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The Physical Architecture Relevance in Designing Virtual Environment

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ABSTRACT

The integration of digital reality systems in building design has been the way forward over the past half-century. The paper analyses the impacts of rising demand for digital environments in the architecture industry and the relevance of an architect in designing virtual environments (VEs). As there are numerous architectural design considerations, the physical architecture relevance is streamlined into three components, namely relevance in human lifestyle changes, relevance in sense of touch and relevance in scale. Likert-scale survey questionnaire collects data to evaluate the implications of different physical spatial qualities on the user's satisfaction, perception, and cognition. Architect is relevant in addressing the design limitations and fostering collective multidisciplinary synergy in the effort of establishing a positive impact for VEs. Semi-structured interviews are carried out to examine the different relationships between physical spatial layout and VEs. By optimising the functional, spatial, ergonomic, sensuous, economic, and technological relationships, an architect's expertise is fundamental for an immersive mixed-reality experience. Content analysis is conducted to synthesize the future roles of an architect. Architect is relevant in formulating a holistic design strategy from the environmental, social and governance aspects. The evolving roles of an architect are synthesized based on the Architects (Scale of Minimum Fees) Rules 2010. Digital transformation is momentous and adaptation strategy is the way forward. The demand for an architect will not become redundant, but it will evolve alongside the context of VE. Human-centric VE with XR technology-infused activities is the key to digitalising the built environment.

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1. Introduction

The boundary between the physical and digital world has been gradually broken down by the advancement of technology. From physical retail stores to the blooming scene of electronic commerce platforms, the refurbishment of a traditional library with the incorporation of digital gadgets, or even the surging worldwide demands for smart mobile devices, the digital threshold for one to access the virtual world from the physical world is becoming effortless (Thomas, 2001). Architecture is characterised by the articulation of its spatial context and scale (Berthol, 1997). The digital revolution has introduced various digital reality technologies such as virtual reality, augmented reality and mixed-reality systems that can present hyper-realistic 3-dimensional graphics and recognize gestural interactions in building design (Aaron et al., 2021). This allows a greater extent of spatial flexibility and equips the physical space with higher versatility to cater to diverse functional programs and activities.

1.1 Problem Statement

Augmented reality and virtual reality devices work best under dark conditions where the artificial lighting from gadgets does not have to compete with natural lighting (Erikson et al., 2020). Spaces operating on Extended Reality (XR) technologies are often designed with minimal opening so that they are naturally dark and acoustically insulated. In this case, the interior space serves as a controlled internal environment that complements the operation of XR technologies better. The withdrawal of fundamental architectural elements such as windows, materials and texture has eventually resulted in the lifeless and monotonous design of architectural space. The absence of natural lighting and ventilation in an exhibition area not only contributes to a higher carbon footprint with additional energy consumption for artificial lighting and mechanical cooling load, but it also disconnects the users from the real-time condition and surrounding context.

1.2 Literature Review

The relevance of an architect to thrive in this digital era is being questioned due to the active adoption of virtual reality into our daily lives. Hence, the published academic papers are reviewed to evaluate the architect's relevance in designing virtual environments (VEs). As the architectural design considerations involve numerous design principles and elements, this paper would streamline the physical architecture relevance into three main components that contribute the most significant impacts in designing VEs based on the published academic papers.

1.2.1 Relevance in Human Lifestyle Changes

Extended Reality (XR) infuses the virtual world into the physical world gradually. While XR allows a more personalized and immersive experience, it has permeated into our daily lives: the way we educate and learn, the strategy and implementation tool for marketing, the interactive augmented reality gadgets we use during our visits to museums or galleries, etc. (Marr, 2021). It is evident that the XR technologies are changing the human' lifestyle and how people live, work and play.

For instance, the accelerated trend of 'Working-from-Home' is further intensified with the emergence of XR technology which facilitates remote working and mitigates its challenges (Fereydooni & Walker, 2020). This new norm has turned the users' attention to a more flexible yet interactive workspace alternative, which indirectly results in a higher demand for home-office and co-workspace. In addition, the convenience of virtual platforms for collaborative meetings has reshaped the work culture and has benefited the healthcare industry significantly during the COVID-19

pandemic (Idris & Edris, 2021). In this case, several acoustically tailored individual meeting pods would be more appropriate than a large meeting room design for offices to cater for the need for privacy for virtual meetings. The wellness design of residential units is emphasized as the time spent at home becomes longer.

Built spaces are to adjust to adapt to the change of different patterns of use and spatial layouts are reconfigured to accommodate the change (Kolarevic & Parlac, 2015). Hence, there is a direct correlation between the XR technology's influence on daily life and the architectural functional design. The selected publications are reviewed in terms of the influence and impact of XR technologies on human lifestyle. The summary is tabulated as shown in Table 1.

Table 1
Summary of the impacts of XR technologies and human lifestyle changes

	Research Titles	Focus Area	Impacts
1.	Enhancing Cultural Tourism Experiences with Augmented Reality Technologies	Cultural Tourism	• Allowing users to retrieve interactive and personalized multimodal information about historical buildings and monuments of a city • Facilitating archaeologists and historians to reconstruct historical monuments and places virtually • Contributing a great impact on the history knowledge about the effect of time on different materials and the virtual reconstruction of heritage and historical objects
2.	Beyond Virtual and Augmented Reality: AI-Assisted Mixed Reality and its Impacts on Society	Societal Values	• With AI's precise depth perception, it facilitates the surgical process while contributing to healthcare • To make complex decisions with the aid of supercomputers • Customizing training and simulation for education • Providing an alternative for socialization through virtual meeting
3.	Augmented Reality: An Overview and Five Directions for AR in Education	Education	• AR simulation and training alongside the tactile feedback interface improve user's learning performance • Transform learning and teaching materials into a re-usable resource • AR holographic projection technology with portable video conferencing technology enables effortless communication over distance between learners and educators
4.	Potential of Augmented Reality and Virtual Reality Technologies to Promote Wellbeing in Older Adults	Senior Living	• To overcome deterioration in the elderly's mobility, cognitive ability, and socialization • Introduce fun factors that improve the elderly's psychological well-being • Providing a risk-free environment for physical and cognitive training • To motivate and cultivate interest in promoting a positive attitude towards healthcare
5.	Augmented Reality Marketing in Malaysia-Future Scenarios	Marketing	• A better users' information retention, customer service experience, and innovative marketing strategy • Establish a sustainable marketing framework that encourages economic development
6.	New Realities: A Systematic Literature Review on Virtual Reality and Augmented Reality in Tourism Research	Tourism Education	• As a tourism tool for tourism education, destination and cultural heritage marketing, VR allows users to experience audio, visual and spatial impressions of the destination • AR is an information dissemination tool and location guide in museums with its mobile nature • Concern regarding depreciating the authenticity of heritage site

7.	Augmented Reality and Virtual Reality: New Drivers for Fashion Retail?	Fashion Retail	• Enhancing customer experience and potentially increasing customer satisfaction with reduced waiting time for fitting room as customers can virtually try on the garment • Enable retailers to capture shoppers' interests and attention • Reduce demand for physical retail stores with the immersive shopping experience online
8.	Evaluating Virtual Reality and Augmented Reality Training for Industrial Maintenance and Assembly Tasks	Industrial Maintenance and Assemble (IMA)	• Establishing a favourable training platform for complex and highly demanding Industrial Maintenance and Assembly (IMA) task • A systematic training and task execution information documentation such as performance time, number of errors, number of accurate implementations, etc. • Haptic devices promote a better cognitive understanding and flexibility to adapt to users' needs and preferences in accordance with learning strategies and modules

1.2.2 Relevance in Sense of Touch

An experiential architectural design is often well-equipped with the five senses, namely sight, hearing, smell, taste, and touch (Kim & Yang, 2017). The excellence of XR technology in establishing visual enticement and sensational visual cues has benefited numerous industries and contributed significantly to their development. However, the dominance of the sense of sight in XR technology has outdone the other four senses. The absence of other senses in designing VEs withdraws the opportunity to further elevate the immersive experience of VEs.

Among all the five senses, the sense of touch allows the most direct and unequivocal impression of the tangible quality and palpability of architecture (Pohl & Loke, 2012). One would feel rough upon touching the raw concrete wall, and one would feel hot in a warm room. The connection to space is explicit and authentic. Thus, the publications emphasizing the integration of sense of touch into the XR technology are reviewed and tabulated as shown in Table 2.

