International Journal for Housing Science and Its Applications
Publish August 4, 2025. Volume 46, Issue 3 Pages 2282-2295

https://doi.org/10.70517/ijhsa463191

A Study of Secure Construction of Learning Scenarios from a Meta-Universe Perspective

Shang Wang[1] and Jia Yan[2,*]
[1] School of Art, Design and Fashion, Luoyang Institute of Science and Technology, Luoyang, Henan, 471000, China
[2] Foreign Languages School of HAUST, Henan University of Science and Technology, Luoyang, Henan, 471000, China
Corresponding authors: (e-mail: xbti82@163.com).

Abstract This paper utilizes the meta-universe scene construction technology to build virtual and real environments that serve learning and provide new paths for learning development. The construction basis of three-dimensional image is proposed, and it is pointed out that after the three-dimensional model is constructed in Unity 3D, the scene projection is transferred to Game panel by Camera to realize the visualization operation. Based on the appropriateness of blockchain technology and smart learning scenarios, propose a blockchain-based IoT data security collection scheme. Discuss the possible threats in the scheme, utilize the theory of reputation assessment to ensure the security of data collection, and propose the reputation assessment algorithm based on sampled data. Simulate and analyze the reputation assessment algorithm based on sampled data. Combine the survey data to analyze the propagation development of the meta-universe learning scenario. In the linear regression model, the regression coefficients of platform accompaniment, ease of use, learning immersion, resource effectiveness, platform interactivity and classroom engagement β are 0.467, 0.513, 0.363, 0.392, 0.336, 0.319, respectively, and all of these independent variables have a positive impact on the attitude of meta-universe learning scene use. Thus, in the subsequent development and promotion of meta-universe learning scenarios, we can focus on the convenience of scenario development and construction as well as the ease of use of the learning platform.

Index Terms blockchain technology, scene construction, reputation assessment, learning scene

I. Introduction

With the advent of the meta-universe era, higher education is undergoing a series of profound changes. Schools need to start rethinking the value of space as a place of learning and how the service scene should be redefined and empowered to carry the needs of future learning [1], [2].

Under the deep development of the digital transformation of education, the traditional learning scene is also changing and gradually forming new forms. Mainly with the support of new technology and new equipment, the library's massive resources are revitalized, personalized, precise and intelligent services for user needs are carried out, the innovation and entrepreneurial ability of students is improved, a new learning mode is explored, a new learning ecology is created, and innovative talents are cultivated, which prompts the library, classroom and other learning scenarios to take on a new life under the background of the digital transformation of education[3]-[7]. Such learning scenarios integrate the latest scientific and technological achievements and innovative teaching concepts, transcend the limitations of physical space, and aim to closely link learning resources, teaching activities and learners through digital means, forming a borderless learning environment and constructing a diversified, intelligent and interconnected educational ecosystem [8]-[11]. In the era of meta-universe, the concept of learning scenarios has been further enriched and developed, which utilizes cutting-edge technologies such as virtual reality, augmented reality, artificial intelligence, blockchain, etc., to create an immersive and interactive learning space, so that learners can experience unprecedented learning in a virtual environment [12]-[15]. It can be said that the learning scenario is envisioned as a multidimensional learning space that builds the association and interaction of users, resources, and spatial triadic knowledge operation boundaries on the basis of playing the knowledge aggregation of different learning scenarios and the ecological capacity of knowledge learning, which is not only a major upgrade of the traditional learning scenario, but also a major innovation of educational concepts and practices [16], [17].

However, it is due to the intelligence and digitization of meta-universe education that there are security problems in its educational and learning environments. The first and foremost is the leakage of individual's private data, on the one hand, due to the utilization or trafficking of personal information without consent by the product vendors of data capturing devices, and on the other hand, the data leakage caused by external attacks [18], [19]. Secondly, the prolonged meta-universe learning scenarios lead to individuals' confusion between the real world and the reality scenarios constructed by virtual reality and augmented reality, and the AI virtual assisted teachers, due to their program settings, generate teaching contents that deviate from those generated by real teachers in different teaching scenarios [20]-[22]. Finally, the laws related to meta-universe education are seriously insufficient, and the laws are inevitably needed for the right of attribution and risk responsibility of individual authentication information, virtual resources and property in the environment [23], [24]. Therefore, the construction of a safe learning scenario in the meta-universe educational environment has become an important element in the development of meta-universe education.

