmoudi *et al*, n.d.).	Metaverse-enabled Virtual Commerce Revolution
13.	This still requires a substantial investment in terms of the equipment and infrastructure required to operate and maintain these technologies (International *et al*., 2023).	Investment in Technology Infrastructure and Maintenance

14.	Smaller organizations may be forced to wait out the process until the technology is more stable and tested, and as a result more affordable (International *et al*., 2023).	Technology Adoption Challenges for small organizations
15.	The initial investment is a concern since the hardware is still expensive. However, experts believe that the cost will go down with time (Upadhyay & Khandelwal, 2022).	Cost Concerns and Future Outlook of Technology Investment.
16.	However, emerging Industry 5.0 and Society 5.0 reaches beyond CPS and covers the entire value chain of manufacturing, and faces economic, environmental, and social challenges (Yao *et al*., 2024)	Challenges in Industry 5.0 and Society 5.0 Integration
17.	Industry 5.0 is emerging to account for environmental and societal costs and benefits as well, with human-centricity, sustainability and resilience as its core elements (Breque *et al*., 2021)	Human-centric and Sustainable Industry 5.0 Framework
18.	The metaverse refers to a three-dimensional virtual world where avatars engage in political, economic, social and cultural activities (Park & Kim, 2022).	Avatar-populated Three-Dimensional Virtual Environment.
19.	Metaverse is also known as Extended Reality (XR), where the components in it are a combination of technologies known as Augmented Reality (AR) and Virtual Reality (VR) (Buchner, 2022; Jeffri and Awang Rambli, 2021; Xi *et al*, 2022).	Extended Reality (XR) Integration of AR and VR in Metaverse.
20.	Metaverse is emerging as a virtual platform for the real estate investment and other transactions like digital land, non-fungible tokens (NFTs) etc. (Mehta & Joshi, 2023).	Metaverse-enabled Virtual Real Estate Market.
21.	There will be a fully functioning economy in the metaverse to facilitate the buying and selling of digital objects as well as investing (Amaizu *et al*., 2024).	Metaverse Digital Economy
22.	With the acquisition of Oculus, Meta aspires to give users more immersive experiences, especially with the rollout of the Quest 2 VR headsets (Park & Kim, 2022).	Meta's Immersive Experience Aspiration with Oculus Acquisition.

Table 4 *Key Issues, Challenges, and Trends (Environmental)*

No	Drivers and Trends	Key Terms
1.	New devices will need to be designed to provide a truly seamless experience for metaverse users (XR Today, 2021; ITU News, 2022).	Seamless Experience-Centric Device Design for the Metaverse
2.	Consideration of energy consumption and sustainability in the development of virtual environments is crucial for minimizing the environmental impact of the Metaverse (Askr, 2023).	Energy-efficient and Sustainable Virtual Environment Development in the Metaverse
3.	The metaverse is an interactive 3D virtual world, in which users can engage as avatars with others and digital entities (Davis *et al*., 2009).	Interactive 3D Virtual World Concept of the Metaverse
4.	Integrating the metaverse and AI in the manufacturing process can improve workplace safety by providing real-time monitoring of the manufacturing process and identifying potential hazards (Wierenga, 2021).	Metaverse and AI Integration for Real-time Workplace Safety Monitoring
5.	The metaverse technology will help boost industrial production exponentially by providing services like digital simulations of products, energy monitoring, remote diagnosis of production sites, training of employees, etc. (Hussain *et al*., 2023).	Metaverse-enabled Industrial Production Enhancement
6.	In fact, for developing manufacturing including Industry 4.0, we need a balance between the natural environment, economic development and social development (Zengin *et al*., 2021).	Balanced Development Approach in Manufacturing, Including Industry 4.0
7.	The metaverse opens an abundance of opportunities, no longer a vision, now a reality (Amaizu *et al*., 2024).	Realization of Metaverse Opportunities
8.	The metaverse promises to revolutionize the internet by introducing a new era of three-dimensional objects (Amaizu *et al*., 2024).	Metaverse-driven Three-Dimensional Internet Revolution