Table 2
Summary of the integration of sense of touch in XR technologies

	Research Titles	Findings
1.	REVEL: Tactile Feedback Technology for Augmented Reality	• REVEL is an Augmented Reality (AR) tactile technology that transforms the physical tactile sensation of real objects into a virtual tactile quality texture using the gadget worn by users • Utilizing the principle of reverse electro-vibration to apply a weak electrical signal on any part of the user's body and thereby create an oscillating electrical field around the user's fingers • Integrating dynamic tactile sensations to the VE context
2.	Virtual Reality and Stimulation of Touch and Smell for Inducing Relaxation: A Randomized Controlled Trial	• As the stimulation of the sense of touch provides the user with more sensory information, it improves the mood induction and the sense of presence in VE
3.	Touching the Past: Haptic Augmented Reality for Museum Artefacts	• With the Sensable™ Omni 6DoF Haptic Augmented Reality technology, it allows museum visitors to virtually touch the actual physical non-touchable artefact • A replica is created by laser scanning in reference to the original artefact, while VR and co-location interfaces are incorporated to establish the illusion of touching the actual artefacts while the user is experiencing the texture of the replica

1.2.3 Relevance in Scale

Utilizing the latest technology of XR to enrich visitors' experience is popular in the context of museums and galleries (Jung et al., 2016). The rapid development of fully immersive virtual reality devices is introducing a more interactive and sensuous user experience into the physical space. However, VEs are often larger than the physical spaces and exceed the available physical walking limit (Kelly et al., 2020). User mobility in VEs is restricted by physical constraints such as limited floor area, spatial volume and height, floor levelling, etc.

The architects must be well-versed in the activities carried out by the end-users in VEs. The activities can range from small-scale activities such as gaming and virtual meetings that involve minimal body movements to large-scale events such as the marathon in metaverse organised by Decentraland, a 3-dimensional virtual world browser-based platform that promotes users' shared digital experience (Decentraland, 2022). Architecture for VE might be the prospect of a global built environment and be the newly emerged building typology (Bourdakis & Charitos, 1999). The incorporation of XR technology would enhance the overall physical spatial experience with the architect's design consideration for scaling technology and holistic understanding of the relative scale between physical space and VE. Thus, the integration of technology and design innovation to enhance the user's reality presence with physical space relative scale is evaluated. The selected publications are summarised and tabulated according to the XR scaling technologies as shown in Table 3.

Table 3
Summary of the XR technologies and innovations in scaling the VEs

	Research Titles	Technologies	Findings
1.	A Generic Model for Embedding Users' Physical Workspaces into Multi-Scale Collaborative Virtual Environments	Immersive Interactive Virtual Cabin (IIVC)	• Establish a generic software model to integrate VE into physical space • To augment the VE spatial experience into a multi-sensory space with features of the physical environment such as sound, visual and motion • An immersive device that allows the user's head-tracking and co-location of physical objects while user navigating in VE • To enhance the collaboration and interaction between users with the functionalities of scaling, moving and rotating
2.	Peripheral Stimulation and its Effect on Perceived Spatial Scale in Virtual Environments	Static Peripheral Stimulation	• Static white light stimulation towards far peripheral locations stimulates a positive change and a more accurate visuospatial perceived scale in VE
3.	The Relationship between the Body and the Environment in the Virtual World: The Interpupillary Distance Affects the Body Size Perception	Manipulation of Interpupillary Distance (IPD)	• The higher the interpupillary distance, the smaller the external environment the users would perceive • With a fixed IPD, users would perceive their body size as significantly larger while the external world changes minimally when the users' eye levels are increased, and their hands are enlarged
4.	1:1 Scale Perception in Virtual and Augmented Reality	SCENIC II Virtual Cockpit, Head Mounted Display (HMD) & Cylindrical Screen	• Underestimation of scale in VEs occurs when using a cylindrical screen • HMD is more suitable for evaluating dimensions at a closer distance
5.	Designing and Evaluating a Workstation in Real and Virtual Environment: Toward Virtual Reality-Based Ergonomic Design Sessions	Co-localized Simulation with haptic devices	• With the aid of sensor-sharing and sensor-bridging communication, the mechanical limitation can be resolved • The user can use 6-DoF devices and maximise their manipulability with flexibility in translation and rotation while maintaining the 1:1 scale perception of the virtual object

1.3 Research Aim

The current paper is significant for the assessment of physical architectural design for a digital environment and the speculation of the future roles of an architect. The paper is exploratory and will gain insights into the architecture industry and its future development.

1.4 Research Objectives

The XR technologies would be the next leap in the architectural revolution as digital environments offer immense potential in social and economic contexts (Milekic, 2000). The paper explores how the emerging trend of XR system integration into the building design will affect the architect's relevance in physical spatial design. The purpose is to examine the pros and cons of leveraging the physical built environment for more immersive VEs. The future demand for virtual space and physical space is reviewed and analysed. Hence, the three main research objectives are proposed as the followings:

i. To investigate the implications of different physical spatial qualities on the user's satisfaction, user's perception, and user's cognition in the virtual environment.
ii. To evaluate the relationship between physical spatial layout and virtual environment in the pursuit of the immersive mixed reality experience.
iii. To examine the future role of an architect in designing in the context of the virtual environment and innovating physical architecture for the virtual environment.

1.5 Research Questions

The research questions are formulated as follows:

i. What are the implications of different physical spatial qualities on the user's satisfaction, user's perception, and user's cognition in the virtual environment?
ii. How does the difference in the relationship between physical spatial layout and virtual environment enhance the immersive mixed reality experience?
iii. In the near future, will the role of an architect be geared towards designing in the context of the virtual environment and innovating physical architecture for the virtual environment?

2. Methodology

The paper evaluates the physical architecture relevance in designing VEs through the understanding of spatial implications, relationships, and potential adjustments to the role of architects. The methodology of this paper is summarized in Figure 1.