This paper analyzes the main technology of constructing meta-universe learning environment, and expresses the virtual world construction technology and interaction technology, virtual-real space connection technology and meta-universe management technology one by one. It proposes the basic technology for the construction of meta-universe learning scene, including the foundation of three-dimensional geometric modeling and the foundation of visualization. Combined with blockchain features, the blockchain-based IoT data security collection scheme is proposed, in which the reputation assessment algorithm is based on trusted sampling data to ensure data security. Analyze the effectiveness of the reputation assessment algorithm based on sampling data. Combine the data questionnaire and linear regression to analyze the key factors of the application development of the meta-universe learning platform, and understand the development direction of the meta-universe learning platform through variable coefficients.

II. Learning scenario construction and management in a meta-universe environment

The metaverse is a virtual world constructed by digital technology and consists of a variety of digitized information, virtual entities and virtual communities. It simulates and interconnects with the real world, enabling users to perform various activities in a virtual environment.

Meta-universe provides a brand new development direction for the educational scenario, which can provide students with a more practical and innovative learning environment and improve their comprehensive quality and innovation ability. At the same time, the construction and application of meta-universe need to be continuously improved and developed to adapt to the changing educational needs and technological development.

As a kind of virtual reality technology, meta-universe has the following significant features:

(1) High degree of realism
(2) Highly interactive
(3) Highly open
(4) Highly visualized

In summary, metaverse as a virtual reality technology has the characteristics of high realism, high interactivity, openness and high visualization.

II. A.Key technologies for the construction of meta-universe learning environments

Technology is the basis for the construction of meta-universe learning environments as well as a factor that affects the achievement of educational goals. Meta-universe is usually seen as a fusion of real and virtual worlds, and the existence of human beings in the meta-universe makes the inner world of human beings the third world that guides the construction of virtual worlds [25], [26].

The connection between the virtual world, the real world, and the inner world is an important factor in distinguishing or summarizing the technologies related to the metaverse. The connection between the inner world and the virtual world is related to the realization of the human conception of the construction of the virtual world. People are again in the real world, and the connection between the real world and the virtual world is the key to the realization of the information transfer between the people or things existing in the reality and the people or things in the virtual world.

In short, the connection between the virtual world, the real world, and the inner world is established by various types of technologies related to the metaverse. The construction of the virtual world is accomplished by the virtual world building technology. The real world and the virtual world are connected with each other by the virtual space connection technology. The inner world and the virtual world are connected by the virtual world interaction technology. The technologies related to the operation and management of the metaverse can be categorized as metaverse management technologies.

II. A. 1) Virtual world-building techniques

In educational application scenarios, virtual world construction technology refers to the underlying technology needed to build virtual teaching scenes, digital learning spaces or virtual characters, etc. It includes 3D modeling technology, scientific simulation technology, system integration technology, etc.

Three-dimensional modeling technology can realize the creation of virtual scenes or products, such as the use of software to establish three-dimensional models, the use of scanning technology to scan the real object will be converted into a virtual three-dimensional model.

Scientific simulation technology can simulate the scene and process in the scene reality, realize the phenomenon law simulation, result prediction, design optimization and so on.

System integration technology refers to the technology that integrates, optimizes and coordinates different systems, resources, data, etc. to achieve a more efficient, reliable and intelligent integrated system, which is able to integrate 3D modeling technology, scientific simulation technology, etc. in the meta-universe to satisfy the needs of learners to create and edit in the virtual scene.

II. A. 2) Virtual world interaction techniques

In the educational application scenario, the virtual world interaction technology is the technology in which a person enters the virtual world of the human meta-universe and interacts with it with the help of equipment, including virtual reality (VR) technology, mixed reality (MR) technology, augmented reality (AR) technology, holographic projection technology, brain-computer interface technology and so on.

II. A. 3) Techniques for connecting virtual and real spaces

The virtual-real space connection technology in the meta-universe is the technology that interconnects and interacts the real world and the virtual world with each other, and it contains the sensing technology, digital communication technology, Internet of Things technology and interface technology, etc., mainly based on the Internet of Things.