9.	The industrial metaverse builds upon this merit and extends by including further resources, thus allowing for more environmental indicators to be captured and studied (Assad *et al*., 2024).	Industrial metaverse
10.	DT technology has gained significant merit so far in preserving the environmental sustainability of the system." Key term: Environmental sustainability (Assad *et al*., 2024).	Environmental sustainability
11.	According to the Shift Project report, digital growth is unsustainable; in fact, the energy consumption of current digital activities is growing at 9% per year, and with the advent of the metaverse, this growth can only continue to grow exponentially (Mezzetti *et al*., 2023).	Advent of the metaverse
12.	The metaverse will rely on an infrastructure based on cloud computing, blockchain, artificial intelligence, and virtual reality (Mezzetti *et al*., 2023).	Infrastructure
13.	Wellbeing resources will be available in real-time, and an employee can choose to spend their break in the comfort of their homes to eliminate stress (Stocks, 2016)	Wellbeing resources
14.	The Metaverse provides a platform for remote learning and collaboration, which can reduce the need for physical infrastructure and travel, potentially lessening environmental impact (Mitra, 2023).	Remote Learning
15.	The Metaverse's virtual experiences could potentially reduce the environmental impact of physical travel for educational purposes, offering virtual field trips and remote learning opportunities (Klein, 2022).	Virtual experiences
16.	The digital nature of metaversity suggests a reduced environmental impact compared to traditional physical campuses (Son, 2022).	Digital nature
17.	The environmental impact of technologies like cloud computing and blockchain is significant, with concerns about CO2 emissions and energy consumption (Mezzetti *et al*., 2023).	Environmental impact
18.	The Metaverse is a virtual environment that has the potential to revolutionize the procurement, operations management (Shwedeh *et al*., 2024).	Revolutionize
19.	Sustainability goals and pledges are proving to be daunting challenges for most nation states across the world, especially those with a higher Gini index (Yencharis, 2003).	Sustainability goals
20.	Sustainability is addressed in a myriad ways from JIT manufacturing of user-selected prototypes to clean server houses that incorporate the latest green energy solutions (Yencharis, 2003).	Green energy solutions
21.	We're able to share knowledge with employees in a much more efficient and sustainable way (Asbell-Clarke, 2023).	Sustainable training
22.	Work on real-world skilling opportunities using real-world scenarios and high-pressure situations (DN, 2022).	Real-world skilling opportunities

Table 5 *Key Issues, Challenges, and Trends (Political)*

No	Drivers and Trends	Key Terms
1.	Employees may be subject to racist harassment because of their avatar's representation (Tawakley, 2022).	Avatar-based Racist Harassment.
2.	Regulatory frameworks and governance structures need to address issues related to data privacy and security in the Metaverse to ensure user protection (Askr, 2023).	Data Privacy and Security Regulations in the Metaverse
3.	The rapid development of the metaverse industry cannot be achieved without the support of relevant policies (Notice of the State Council, 2022).	Policy Support for Metaverse Industry Development
4.	China should accelerate the research and demonstration of metaverse and actively try to develop the technology and industry under the premise of safety and control, while cautiously dealing with problems that may be brought about (King, 2022).	China's Approach to Metaverse Development: Safety, Control, and Caution.
5.	The metaverse is an interactive 3D virtual world, in which users can engage as avatars with others and digital entities (Davis *et al*., 2009).	Interactive 3D Virtual World.
6.	The critical analysis of ethical and prior philosophical evaluability, as with the practical application of emerging technologies, highlights the importance of	Ethical Considerations in Technology Development and Integration