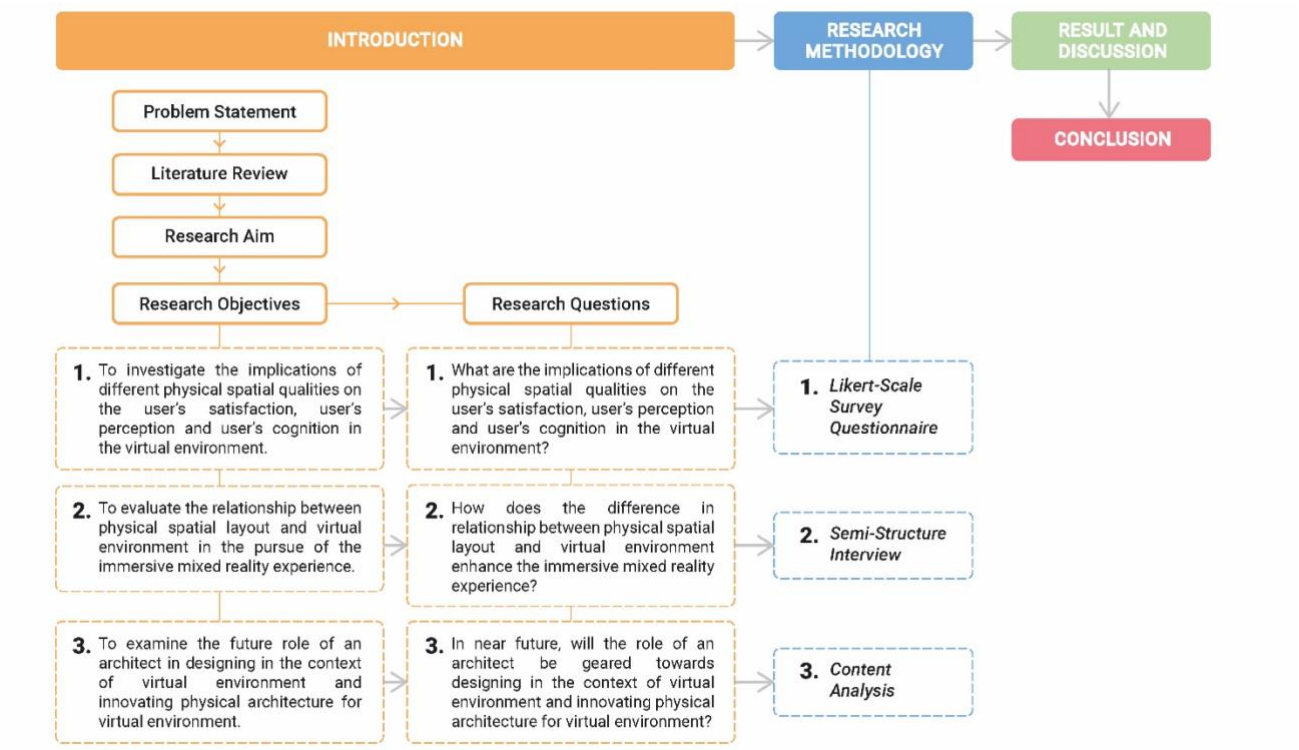


Fig. 1. Methodology summary

2.1 Likert-scale Survey Questionnaire

The survey questionnaire data and information are sorted and analysed with Constant Comparative Analysis (CCA). CCA is implemented as the approach to retain the subjectivity of the quantitative data collected and to fully utilise the benefits of a qualitative survey questionnaire (Schneider and Wagemann, 2010). CCA is supported by the Grounded Theory established by Glaser and Strauss, where the raw qualitative data are categorised into groups according to the attributes, and the structured tabulation is further evaluated to formulate a new theory (Boeije & Hennie, 2002). The findings are tabulated according to their respective subjects with contradiction, expansion, and support organizing methods. The groups are compared, and the results are synthesized. The implications of different physical spatial qualities on the user's satisfaction, user's perception and user's cognition in the virtual environment are identified and analysed.

2.2 Semi-Structured Interview

Interview data are collected to understand the relationship between physical spatial layout and virtual environment in the pursuit of the immersive mixed reality experience. Architects with experience in designing virtual projects are identified as the primary information providers to discuss and contribute critical viewpoints on their user experience on the integration of VE and XR technologies. Semi-structured interviews are conducted to obtain interviewees' pertinent conjectures and reasoning on the research topic. The interviews are recorded and transposed into transcribed verbatim. The diversity of VEs and their corresponding physical spatial layout relationships are evaluated, and the design considerations are synthesized. It is significant as it determines the way forward for the architecture industry in developing an architectural physical constitution in the context of VEs.

2.3 Content Analysis

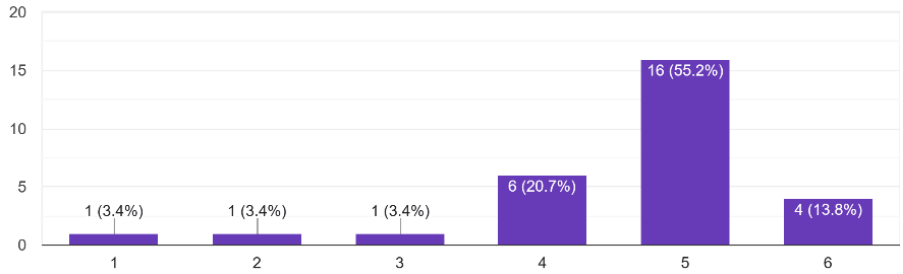
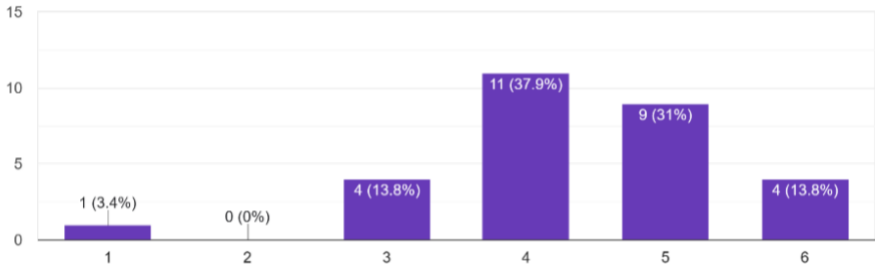
Content analysis is conducted to examine the future role of an architect in designing in the context of VEs and innovating physical architecture for VEs. The active adoption of XR technologies and VEs in various industries in Malaysia is analysed and the data collected is interpreted textually in relation to their potential implications for the built environment. It involves examining the characteristics, patterns, and meanings of the data from various resources such as media resources, social media posts and focus group interviews. The identified trend provides a structured approach to analysing and synthesising the future role of an architect.

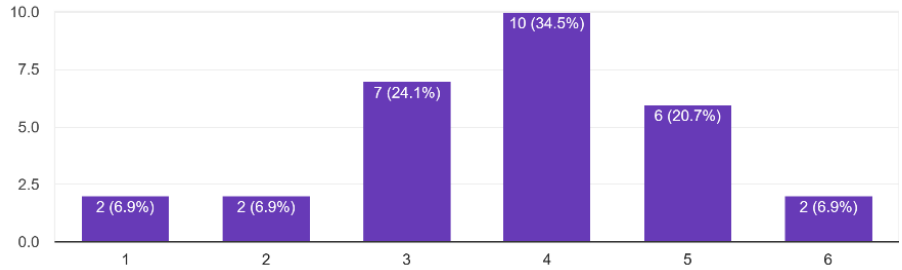
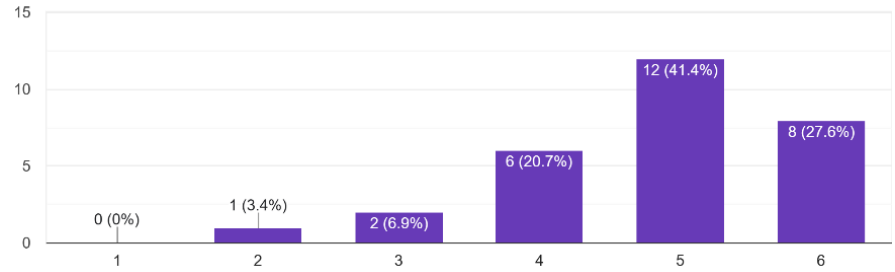
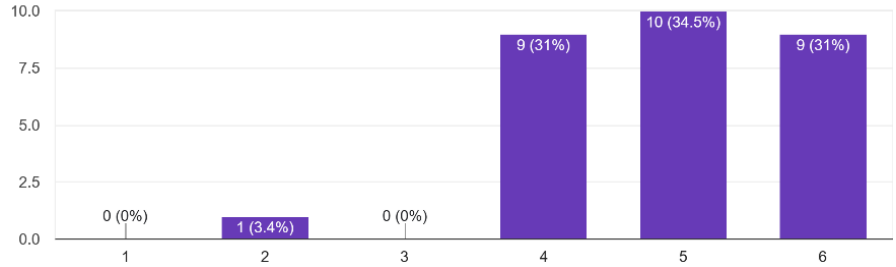
3. Result and Discussion

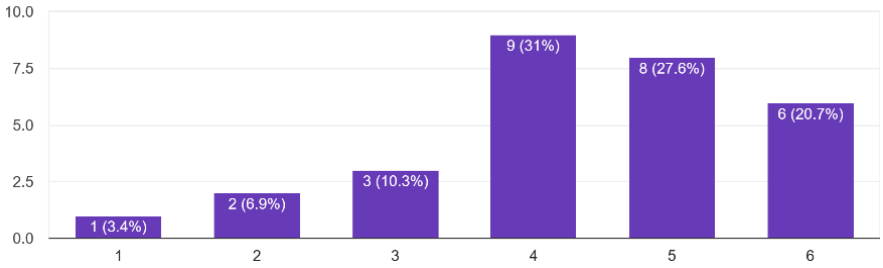
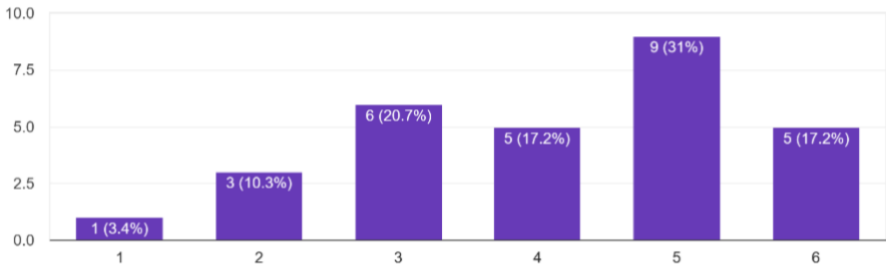
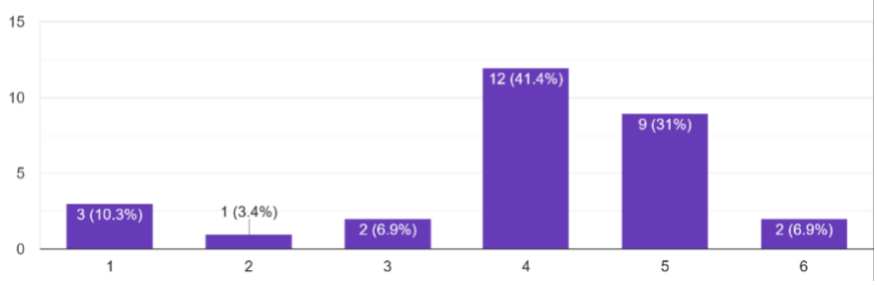
3.1 Likert-scale Survey Questionnaire
3.1.1 Result