Sensing technology provides technical support for the signal and information source for the meta-universe to perceive everything in the physical world. Digital communication technology provides technical support for signal transmission. Internet of things technology provides reliable technical guarantee for the interconnection of all things in the meta-universe and the symbiosis of reality and reality.

Internet of things refers to the “Internet of everything connected”, is the extension and expansion of the network on the basis of the Internet, which can combine various information sensing devices with the network to form a huge network, realizing the interconnection and intercommunication of people, machines and things at any time and any place.

II. A. 4) Meta-universe management techniques

The metaverse needs not only to be built but also to be run, and the technology needed to organize or guarantee its stable operation is metaverse management technology. Meta-universe management technology synthesizes the three worlds and guarantees the operation of the meta-universe. The trust mechanism, evaluation mechanism, resource sharing mechanism, and management mechanism required for the operation of the meta-universe involve technologies such as blockchain technology, non-homogenized tokens (NFT), and identity authentication technology.

Blockchain technology is a decentralized distributed ledger technology, and its core features are decentralization, invertibility, traceability, transparency, etc. The application of blockchain technology in the meta-universe ensures the traceability of the information and guarantees the individual's affirmative right to the information.

II. B. Learning scenario construction based on meta-universe

II. B. 1) Basics of 3D geometric modeling

In the field of meta-universe research under the virtual reality environment, 3D graph transformation plays an extremely crucial role, and the application scope involves many aspects. Especially in 3D geometric modeling, virtual scene production, etc., they are all based on the theoretical foundation of graph transformation, which is strongly related to 3D graph transformation. 3D graphic transformation is the process of transforming an original 3D graphic into another 3D graphic mainly by means of translation, rotation, and scaling.

The transformation of a point in 3D space introduces the same chi-square coordinate technique as the 2D transformation, which can be expressed by multiplying the normalized chi-square matrix of the set of graph vertices by a given transformation matrix. The following is an expression for the chi-square coordinate transformation in a 3D transformation matrix:

$$\begin{bmatrix} x' & y' & z' & 1 \end{bmatrix} = \begin{bmatrix} x & y & z & 1 \end{bmatrix} T_{3D} = \begin{bmatrix} x & y & z & 1 \end{bmatrix} \begin{bmatrix} a & b & c & p \\ d & e & f & q \\ g & h & i & r \\ l & m & n & s \end{bmatrix} \tag{1}$$

Depending on the different graphical transformation functions, it can be divided into 4 sub-matrices:

$$T_1 = \begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix} \tag{2}$$

The T_1 is a submatrix of order 3×3 that performs miscutting, scaling, reflecting, and rotating transformations of the graph as a function of the order:

$$T_2 = \begin{bmatrix} l & m & n \end{bmatrix} \tag{3}$$

T_2 is a submatrix of order 1×3 that makes a parallel transformation of the graph:

$$T_3 = \begin{bmatrix} p \\ q \\ r \end{bmatrix} \tag{4}$$

T_3 is a submatrix of order 3×1 that transforms the graph projectively.

$T_4 = [s]$, is a submatrix of 1×1 order that scales the overall graph. Let the initial 3D point coordinate position be $p(x, y, z)$, and the spatial coordinate position after the 3D basic geometric transformation be $p'(x', y', z')$.

(1) When p three-dimensional point after translation to get three-dimensional point p', the corresponding p' as Eq:

$$\begin{bmatrix} x' & y' & z' & 1 \end{bmatrix} = \begin{bmatrix} x & y & z & 1 \end{bmatrix} T_t = \begin{bmatrix} x & y & z & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ T_x & T_y & T_z & 1 \end{bmatrix} = \begin{bmatrix} x+T_x & y+T_y & z+T_z & 1 \end{bmatrix} \tag{5}$$

where T_x, T_y, and T_z are translation parameters, when $x+T_x$, $y+T_y$, and $z+T_z$ result in negative, it represents the movement along the coordinate axis in the opposite direction.