	ethical considerations in developing and integrating technologies in various industries (Heilala *et al*, 2023).	
7.	The mechanism of trust affecting collaboration in virtual teams and the moderating roles of the culture of autonomy and task complexity (Choi & Cho, 2019).	Trust Mechanism in Virtual Team Collaboration
8.	Impact of remote working on wellbeing of the employee, or, for example, unclear legal basis for remote work in some countries, including tax rules (Tyutyuryukov & Guseva, 2021).	Remote Work Impact on Wellbeing and Legal Considerations.
9.	The Metaverse is a complex system that involves multiple parties and data sources, which makes it vulnerable to cyber-attacks and data breaches (Kshetri, 2021).	Cybersecurity risk in the Metaverse
10.	The use of digital assets, such as virtual currencies and tokens, raises questions about their security and regulation (Kshetri, 2021).	Security and Regulation of Digital Assets.
11.	Cybersecurity is used to combat these risks. It preserves the supplied information and adheres to industry norms (Oxford Analytica, 2022).	Cybersecurity Measures for Data Protection and Compliance
12.	As regulations seek to keep up with these advancements, it is clear that there is no turning back (International *et al*., 2023).	Irreversible Regulatory Adaptation to Advancements
13.	The unpredictability introduces a difficult factor to control (International *et al*., 2023).	Challenges of Managing Unpredictability.
14.	As such, in 2021 the European Union proposed Industry 5.0 to complement Industry 4.0 officially presented by Germen at the Hannover Messe fair 10 years ago in 2011, with further consideration of the role and contribution of industry to society (Breque *et al*., 2021).	European Union's Proposal of Industry 5.0.
15.	The metaverse refers to a three-dimensional virtual world where avatars engage in political, economic, social and cultural activities (Park & Kim, 2022).	Three-Dimensional Virtual World.
16.	The team identified similarities and differences in functions across (Assad *et al*., 2024).	Team analysis
17.	Increasingly, companies and training institutions need to understand the global impact of their methodological and technological choices in the virtual world have on the real world (Mezzetti *et al*., 2023).	Sustainability
18.	Privacy and cybersecurity are issues related to the use of digital devices that collect and use data, which must be ensured under a regulatory and informational perspective (Mezzetti *et al*., 2023).	Data protection
19.	Other aspects of society are also in crisis, including increased globalization, persistent inequality, environmental degradation, public health concerns, and political turmoil (Klein, 2022).	Economic instability
20.	Creating a supportive policy to provide a safe and supportive working environment for all employed is done through the online and physical worlds using traditional ways, such as providing access to online wellbeing programs and holding regular events (Stocks, 2016).	Supportive policy
21.	Governments are preparing legislation to govern activities within the Metaverse, highlighting the need for cybersecurity and data protection in virtual environments (Klein, 2022).	Legislation

Table 6 *Key Issues, Challenges, and Trends (Value)*

No	Drivers and Trends	Key Terms
1.	To assess the effectiveness of training, the metaverse offers advanced evaluation methods that can be incorporated into the program during training (Danylec *et al*., 2022).	Metaverse-Based Training Evaluation.
2.	However, despite the potential benefits, the metaverse has not yet been fully implemented in a workplace training setting (Kirkpatrick & Kirkpatrick, 2016).	Challenges in Metaverse Adoption for Workplace Training
3.	The lack of familiarity that participants may have with metaverse technologies, particularly VR, may hinder their ability to effectively participate in metaverse training (Hsu *et al*., 2013).	Impact of Technology Familiarity on Metaverse Training Participation