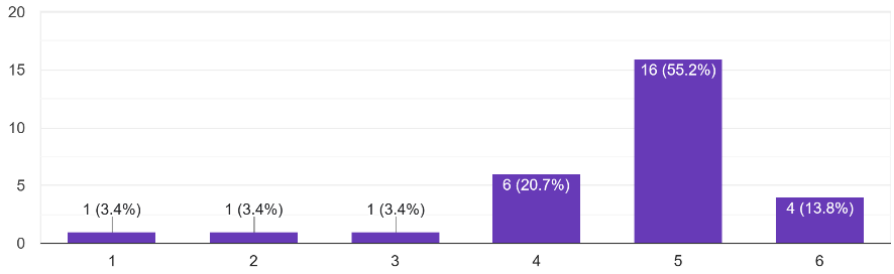
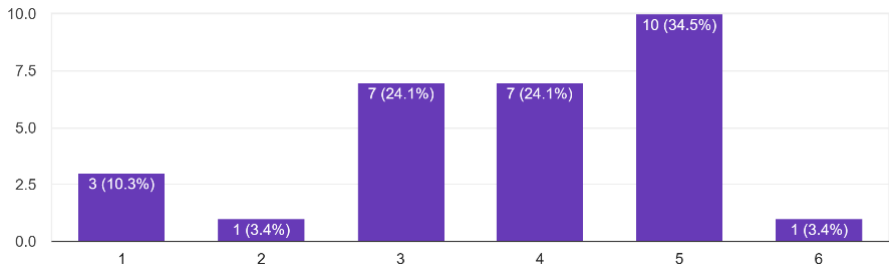
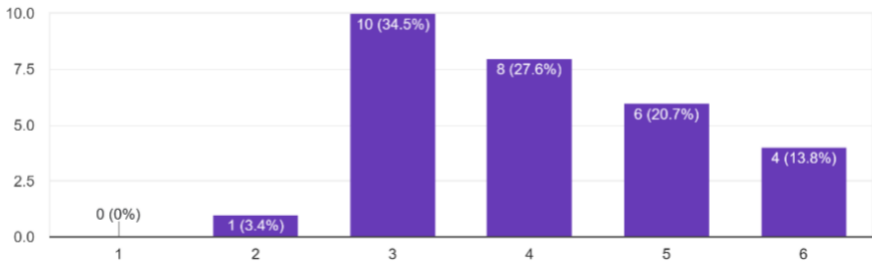
The Likert-scale Survey Questionnaire consisted of 15 questions, each designed to capture specific aspects of participants' knowledge, opinions, and attitudes towards XR technology and its integration with physical spaces. The 60 respondents included a mix of professionals, students, and general users with varying degrees of exposure to XR. The target group for this research comprised a diverse demographic to ensure a comprehensive understanding of the perceptions and potential impacts of XR technology. This diverse sampling ensured a well-rounded analysis of the data collected through the questionnaire and the findings are tabulated and analysed under Table 4.

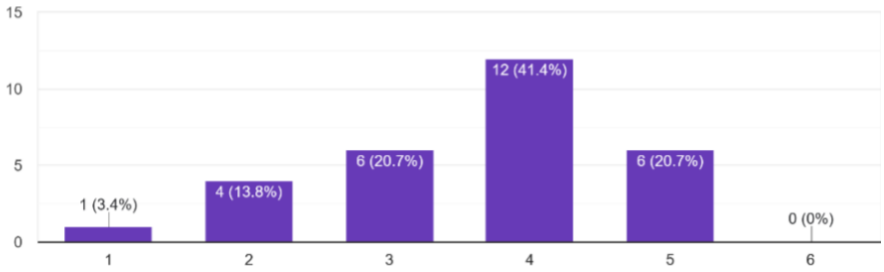
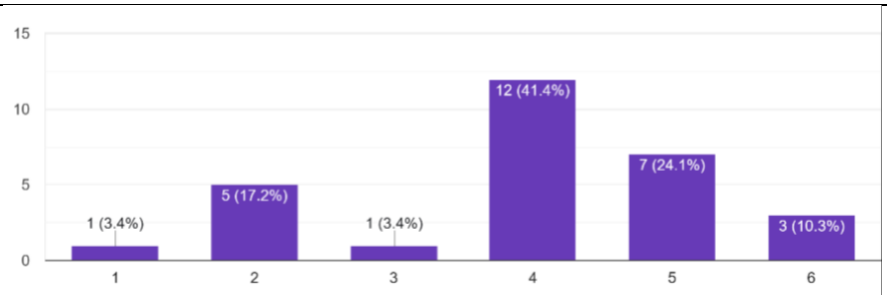
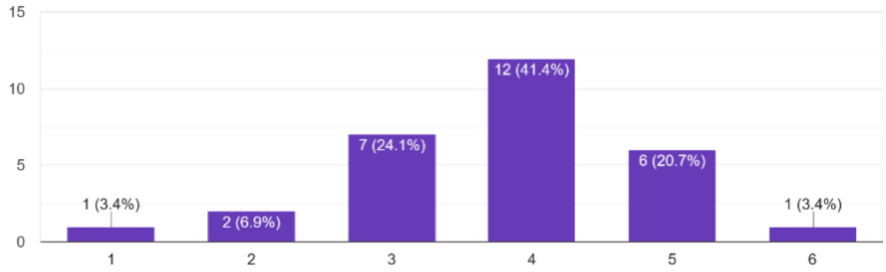
Table 4
Findings and analysed results on Likert-scale survey questionnaire

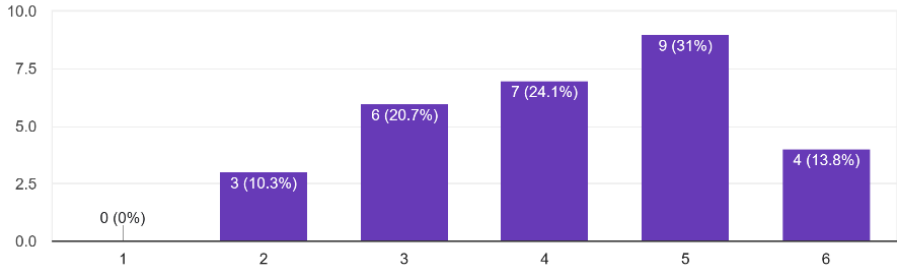
	Likert-scale Survey Questionnaires	Findings and Results
1.	How familiar are you with Extended Reality (XR) technology?	 Familiar – 55.2% Slightly Familiar – 20.7% Very Familiar – 13.8% The result indicates that there is a significant portion of the participants have knowledge and understanding of XR technology and its applications. This has justified the reliability of the data collected from the questionnaire in achieving the research objective.
2.	In your opinion, how useful is Extended Reality (XR) technology in enhancing user experience?	 Slightly Useful – 37.9% Useful – 31.0%