(2) When the p' 3D points are transformed in a certain proportion, the corresponding p' is as in Eq:

$$\begin{bmatrix} x' & y' & z' & 1 \end{bmatrix} = \begin{bmatrix} x & y & z & 1 \end{bmatrix} T_s = \begin{bmatrix} x & y & z & 1 \end{bmatrix} \begin{bmatrix} a & 0 & 0 & 0 \\ 0 & e & 0 & 0 \\ 0 & 0 & i & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} ax & ey & iz & 1 \end{bmatrix} \tag{6}$$

In Eq. a, e, i represent the scale factors in x-axis, y-axis and z-axis, respectively. When the values of a, e, i are unequal, it means that the 3D points are transformed in a locally proportional way, which will lead to the deformation of the transformed object. On the other hand, when the values of a, e and i are equal, it means that the 3D points are transformed in the way of overall scale, and the transformed object will not be deformed.

(3) When a given 3D point in Unity rotates around a given axis at an angle of α, the corresponding representation is as follows:

When it is rotated around the z axis, as shown in the following equation:

$$\begin{aligned}[x' \quad y' \quad z' \quad 1] &= [x \quad y \quad z \quad 1]T_{r_z} \\ &= [x \quad y \quad z \quad 1]\begin{bmatrix} \cos\alpha & -\sin\alpha & 0 & 0 \\ \sin\alpha & \cos\alpha & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \\ &= [x\cos\alpha - y\sin\alpha \quad x\sin\alpha + y\cos\alpha \quad z \quad 1]\end{aligned} \tag{7}$$

when it is rotated about the x -axis, as shown in the following equation:

$$\begin{aligned}[x' \quad y' \quad z' \quad 1] &= [x \quad y \quad z \quad 1]T_{r_x} \\ &= [x \quad y \quad z \quad 1]\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\alpha & -\sin\alpha & 0 \\ 0 & \sin\alpha & \cos\alpha & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \\ &= [x \quad y\cos\alpha - z\sin\alpha \quad y\sin\alpha + z\cos\alpha \quad 1]\end{aligned} \tag{8}$$

when it is rotated about the y -axis, as shown in the following equation:

$$\begin{aligned}[x' \quad y' \quad z' \quad 1] &= [x \quad y \quad z \quad 1]T_{r_y} \\ &= [x \quad y \quad z \quad 1]\begin{bmatrix} \cos\alpha & 0 & \sin\alpha & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\alpha & 0 & \cos\alpha & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \\ &= [x\cos\alpha + z\sin\alpha \quad y \quad z\cos\alpha - x\sin\alpha \quad 1]\end{aligned} \tag{9}$$

II. B. 2) Fundamentals of 3D model visualization

After the 3D model is constructed in Unity 3D, the Camera projects the scene to the Game panel to realize the visualization effect after running. The user then wears a VR headset to present a virtual learning scene with real stereoscopic effects. The 2D images such as the plane in the scene are visualized by means of camera orthogonal projection transformation, while various other 3D models are realized by means of camera perspective projection transformation.

(1) Camera orthogonal projection transformation

The View Volume under orthogonal projection transformation is a regular rectangle composed of six planes. Orthogonal projection is the use of parallel lines according to the original scale of the object through the scene Camera projected onto the Game panel, which will not have perspective contraction effect due to the distance from the Camera, so it will ignore the size of the same object at different distances at the same time changes.

The six parameters n, f, l, r, t, and b are used to define the front, back, left, right, top, and bottom of the rectangular enclosing box, respectively, and the essence of orthogonal projection transformation is the process of transforming the rectangular body to the canonical view body CVV by translation and scaling. The orthogonal projection viewbody transformation process is shown in Figure 1.