4.	Many individuals may be hesitant to adopt this technology, especially if they are not familiar with it, which can hinder their ability to effectively participate in metaverse training (Hsu *et al*., 2013).	Barriers to Adoption of Metaverse Training Due to Lack of Familiarity
5.	Enhancing user experience through innovation and digital transformation is essential for driving the value proposition of the Metaverse (Askr, 2023).	User Experience Enhancement.
6.	In this ecology, one also needs to be commodities, and with commodities comes value as well as value comes the need (Wu *et al*., 2023).	Commoditization and Value Creation in the Metaverse Ecology.
7.	The valuation study of the metaverse industry is an issue that cannot be ignored in this historical context of rapid high-tech development and the opportunity of the advent of the metaverse boom (Wu *et al*., 2023).	Valuation Challenges in the Metaverse Industry.
8.	The metaverse is an interactive 3D virtual world, in which users can engage as avatars with others and digital entities (Davis *et al*., 2009).	Interactive 3D Virtual Environment
9.	By considering the perspectives of different ethical frameworks, such as agent-centered ethics, consequentialist ethics, and virtue ethics, manufacturers can develop AI systems and the metaverse to benefit society's well-being (Heilala *et al*., 2023).	Ethical frameworks for AI and metaverse development
10.	The future for training in Metaverse seems to be bright with benefits for both employers and employees (Upadhyay, Ashwani Kumar *et al*., 2022).	Promising Future of Metaverse Training.
11.	Our study contributes to the growing body of research on the practical applications of a metaverse in the workplace. It highlights the importance of considering various factors for its successful implementation (Šímová *et al*., 2024).	Practical Applications and Implementation Factors of Metaverse in the Workplace
12.	Metaverse can provide new opportunities for creativity, expression, and social interaction (Mayra, 2020).	Potential of Metaverse for Creativity and Social Interaction
13.	The Metaverse represents an opportunity for innovation and entrepreneurship, as companies and individuals seek to create new applications and experiences that leverage this technology (Su, Peng, & Zhu, 2021).	Entrepreneurial Opportunities in the Metaverse
14.	The metaverse can provide rapidly evolving threats, much like any rapidly evolving technology set (Hussain *et al*., 2023).	Emerging Threats in the Metaverse
15.	New labor regulations will be necessary to adapt to and normalize the enormous changes that Industry 4.0's experimental and developing technologies will bring about in society (Hussain *et al*., 2023).	Regulatory Adaptations for Industry 4.0 Technologies
16.	Rather than thinking of it as a replacement option but one that is complementary (International *et al*., 2023).	Complementary Nature of Technology.
17.	The merging of the virtual world and reality is something that has long been awaited and now with the possibilities offered within the metaverse, organizations can have free rein within the virtual space to explore unconventional options (International *et al*., 2023).	Integration of Virtual and Real Worlds in the Metaverse
18.	Therefore, it is necessary to investigate the manufacturing systems from the perspective of socio-technical view for Industry 5.0/Society 5.0 (Oborski, 2003).	Socio-Technical Perspective on Manufacturing Systems.
19.	Such human-centric value-driven manufacturing will be enabled by the Industrial Metaverse as stated below (Breque *et al*., 2021).	Human-Centric Manufacturing Enabled by the Industrial Metaverse
20.	Metaverse is presented as 'the biggest business opportunity in the modern era since the invention of the internet', but its success will depend on the condition that there are fundamental similarities in both physical and virtual interactions, felt as something the same sensorily, so that it can represents the user's reality in socializing, working, and playing (Charlton, 2022).	Success Factors for the Metaverse: Sensorial Similarities
21.	The metaverse is a persistent, online, 3D universe created by combining multiple different virtual spaces (Mehta & Joshi, 2023).	Metaverse
22.	The internet is often seen as a place where communication, sharing, and work take place. Hence the metaverse can be said to be an internet we can interact with like we would with a physical world (Amaizu *et al*., 2024).	Metaverse as an Interactive Internet