		Very Useful – 13.8% Slightly Not Useful – 13.8% The data collected shows that most of the participants have a positive perception of the XR technology's usefulness in enhancing user experience. The general positive perception aligns with the potential advantages which offering immersive and interactive experiences compared with traditional mediums. However, it is important to recognize the presence of the remaining 17.2% of participants who viewed XR technology as not useful as this has highlighted the need to address the potential limitations and challenges that may affect the user experience while leveraging its potential benefits.
3.	How likely are you to use Extended Reality (XR) technology in your personal or professional life?	 Slightly Likely – 34.5% Slightly Unlikely – 24.1% Likely – 20.7% The data reveals that there are varying levels of inclination towards using XR technology while suggesting a moderate interest and acceptance towards adopting it. This has suggested the significance of considering factors such as familiarity, ease of user interface, availability to the public, perceived benefits, etc.
4.	How important do you think Extended Reality (XR) technology is for the future of technology?	 Important – 41.4% Very Important – 27.6% Slightly Important – 20.7% There is a significant number of participants acknowledge the importance of XR technology, underscoring the potential opportunities for integration into various industries such as healthcare, education, entertainment and more. It validates the significance of relevant research regarding virtual environment while informing the demand for resource allocation in fostering innovation and development in the field.
5.	To what extent do you think Extended Reality (XR) technology will change the way we interact with technology?	 Significant – 34.5% Slightly Significant – 31.0% Very Significant – 31.0% The data illustrates an extremely strong belief in the transformative potential of the XR technology. This has suggested that the participants anticipate a substantial shift in the

		ways to engage with the virtual environment, for instance, the emergence of a more immersive XR gadget and the virtual interaction in different industries.
6.	How comfortable are you with the idea of using Extended Reality (XR) technology for immersive experiences?	 Slightly Comfortable – 31.0% Comfortable – 27.6% Very Comfortable – 20.7% With the majority possessing a certain level of comfort with XR technology, this has suggested a general acceptance and willingness to engage with the immersive virtual applications. On the other hand, it is worth noting a combined portion of 20.6% of participants express a lower level of comfort, highlighting some individuals may hesitate and concerned about their exposure to VE.
7.	How concerned are you about the potential negative effects of Extended Reality (XR) technology, such as addiction or disconnection from reality?	 Concerned – 31.0% Slightly Not Concerned – 20.7% Slightly Concerned – 17.2% Very Concerned – 17.2% The finding illustrates an average higher level of concern and a heightened awareness of the potential risks of XR technologies. Participants' concerns commonly relate to the potential psychological impacts, addiction, and privacy and security issues associated with VE. This has signified the need for comprehensive user education, clear guidelines and an established governance body for responsible practices and regulated VE development.
8.	How likely are you to recommend Extended Reality (XR) technology to others?	 Slightly Likely – 41.4% Likely – 31.0% Very Unlikely – 10.3% The data reveals an inclination to recommend XR technology to third parties. Positive recommendations would contribute to the wider acceptance and the generalisation of immersive experiences into our daily lives, which indirectly result in a higher demand for VE.

9.	How much do you think Extended Reality (XR) technology can enhance education and learning experiences?	 Significant – 55.2% Slightly Significant – 20.7% Very Significant – 13.8% The result indicates a strong recognition of the transformation benefits and value that XR technology could potentially contribute to the educational setting. The collective efforts of private and public bodies in incorporating XR technologies such as Augmented Reality (AR) gadgets, simulation science laboratories, virtual field trips and immersive 3D visualization, have been recognized by the growing trend of digitalising curriculum activities. This highlights the potential of integrating XR technology into other industries for an impactful outcome.
10.	How likely are you to pay for Extended Reality (XR) technology or experiences?	 Likely – 34.5% Slightly Likely – 24.1% Slightly Unlikely – 24.1% The result illustrates a relatively mixed sentiment among the participants regarding their willingness to pay for virtual experiences. This could be attributed to the difference in perceived value and benefits based on the immersive experience they have come across, affordability, individual preferences, or a better alternative for financial investment.
11.	In your opinion, how much physical space is required for Extended Reality (XR) technology and virtual activities to be effective?	 A Slightly Small Amount of Space – 34.5% A Slightly Large Amount of Space – 27.6% A Large Amount of Space – 20.7% The wide range of perspectives regarding the physical spatial requirements for VE correlates well with the diversity of virtual activities that require different spatial constraints. Hence, the spatial requirement is highly associated with the level of interaction and movement involved with the specific XR applications, for instance, room-scale virtual reality experience such as a digital gallery that requires users to wear VR headsets may demand more physical space as compared to a digital classroom with AR projectors and minimal user movement. A holistic understanding of the specific XR application is crucial in optimizing the user experience based on the adequate provision of physical space.

12.	How likely are you to modify your physical space to accommodate Extended Reality (XR) technology and virtual activities?	 Slightly Likely – 41.4% Slightly Unlikely – 20.7% Likely – 20.7% The data reveals a relatively low inclination in adjusting their physical space to facilitate the virtual experience. Individuals with limited resources, existing physical space or personal preferences might be less interested in modifying their spaces. However, almost half portion of the participants (41.4%) demonstrate an interest in modification, highlighting the high acceptance of XR technologies into our daily lives. However, the practical aspects such as the readiness and maturity of the technology, maintenance, uncertainty in the available options, etc. would be the factors that influence their affirmation.
13.	How much do you think the physical space requirement affects the adoption of Extended Reality (XR) technology and virtual activities?	 Slightly Significant – 41.4% Significant – 24.1% Not Significant – 17.2% The data indicates a substantial portion of participants who recognize the physical spatial needs for an immersive virtual experience. The varying perspectives have suggested the significance of specific context and use cases of virtual activities, and the relationship between the nature of respective XR technologies with the available physical space.
14.	How much do you think the physical space requirement affects the accessibility of Extended Reality (XR) technology and virtual activities?	 Slightly Significant – 41.4% Slightly Insignificant – 24.1% Significant – 20.7% The majority of the participants recognize the significance of physical space which plays a role in determining the accessibility of virtual activities. Virtual activities such as virtual marathons and interactive games that require larger physical spaces may pose challenges for individuals with limited physical space.

15.	How important do you think it is to have a standard physical space requirement for Extended Reality (XR) technology and virtual activities?	 Important – 31.0% Slightly Important – 24.1% Slightly Not Important – 20.7% The result illustrates a relatively wide spectrum of perspectives while demonstrating a slight inclination towards recognizing the value of standardisation. This can be associated with the different levels of utilisation and inter-operability of XR applications in different industries, for instance, the gaming developers that have tremendous advancement in providing their users with sensational immersive experiences. The finding recognizes the benefits of standardization as it can guide developers, users, and industry stakeholders while ensuring compatibility across different virtual platforms.

3.1.2 Result

The findings demonstrate a positive perception towards the XR technology's usefulness in enhancing user's virtual experience. This is important as it justifies the significance of this research. The majority of the participants acknowledge the potential advantages of the immersive virtual experience offered by XR technology compared to the traditional mediums. However, the presence of participants who possess a negative impression towards the integration of VE highlights the need to address concerns and limitations while leveraging its benefits. The implications of different physical spatial qualities on the user's satisfaction, user's perception and user's cognition in the virtual environment are multifaceted. The factors that contribute significant impacts on the user experience are synthesized in Table 5.

Overall, the findings emphasize the importance of considering different physical spatial qualities in relation to the virtual environment to enhance the overall user's satisfaction, perception, and cognition. Addressing the physical spatial limitation, coupled with comprehensive regulations adhering to ethical standards and user safety and collective multidisciplinary synergy that ensures compatibility across different virtual platforms would further contribute to a favourable impact. With that, architects are relevant in contributing their expertise in spatial layout for an immersive and interactive virtual experience.

Table 5
Summary of the synthesized factors that contribute impact on the user's satisfaction, perception, and cognition

A. User's Satisfaction		
A.1	Human Comfort	The physical comfort of the user during the virtual experience can greatly affect satisfaction. Factors such as ergonomics, appropriate equipment sizing and minimizing physical discomfort can contribute to a more engaging and immersive experience.
A.2	Ease of Movement	The availability of sufficient physical space for movement and interaction can enrich user satisfaction. Users are more engaged and immersed when they have the freedom to navigate and explore the virtual environment without constraints.
A.3	Accessibility	The accessibility of the virtual environment, including considerations for users with disabilities or limited mobility, can significantly impact user satisfaction. Providing options for customization and adaptability to individual needs can improve the overall user experience.
B. User's Perception		

B.1	Immersion	Physical spatial qualities that promote a sense of immersion, such as a realistic and spatially coherent environment, can positively influence user perception. Users are more likely to perceive the virtual environment as engaging, realistic, and valuable when the physical space aligns with the virtual content.
B.2	Interactivity	The physical spatial qualities that enable meaningful interactions with the virtual environment can enhance user perception. Users would perceive the technology as more advanced and innovative when they can physically interact with objects and navigate throughout the virtual space. The higher the correlation between physical space and virtual environment, the more senses would be engaged by the users, hence a higher level of perception.
C. User's Cognition		
C.1	Spatial Understanding	The physical setting of the virtual environment plays a crucial role in the user's cognitive understanding and navigation. When the virtual space aligns with users' spatial cognition, it can facilitate better orientation, object manipulation and spatial reasoning.
C.2	Contextual Relevance	The physical spatial qualities should be tailored to the specific context and use cases of the virtual activities. For instance, in educational simulations, the physical space should be designed to mimic real-world scenarios, enhancing users' cognitive engagement, and learning outcomes.