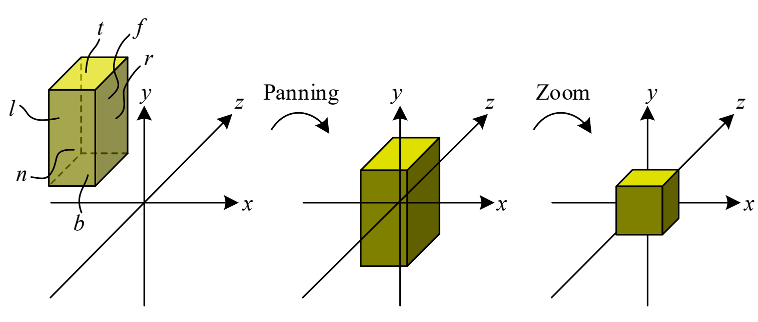


Figure 1: Transformation process of orthogonal projection view body

The final orthogonal projection matrix M_{orth} for Unity is obtained as:

$$M_{orth}=\begin{bmatrix}\frac{2}{r-l} & 0 & 0 & -\frac{r+l}{r-l}\\ 0 & \frac{2}{t-b} & 0 & -\frac{t+b}{t-b}\\ 0 & 0 & -\frac{2}{f-n} & -\frac{f+n}{f-n}\\ 0 & 0 & 0 & 1\end{bmatrix} \tag{10}$$

However, the orthogonal projection transformation is mostly applied to 2D animation or UI interface, which is detached from the concept of fitting the real stereoscopic situation in the meta-universe environment. Therefore, it is also necessary to have perspective projection transformation that can satisfy the 3D model and allow the user to display the scaling effect of different distances after wearing a VR headset.

(2) Camera Perspective Projection Transformation

The View Volume under perspective projection transformation is an irregular view cone, which can be scaled to the screen shown on the Game panel according to the distance of the 3D object from the Camera.The transformation process of perspective projection matrix in Unity needs to be divided into two steps, the View Frustum view cone needs to be transformed into a rectangular enclosing box first, and then orthogonal projection transformation is carried out to the CVV.

The perspective projection matrix M_{persp} for Unity is obtained as:

$$M_{persp}=\begin{bmatrix}\frac{2n}{r-l} & 0 & \frac{r+l}{r-l} & 0\\ 0 & \frac{2n}{t-b} & \frac{t+b}{t-b} & 0\\ 0 & 0 & -\frac{f+n}{f-n} & -\frac{2fn}{f-n}\\ 0 & 0 & 1 & 0\end{bmatrix} \tag{11}$$

Let the camera's FOV attribute be fov and the camera's current aspect ratio be $aspect$, yielding a final M'_{persp} of:

$$M'_{persp}=\begin{bmatrix}\frac{\cot\left(\frac{fov}{2}\right)}{aspect} & 0 & 0 & 0\\ 0 & \cot\left(\frac{fov}{2}\right) & 0 & 0\\ 0 & 0 & -\frac{f+n}{f-n} & -\frac{2fn}{f-n}\\ 0 & 0 & -1 & 0\end{bmatrix} \tag{12}$$

Suppose a 3D point $P_v(x,y,z)$ in the scene, whose position $P_{p_{clip}}$ obtained after perspective projection transformation is:

$$P_{p_{clip}}=M'_{persp}*P_v=\begin{bmatrix}x\frac{\cot\left(\frac{fov}{2}\right)}{aspect}\\ y\cot\left(\frac{fov}{2}\right)\\ -z\frac{f+n}{f-n}-\frac{2fn}{f-n}\\ -z\end{bmatrix} \tag{13}$$

Various 3D models in the learning scene are shown on the display screen after running through perspective projection, after which the user can display the stereoscopic 3D effect through the HTC Vive Pro headset to operate the learning tools in the scene from the first viewpoint, and feel a more realistic learning process.

II. C.Key technologies for secure construction of learning scenarios

II. C. 1) Blockchain

Blockchain is not a single and entirely new technology, but rather the result of the integration of multiple existing technologies (e.g., cryptographic algorithms, P2P file transfers, etc.). These technologies are skillfully combined with databases to form a new way of recording, transferring, storing and presenting data.

Narrowly speaking, blockchain is a kind of chain data structure that combines data blocks in chronological order in a sequentially connected manner, and cryptographically ensures that it becomes a distributed shared ledger that is tamper-proof and unforgeable. In layman's terms, blockchain is a kind of universal bookkeeping, everyone in the blockchain system has the opportunity to participate in bookkeeping, and the system sends the content of the bookkeeping book to everyone in the system for backup, so that everyone in the system has a complete book.

Blockchain realizes and establishes a distributed credit system, which is an upgrade of the existing Internet, and in the future blockchain network, it can realize information transfer, value transfer and credit transfer.