Appendix B

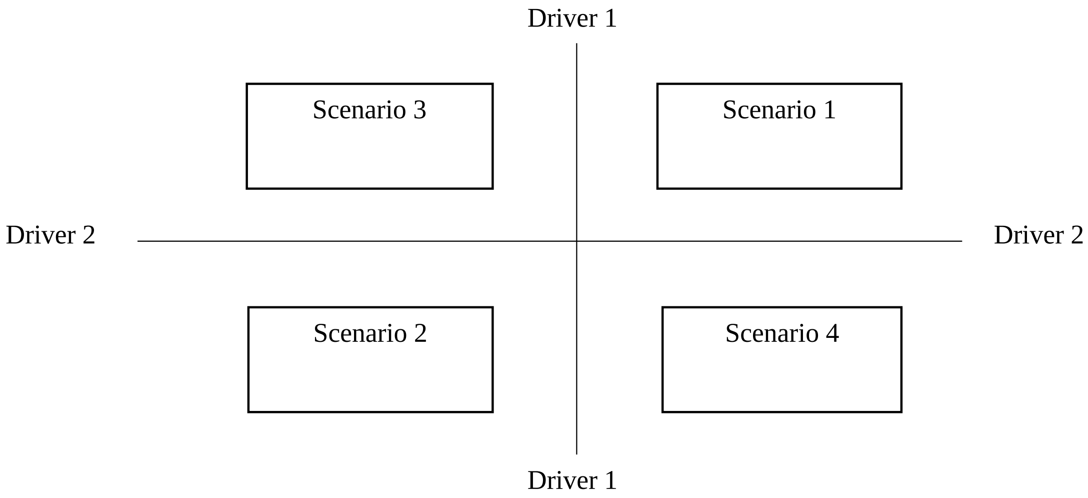

Fig. 2 *Four quadrants for scenario building*

Appendix C

Table 7 *Table with key terms of issues, challenges, and trends*

Social	Technological	Economic	Environmental	Political	Value
1)Workplace Cyberbullying	1)AR-Metaverse Cognitive Overload.	1)High-cost Barrier in Creation and Implementation	1)Seamless Experience-Centric Device Design for the Metaverse	1)Avatar-based Racist Harassment.	1)Metaverse-Based Training Evaluation.
2Virtual Representation Harassment	2) etaverse-Based Training Evaluation.	2)Emerging Metaverse Technology	2)Energy-efficient and Sustainable Virtual Environment Development in the Metaverse	2) Data Privacy and Security Regulations in the Metaverse	2) Challenges in Metaverse Adoption for Workplace Training
3) Metaverse-Induced Dissociation	3) Metaverse Adoption Gap in Workplace Training	3) AI-driven Metaverse Accessibility Enhancement	3) Interactive 3D Virtual World Concept of the Metaverse	3) Policy Support for Metaverse Industry Development	3) Impact of Technology Familiarity on Metaverse Training Participation
4) Emerging Technology	4) Metaverse Technology Literacy Barrier	4) Meta-Universe Transformation Initiatives	4) Metaverse and AI Integration for Real-time Workplace Safety Monitoring	4) China's Approach to Metaverse Development: Safety, Control, and Caution.	4) Barriers to Adoption of Metaverse Training Due to Lack of Familiarity
5) AI-Driven Inclusivity	5) Metaverse Technology	5) Metaverse Economic Framework.	5) Metaverse-enabled Industrial	5) Interactive 3D Virtual World.	5) User Experience Enhancement

	Adoption Resistance		Production Enhancement		
6) Global Metaverse Adoption	6) Metaverse Accessibility Barriers	6) 3D Experience E-Retailing in the Metaverse	6) Balanced Development Approach in Manufacturing, Including Industry 4.0	6) Ethical Considerations in Technology Development and Integration	6) Commoditization and Value Creation in the Metaverse Ecology.
7) Metaverse Market Integration	7) Smart Metaverse Optimization	7) I6.0 Metaverse Integration Advantages	7) Realization of Metaverse Opportunities	7) Trust Mechanism in Virtual Team Collaboration	7) Valuation Challenges in the Metaverse Industry.
8) Interpersonal Communication Skills	8) Metaverse Policy Framework	8) Metaverse Application Market Growth Projection.	8) Metaverse-driven Three-Dimensional Internet Revolution	8) Remote Work Impact on Wellbeing and Legal Considerations.	8) Interactive 3D Virtual Environment
9) AI-Metaverse Synergy	9) Metaverse Industry Valuation Analysis	9) Cost Reduction Benefits of Remote Working	9) Industrial Metaverse	9) Cybersecurity risk in the Metaverse	9) Ethical frameworks for AI and metaverse Training
10) Metaverse Business Platform	10) Avatar-based Interactive 3D Environment	10) Global Talent Access and Organizational Performance Enhancement through Remote Working	10) Environment Sustainability	10) Security and Regulation of Digital Assets.	10) Promising Future of Metaverse Training.
11) VR-Enhanced Remote Work	11) 3D Experience Retailing in the Metaverse	11) Metaverse-driven Gaming Industry Transformation.	11) Advent of the Metaverse	11) Cybersecurity Measures for Data Protection and Compliance	11) Practical Applications and Implementation Factors of Metaverse in the Workplace
12) Digital Workplace Transformation	12) Financial Security Threats in Web3 Metaverse.	12) Metaverse-enabled Virtual Commerce Revolution	12) Infrastructure of Metaverse	12) Irreversible Regulatory Adaptation to Advancements	12) Potential of Metaverse for Creativity and Social Interaction
13) Virtual Team Collaboration	13) VR Training Applications Across Industries	13) Investment in Technology Infrastructure and Maintenance	13) Wellbeing Resources	13) Challenges of Managing Unpredictability	13) Entrepreneurial Opportunities in the Metaverse
14) Extended Reality (XR)	14) Digital Work Environment Upgrade.	14) Technology Adoption Challenges for small organizations	14) Remote Learning	14) European Union's Proposal of Industry 5.0.	14) Emerging Threats in the Metaverse