3.2 Semi-Structured Interview
3.2.1 Result

Semi-structured interviews were conducted with two industry professionals, Ar. Qhawarizmi Norhisham and Ar. IDr. Ts. Ridha Razak. Both interviewees have shared their respective industry experiences and interpretations and introduced several exclusive insights on the research topic. The semi-structured interview data are analysed qualitatively and six different types of relationship between physical spatial layout and VEs are deducted from the analysed result. The six different types of relationships are functional relationship, spatial relationship, ergonomic relationship, aesthetic relationship, behavioural relationship, and technological relationship. The findings and results are analysed and tabulated according to the types of relationship under Table 6.

Table 6
Tabulation of analysed interview findings according to the different types of relationships between physical spatial layout and virtual environment

A. Functional Relationship	
Ar. Qhawarizmi Norhisham	The Synergy between Physical and Digital Spaces It is crucial to establish a synergy between the physical and digital spaces where both serve the same spatial function. Both types of spaces should complement and enhance each other rather than strive for complete realism in virtual spaces. The flexibility of digital spaces that allow for experimental designs and creative innovations unconstrained by physical limitations, should be employed as virtual users' perquisite instead of specifying realism as the goal.
Ar. IDr. Ts. Ridha Razak	Types of Virtual Environments 1. Close Type: Designed for specific communities' usage, such as gaming and training 2. Open Type: Allows for mass engagement and social interaction, exemplified by platforms like Roblox and Decentraland 3. Very Open Type: Refers to immersive smart cities like the Seoul Metaverse Masterplan which houses diverse cyber blocks
B. Spatial Relationship	
Ar. Qhawarizmi Norhisham	Spatial Design Considerations for Virtual Activities Spaces for NFTs and cyberpunk-themed artworks are used as examples for the articulation of spatial design considerations. The metaverse can be seen as a 3D website, with links to relevant information and seamless flows for the users. The physical space should be designed to enhance the value of the digital content hosted within the metaverse, while regarding the virtual environment as the channel for experience enrichment.

Ar. IDr. Ts. Ridha Razak	Difference between Managing Virtual Design and Physical Construction Project In the digital world, there is borderless communication, while the physical world involves physical touch and tangible materials. The architect's role as the lead consultant varies depending on the purpose of the virtual world and the types of virtual activities that are designed. Architects often lead projects that prioritize spatial layout and design concepts.
C. Ergonomic Relationship	
Ar. Qhawarizmi Norhisham	Using Digital Spaces to Enhance Physical Lives The discussion highlights that the end goal of engaging with the digital world and the metaverse is to enhance humans' life in the physical environment. The digital realm is a means to make money and improve lifestyle in the physical world, rather than living indefinitely in virtual reality. The need to recognize the goal of integrating the virtual environment as a tool to improve spatial quality and living conditions in the physical world is emphasized.
Ar. IDr. Ts. Ridha Razak	Potential Future Impacts Metaverse and virtual living environments will impact various aspects of daily life. Hence, it is notably significant to highlight the integration of multiverse spaces that may lead to the optimization of physical space utilization based on the specific user's ergonomics, while reducing the need for large physical spaces vertically. This is impactful to the architects as they will have opportunities to develop virtual land and monetize their architectural designs as demand rises.
D. Sensuous Relationship	
Ar. Qhawarizmi Norhisham	Importance of Physical Spaces in the Digital World The interview highlights the significance of physical spaces and the role they play in humans' existence and experiences. While the virtual experiences can be immersive, they are still digital content and lack the tangible aspects of physical spaces. Physical space provides the foundation for human touch, empathy, and meaningful experience.
E. Economic Relationship	
Ar. Qhawarizmi Norhisham	Digital Real Estate and Architectural Standpoint The concept of digital real estate such as virtual land in the Metaverse possesses a similar economic framework as the physical real estate. Architects should understand the underlying value system of digital real estate and their roles within the broader context of value creation, popularity and browsing traffic. Factors such as digital branding, marketing and influential figures play a significant role in attracting users to the digital spaces.
Ar. IDr. Ts. Ridha Razak	Determining the Value of Virtual Assets The value of virtual assets, similar to physical assets, is determined by factors such as scarcity and demand. Virtual developers would manipulate the value by creating the illusion of scarcity by limiting the availability of virtual properties and estates to increase their value. The extent of engagement and the opportunities for socialization within the virtual worlds contribute to the enrichment of the value of virtual assets as well.
F. Technological Relationship	
Ar. Qhawarizmi Norhisham	Architects Embracing Digital 3D Creation The diminishing control of architects in digital design is acknowledged, with the emergence of 3D digital creators without formal architectural training and the involvement of several other industries as stakeholders. Hence, architects should focus on demonstrating their value through design improvements that enhance user engagement and experiences. Architects should announce their importance of presence in this by manifesting their understanding and expertise in circulation design, movement pattern, audience dynamic and engagement, and spatial arrangement, setting them apart from digital artists.
Ar. IDr. Ts. Ridha Razak	Benefits of Digitalization in the Architecture Industry The adoption of AI and analytics can facilitate in data collection, idea generation and information filtering for the design process. Digital twins would serve as the community platforms, and data storage and aid in future renovation and planning. Digitalization also opens up opportunities for architects to generate passive income through creativity and imagination.

Firstly, functional relationship refers to how the physical spatial layout and virtual environment work together to fulfil a specific task or objectives or the needs of a building functional programme. It involves designing physical space to accommodate the functional needs of the virtual environment, such as providing sufficient room for movement, interaction with virtual objects, or performing specific actions within the virtual space.

Secondly, spatial relationship emphasizes how the physical spatial layout and virtual environments coexist within the same area, forging the mixed-reality experience. It involves holistic design consideration of the architectural layout, arrangement, and organization of the physical spatial elements to align with the virtual environment. For example, the physical room layout should correspond to the virtual space dimensions, allowing users to move and interact naturally without any perceptible mismatch.

Thirdly, ergonomic relationship refers to the interaction between human users and the physical and virtual components within the mixed reality environment. The relationship considers factors such as anthropometrics, user reach, posture, and potential movement patterns to ensure that users can effectively engage with the virtual environment while maintaining physical comfort. The physical space should be designed to accommodate users of different heights, ensuring that they can comfortably reach the specific virtual objects and maintain a natural posture throughout their interactions.

Fourthly, sensuous relationship explores the visual and sensory incorporation between the physical and virtual elements. It involves designing the physical space and virtual environment to create a cohesive and visually appealing experience as a single coherent entity. This relationship considers factors such as lighting, colour schemes, texture, spatial volume, and overall ambience to establish a harmonious yet immersive virtual experience that engages with humans' five senses.

Fifthly, economic relationship in the context of the immersive mixed-reality environment refers to the relationship between the cost associated with implementing and maintaining the physical spatial layout and the virtual environment, and the potential economic benefits or returns on investment (ROI) that can be derived from the demand of virtual activities. It is essential in determining the financial feasibility and viability of implementing and integrating and an immersive mixed-reality environment while facilitating decision-making regarding investment in the construction design of physical space, research, and development of XR technology and on-going maintenance.

Sixthly, technological relationship emphasizes the integration and compatibility between the physical spatial layout and the virtual environment. It involves leveraging technological advancements, such as tracking systems, motion sensors, and augmented reality display technologies, to bridge the gap between the physical and virtual elements. Physical space equipped with motion capture sensors or cameras to rack user's movements accurately would enable real-time interaction and synchronization with the virtual environment.

3.2.2 Discussion

The analysed results justify the difference in the relationship between physical spatial layout and virtual environment that contributes collectively to impact the user's virtual experience. Each relationship addresses specific aspects and design considerations that are essential for creating an interactive and engaging mixed-reality environment. In reference to the analysed results, several essential components can be deduced in the pursuit of an interactive and immersive mixed-reality experience by an architect.

Physical spatial layout is significant as the crucial foundation for designing an immersive mixed-reality environment. This includes design requirements and considerations such as spatial planning, layout design, structural considerations, and ergonomic considerations by a professional architect. Physical spaces serve as the backbone for accommodating virtual human interactions, providing functional structures while ensuring safety and comfort within the mixed reality environment. This highlights the importance of holistic understanding in designing physical spaces to establish a strong foundation for immersive virtual experiences.