15) Metaverse Ethics	15) Metaverse Integration in the Workplace.	15) Cost Concerns and Future Outlook of Technology Investment.	15) Virtual Learning	15) Three-Dimensional Virtual World.	15) Regulatory Adaptations for Industry 4.0 Technologies
16) Co-located Collaboration	16) Immersive Technologies in the Workplace	16) Challenges in Industry 5.0 and Society 5.0 Integration	16) Digital Nature	16) Team Analysis	16) Complementary Nature of Technology.
17) AI-enabled information gathering	17) Multifaceted technological integration in the Metaverse	17) Human-centric and sustainable industry 5.0 framework	17) Environmental impact	17) Sustainability	17) Integration of virtual and real worlds in the Metaverse
18) Technological disconnection	18) Virtual world infrastructure in the Metaverse	18) Avatar-populated three-dimensional virtual environment	18) Revolutionize	18) Data protection	18) Socio-Technical perspective on manufacturing systems
19) Metaverse-Driven learning and development	19) Hyper realistic virtual environments	19) Extended reality (XR) integration of AR and VR in Metaverse	19) Sustainability goals	19) Economic instability	19) Human-centric manufacturing enabled by the industrial Metaverse
20) Sustainable Technological Development	20) Industry 4.0-enabled Virtualization.	20) Metaverse-enabled Virtual Real Estate Market.	20) Green Energy Solutions	20) Supportive policy	20) Success Factors for the Metaverse: Sensorial Similarities
21) Cyber-Physical-Social Integration	21) Technology-Enabled Remote Work Transformation	21) Metaverse Digital Economy	21) Sustainability training	21) Legislation	21) Metaverse
22) Open Manufacturing Ecosystem	22) Individual Utilization of AI and Metaverse Technologies	22) Meta's Immersive Experience Aspiration with Oculus Acquisition.	22) Real-Word skilling	22) Intellectual Property	22) Metaverse as an Interactive Internet
23) Digital Preference Amidst Pandemic	23) Immersive Training Simulations				
24) Virtual Social Environment	24) XR-based Immersive Environments				
25) Socially-oriented 3D Virtual Network	25) Metaverse enable Workplace Training				
26) Integrated Digital Social Environment	26) Socio-Technical Wisdom				

	Manufacturing Framework
27) Metaverse Pioneering Sectors	27) Blockchain-Enable Industrial Metaverse Roadmap
28) Global Collaboration with Real-Time Translation	28) Cross-Industry Metaverse Adoption
	29) Metaverse enabled Virtual Meetings
	30) Blockchain-powered Decentralized Metaverse
	31) Browser-based 3D Avatar Metaverse
	32) AI-Driven Immersive Metaverse Trends
	33) Key Technologies Shaping the Metaverse

Appendix D

Table 12 *Summary of demographic profiles*

	Frequency *(f)*	Percentage (%)
Gender		
Male	127	50.6
Female	124	49.4
Age (Years)		
Below 30	39	15.5
31 – 40	86	34.3
41 and above	74	29.5
51 and above	52	20.7
Education Qualification		
SPM/STPM/Diploma	42	16.7
Degree Level	87	34.7
Master Level	88	35.1
PhD Level	34	13.5
Experience in HR (Years)		
<1 years	42	16.7
1- 5 years	85	33.9
5 – 10 years	80	31.9
> 10 years	44	17.5
Current Position/ Job Title		
HR Assistance	48	19.1
HR Specialist	90	35.9
HR Manager	73	29.1

HR Director	39	15.5
HR Admin Executive	1	0.40
Company Size (Number of Employees)		
Less than 50	27	10.8
50 – 199	78	31.1
200 – 499	55	21.9
500 – 999	63	25.1
1000 and above	28	11.2
Experience with Technology in Training and Development		
None	39	15.5
Limited	83	33.1
Moderate	82	32.7
Extensive	47	18.7
Familiarity with Metaverse Technology		
Not Familiar at all	36	14.3
Slightly Familiar	84	33.5
Moderate Familiar	89	35.5
Very Familiar	42	16.7
Current use of Technology for Training and Development		
None	30	12.0
Basic Tools	67	26.7
Advanced Tools	53	21.1
Cutting-edge Technology	74	29.5
Metaverse-related Technology	27	10.8

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