As a designer, the architect should address the limitations and challenges when designing for immersive mixed environments, for instance, the spatial constraints such as limited physical space to incorporate virtual elements effectively, and the technological limitations such as hardware

requirements or software incompatibility. Collaborative and multidisciplinary efforts from digital artists, developers, technologists, and other experts are needed to bridge the gap between physical spatial layout and virtual environment. Architects should contribute their effort in taking the lead in navigating these challenges by innovating practical solutions and initiating a collective synergy by professionals and experts from different industries.

The architect serves as a social agent between the architectural outcome and the end users. The importance of a human-centric design approach in creating immersive mixed environments should be emphasized. Understanding the needs, preferences, and behaviours of the end users is essential for designing mixed-reality environments that effectively fulfil the end users' functional requirements. The significance of incorporating user feedback throughout the design process is emphasized in the findings. By focusing user's needs as the design core, architects can create an immersive mixed-reality environment that caters to the expectations and desires of the intended audience.

Architects should be attentive to the rapid advancements of XR technology. A thorough understanding allows better and more coherent integration into the physical space, serving as a driving force for the immersive mixed-reality experience. Emerging technologies such as augmented reality (AR) and virtual reality (VR) are constantly evolving and offering new possibilities in establishing a more interactive virtual experience. Commitments is required in harnessing the XR technologies to transform the way physical spaces are conventionally designed and experienced while staying updated with the technological development and exploring innovative ways for a seamless integration.

Architects should also acknowledge the dynamic nature of the immersive mixed-reality environment, highlighting the importance of flexibility in design. XR technology and user preference would change over time. This has necessitated spaces that can adapt to these evolutions. Designing for flexibility and adaptability allows the integration of virtual activities to remain relevant and sustainable in the longer term. This has also expressed the need for modular design approaches, scalable solutions, and flexible layouts that can accommodate future advancements and modifications without significant physical spatial adjustments.

In the essence of the analysed results, they highlight the different relationships between physical spatial layout and virtual environments and how can each scenario impact and enhance the immersive mixed reality experience. Architects should consider and optimize the relationship, namely the functional, spatial, ergonomic, sensuous, economic, and technological relationships to engage both the physical and virtual realms well. In this case, architects are relevant in demonstrating their expertise in crafting an experiential spatial layout, innovating solutions for virtual activities and potential spatial and technological limitations, establishing human-centric design, initiating collaborative efforts from multidisciplinary professionals, and designing for flexibility and adaptability.

3.3 Content Analysis
3.3.1 Result

In the near future, the job scope of architects would be potentially accustomed to the blooming VEs. With more nationwide industries permeating their business activities into the VEs, architects' commitment to considering and understanding virtual designs, exploring innovative approaches to physical architecture for virtual spaces, and the development of metaverse-related project frameworks are in demand. Data was collected from various sources, including media reports, social media posts, and articles which provide insights of the latest trends and industry developments, and capture the real-time discussions and public sentiment on these topics. Hence, the Malaysian industries with active adoption and inclusion of virtual activities into their operation framework are analysed and tabulated under Table 7.

Table 7
Tabulation of findings of the Malaysian industries with active adoption and inclusion of virtual activities

Industries	Integration of Virtual Activities
Fashion	KL Fashion Weekend 2021 Hosted by Tradisi Busana PR, it is the first fashion event that was presented phygitally with a seamless combination of the physical and virtual worlds. Non-fungible Tokens (NFTs) by the local fashion designer were introduced during the event.
Entertainment	Monsta's 'Mad Mecha' Joining the Sandbox Gaming Metaverse Monsta, the Malaysian character media company that is known for popular icons such as Mechamato, BoBoiBoy, Papa Pipi, and Fly with Yaya is joining the Sandbox Gaming Metaverse with Mad Mecha, the exclusively designed virtual gaming world for Sandbox. With the vision of providing an immersive and unique experience for their audience base, Monsta would be launching their series of stylish collectable robots and various digital collectables for the Sandbox community.
Education	SEGi MetaCampus In collaboration with Magnus Games Studio, SEGi MetaCampus takes the initiative to bridge multiple 3D universes into the education framework. It incorporates virtual learning and life-long learning into the self-sustainable virtual environment in the Metaverse. Various interactive activities such as attending online lectures and events, playing games, shopping, unlimited access to online learning management and other different educational facilities are provided in the virtual campus.
Events	Accenture Careerverse Careerverse is a web-VR environment where the firm will scout tech talents. With the integration of AR, VR and MR technology to its client base developed by Entropia Extended Reality (EXR), potential candidates can communicate with recruiters virtually, while engaging with leaders from tech giants worldwide such as AWS, Google and SAP.
Telecommunication	Celcom AR Integrated Consumer Apps In collaboration with Nonvoice, the world's first 5G app agency, Celcom Axiata Bhd. introduced its first augmented reality (AR) services which include digitalised experience in AR games, education, digital collectables, non-fungible tokens (NFTs) and sports. The platforms also offer a network of expert agents and investors to facilitate their services.
Tourism	Penang360 Digital Tourism Penang360 is a virtual platform that stimulates immersive 360° virtual tours of tourist destinations in Penang. With its tagline 'Heritage Meets Digital', users can explore the UNESCO World Heritage site, places of attraction, street foods and dining, shopping, fitness and events through digital reality with an immersive virtual experience.
Real Estate	i-City Metaverse Theme Park In partnership with China Mobile Internation (CMIM), i-City is planning a technology platform for the integration of metaverse virtual experience into the i-City theme park and i-City's City of Digital Lights. The initiative will be enhanced by the implementation of 5G with hyperscale cloud computing technology.
	Matrix Metaverse Property Showcase Matrix Concepts Holdings Bhd. has implemented the first virtual property showcase in Malaysia. While allowing users to craft their avatars and engage with others in the virtual environment, the platform simulates a 360° show unit virtual tour with a teleporting capacity between all show units.
Agriculture	Agribusiness in the Metaverse In partnership with PT Mitra Sangkara Abadi (MSA) from Indonesia, Rimaunangis Sdn. Bhd. ventured into Malaysia's first agriculture metaverse. This platform digitalised the business framework for farmers and ranchers while providing them the opportunity to market their plantation and livestock products globally and establishing attractions for investment in Malaysian agribusiness.
Banking	Digital Bank by Axiata's Boost and RHB With RHB as one of the five digital bank license holders in Malaysia, RHB aims to establish the digital banking platform in collaboration with Axiata Group with an approximate RM100 million initial capital commitment for digital financial services.
	Hong Leong Bank Hackathon 2022 Metaverse In collaboration with JomHack Malaysia, Google Cloud and Rakuten RapidAPI, Hong Leong Bank Bhd. organised a 24-hour hackathon, 'Can You Hack It' that attempts to seek potential talents for the employment of Digital Bank.
Healthcare	SunMed's Telemedicine Command Centre

	In line with the Telemedicine Blueprint supported by the Ministry of Health Malaysia, Sunway Medical Centre Velocity has set up a virtual clinic that provides virtual medical care for patients. Teleconsultation services are established with a professional medical team of doctors, clinical psychologists, speech therapists, rehabilitation teams, audiologists, and dietitians. Nationwide medication delivery and home phlebotomy services are available as well.
Oil and Gas	Petronas Artificial Intelligence Centre of Excellence (AI CoE) Petroliam Nasional Bhd. (Petronas) has launched the AI CoE in partnership with Baker Hughes, Boston Consulting Group (BCG) and Microsoft. The centre aims to establish synergy between BCG Gamma's deep AI expertise and Petronas' experience in utilizing AI in the energy value chain while leveraging the implementation of AI to enhance the reliability, safety and efficiency of the oil and gas energy value chain in Malaysia.

3.3.2 Discussion

In reference to the analysed result, it is evident that there is active adoption and inclusion of virtual activities into their operation framework. Though the integration of Metaverse across various industries in Malaysia is momentous and beneficial to the technological infrastructure development, it is notably essential to highlight its implications and potential influences on the built environment as evaluated under Table 8. The corresponding potential transformation in the roles of an architect is summarized in Table 9.

Table 8
Tabulation of the synthesized results of the implications in reference to the industries

Industries	Implications
Environmental	
Fashion	Virtual fashion shows and retail spaces can reduce the need for physical fashion events, displays, and stores, leading to a potential reduction in carbon footprint related to transportation for goods and energy consumption during the event operation.
Telecommunication	Virtual communication platforms with diverse functions such as bill payment, food and grocery delivery, virtual meetings, etc. adhere to the concept of a 15-minute neighbourhood, where environmental impacts caused by travelling are minimized.
Oil and Gas	Virtual simulations and training programs would enhance the operational efficiency and safety of engineers and technicians while scaling down research activities with high carbon footprint.
Social	
Entertainment	Virtual entertainment breaks down social barriers, fosters inclusivity and enables diverse communities to interact with its immersive virtual environment as the strong attraction indicator. Users can engage in virtual social activities such as virtual gatherings, multiplayer games and virtual events with portable XR gadgets.
Education	Virtual classrooms and learning environments would establish an interactive virtual platform that is highly sociable. Not only that, it provides access to education for individuals who may face geographical or mobility barriers, promoting inclusivity and equality for learning.
Events	Virtual events encourage broader access to users from different backgrounds and geographical locations, enabling the participants to engage in a wider social and networking circle.
Healthcare	Virtual healthcare consultations and telemedicine services would enhance the accessibility to healthcare professionals and optimize workflow to urgent patients during the event of an emergency, especially for remote and underserved areas, leading to better health and social benefits.
Governance	
Tourism	The immersive virtual tourism experience would serve as an excellent branding tool to enhance the destination marketing exposure as it allows users to explore the place virtually. It can also be utilized to promote conservation programs for UNESCO World Heritage Site.
Real Estate	Virtual property tours and architecture visualization streamline the buying and rental process, allowing a higher degree of transaction accountability and transparency while reducing potential disputes.
Agriculture	The integration of virtual agribusiness activity would expand market access and improve resource management. While ensuring its regulatory compliance, it also promotes collaborative

	knowledge sharing and empowers farmers with technological advancement. Hence, a resilient and sustainable agriculture sector that impacts the country's economy positively would be established.
Banking	Virtual banking service provides convenience to financial services, enhances financial inclusion, and improves transaction efficiency. It also establishes new alternatives for interaction between different urban stakeholders from various financial backgrounds.

Table 9
Tabulation of the potential roles of an architect in reference to the environmental, social and governance aspects

The Potential Roles of an Architect
Environmental
Sustainable Design By applying their expertise in sustainable design principles, architects would stay relevant by focusing on creating virtual buildings and spaces that effectively replace the corresponding physical spatial requirements, as smaller physical space means less contribution to carbon footprint. The incorporation of design strategies relating to energy efficiency optimization, renewable energy resources and waste minimization is relevant as well.
Life Cycle Analysis Architects can utilize virtual simulations and modelling tools to conduct life cycle analysis of the buildings in a virtual environment. By assessing the environmental impact of design choices, materials, and construction methods and processes, architects can rationalise the selection of choices and make informed decisions with minimal environmental impacts.
Virtual Energy Modelling The energy performance of a building can be stimulated and optimized with a proposed solution with the virtual tools. Architects should leverage the virtual energy modelling tool to analyse factors such as lighting, heating, cooling, and insulation in the pursuit of a more sustainable building design.
Social
Inclusive Design By considering universal design principles, accessibility guidelines, and user feedback, architects play critical roles in designing inclusive virtual environments. A highly sociable virtual space should cater to all individuals of all abilities and capabilities while ensuring equal access, navigation, and participation.
Collaborative Spaces for Active Engagement By applying the understanding of how people interact and how contact points are formed, architects can design interactive virtual layouts within the immersive setting that foster collaboration and encourage communication among users.
Sensuous User Experience Architects are the social agents of spatial poetics. By considering factors such as ergonomics, aesthetics, textures, materials, and spatial arrangement, architects can design virtual spaces that are purposeful, user-friendly and experiential. A sensuous virtual space has the similar capacity to create a meaningful collective users' memory as a physical space, or even more.
Governance
Compliance and Design Regulations As a collective effort among the architects and relevant regulatory bodies and authorities, a design framework for a virtual environment can be established and authenticated. The standard regulatory requirements and guidelines in reference to the local building codes would ensure users' safety and ethical considerations in the design, development, and operation of the respective virtual environment.
User Privacy and Data Security Architects are relevant in addressing privacy concerns with robust data security and virtual environment design measures. By implementing encryption, authentication protocols and data protection mechanisms, architects can mitigate risks associated with the collection and storage of personal data in virtual platforms.

3.3.3 Recommendation

Leveraging the accelerated trend of virtual and metaverse-related projects in Malaysia, a proposed modification to the basic services stated in Architects (Scale of Minimum Fees) Rules 2010 to accommodate the difference in design requirements for virtual design is relevant. In reference to the

five phases of basic services, the proposed modifications and additions of service are synthesized and tabulated under the Virtual Design Integration (VDI) in Table 10.

Table 10
Tabulation of the architectural consultancy proposed basic services for virtual design integration

Architectural Consultancy Basic Services	
Architects (Scale of Minimum Fees) Rules 2010	Proposed Services for Virtual Design Integration (VDI)
1. Schematic Design Phase • Interpreted project brief • Preliminary conceptual sketch proposals • Preliminary estimates for construction cost	1. Preliminary Project Planning • Kick-off meeting • Documents and requirements checklist • Communication plan with consultants and technical committee
2. Design Development Phase • Authority and client approval • Preparation of working drawings • Project planning and schedule implementation	2. Operation Analysis and Design Development • To outline the user's manual and system requirements and specification • To propose a prototype with the technical architecture and established operational standard
3. Contract Documentation Phase • Facilitate preparation for bills of quantities • Tender for work • Award of contract	3. Content Management • To outline the legal obligation of an architects • For instance, the designing of the main portal page, maintenance interface, analytics and report, user's feedback matrix, etc.
4. Contract Implementation and Management Phase • Perform all functions and duties of the architectural consultancy practice • Architect's instruction to the contractor • Monitor work programme • Inspection of work	4. Integration and Management Plan • To ensure system compatibility and monitor methods for system access • System testing including security testing, integration and performance test • To provide a detailed end-user manual and to coordinate system manager and technical personnel training
5. Final Completion Phase • Issue certificate of completion and compliance • Certify as-built drawings • Issue certificate of making good defects • Prepare the final account for the contract	5. System Completion • To provide and certify handover system documentation in hardcopy and softcopy • To issue a Certificate of Final Acceptance to certify the intellectual property of the system • To provide on-site support for two months and maintenance services for six months • To specify the applicable licensing software and system database warranty period

By actively engaging in the design and development of virtual environments, architects are relevant in contributing their expertise to address and optimise the environmental, social and governance implications of the integration of virtual environments into architectural designs. The roles of an architect will address the evolving VEs and reflect the changing needs of virtual projects. By incorporating Virtual Design Integration (VDI) into the basic services gazetted by the Architects (Scale of Minimum Fees) Rules 2010, architects will play a significant yet pertinent role in effectively integrating virtual environments into all five design phases.

4. Conclusion

The emergence of Virtual Environments (VEs) and the advancement of Extended Reality (XR) technologies have modified the duties of an architect and will continue to forge more adjustments to the architecture industry where drastic alterations would be required. Transformation is necessary for progression and improvement to take place, where adaptation is the determining factor. The demand

for an architect in designing physical spaces where human activities, including virtual activities, intensify would never be diminished, but on the contrary, it will evolve within the context of the mushrooming of virtual activities and XR technologies.

This evolution suggests that architects should actively engage with XR technologies to stay relevant and innovative. Embracing virtual design tools and frameworks will be crucial in addressing the growing demand for integrated virtual and physical spaces. With these, there is a need for ongoing professional development and training in these new technologies to ensure that architects are equipped to meet future challenges.

Future studies should focus on exploring specific strategies for integrating XR technologies into architectural practice, assessing the effectiveness of these technologies in enhancing user experience, and investigating the long-term impacts on the built environment. Research could also examine case studies of successful VEs to provide actionable insights for architects and industry stakeholders. Additionally, exploring the ethical implications and potential societal impacts of these technologies will be essential for guiding the Architect's responsible implementation.

In short, the physical spatial design is an integral element in crafting an immersive and interactive VE that facilitates social connections and quality living. The paper has proven a strong correlation between physical architecture and VE and the architect profession can never be replaced by programme-coded robots or AI which lack the humane touch and empathy to their end users. Human-centric VEs with XR technology-infused digital activities would be the way forward in digitalising the built environment, representing the future of the built environment with architects at the forefront of this digital transformation.

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