II. C. 2) Blockchain Fit Analysis in Smart Learning Scenarios

(1) Usability of Blockchain in Smart Scenarios

The smart learning scene has a large amount of data resources, and the collection of data mainly relies on sensor devices, radio frequency systems, etc., so it has to face the problems of data security and privacy management at any time. As the blockchain uses cryptography principles, the generated data blocks have high security, so in the construction of smart learning scenes, student information as well as learning scene information resources can become data blocks on the blockchain, so that valuable information data flow to higher data blocks, thus promoting the construction of resources and optimizing the utilization of resources.

(2) Feasibility of blockchain in wisdom scene

Learning scene data resources are becoming more and more numerous, the data structure is also diversified, and the data information is more easily exposed. The decentralized management mode of blockchain can realize information transmission and resource sharing, generate timestamps on nodes, ensure the security and reliability of information, realize the storage of unstructured information, ensure the privacy and security of data, and solve the problems of large data volume and complex structure. Therefore, the introduction of blockchain in the construction of smart learning scenarios can break through the dilemma of smart services in learning scenarios and inject new vitality into it.

II. C. 3) Blockchain-based data security collection program

Data acquisition is an important process in the life cycle of IoT data processing, and it is a key part of all kinds of data applications that must be completed first, determining the results of data analysis and the quality of application services. In order to ensure the security of IoT sensor data collection, this paper proposes a secure IoT data collection scheme based on blockchain.

(1) Threats and security objectives

The scheme assumes that the sampled data is trustworthy and can be used to detect the data provided by the data provider and evaluate its reputation value, and the threats and security goals faced by the scheme are discussed below.

Threats: data collection anomalies. Due to the special nature and working environment of IoT sensors, sensors may be subject to various attacks during data collection. Data tampering can cause data consumers to make decisions based on incorrect data, affecting the user experience.

Security Goal: Secure data collection. Reputation assessment theory is utilized to ensure the security of data collection. The trust assessment theory can assess the trustworthiness of data sources by establishing a trust model and assessment mechanism, so as to screen trustworthy data sources and reduce the possibility of data tampering or attack.

(2) Algorithm for credibility value assessment

For ease of representation, the descriptions of the relevant symbols are listed in the table. The symbol descriptions are shown in Table 1.

Table 1: Symbolic specification

Symbol	Explanation
P_c	Data consumer
P_i	The number i is according to the provider
T	Data consumer task requirements
$datatype$	Data type of the request
$\left[a,b\right]$	Required value range
$\left[x_1,x_2\right]$	Required data range
G_i	The noise data set for trading
d_i	The size of G_i
ε_i	The privacy budget used by P_i
S_i	Sample data for G_i
L_i	P_i original data focus on privacy data
u	Noise data
q	Privacy data ratio threshold
Z	The probability of more noise than a definite value
V	Detected malicious node number

After data anomaly detection, the committee calculates the amount of sampled data S_i for the data provider based on its data volume size d_i and data privacy budget ε_i to prevent excessive sampled data from causing privacy leakage at the node. Let the percentage of private data of the data provider P_i be L_i, then the probability of drawing a data that draws no private data is $1-L_i$. Therefore, it can be taken to be satisfied:

$$\left(1-L_i\right)^{S_i} \geq p \tag{14}$$

Maximizing S_i as the amount of data to be sampled makes it impossible to draw the data in the private dataset with probability p, guaranteeing that a larger proportion of data will be drawn from the dataset.

There are d_i data points in dataset G_i, d_iL_i of which are private data, from which S_i data points are to be drawn as sample $\left(S_i < d_i\right)$, there are $\binom{d_i}{s_i}$ ways to draw S_i data points from d_i data points, $\binom{d_iL_i}{k}$ ways to draw k private data from d_iL_i private data, and $\binom{d_i-d_iL_i}{s_i-k}$ ways to draw S_i-k data from $d_i-d_iL_i$ non-private data. Therefore, the probability that the ratio of private data to total private data drawn from the sampled data is less than q can be calculated as:

$$p\left(\text{percentage of private data} < q\right) = \sum_{k=0}^{\lfloor qS_i \rfloor} \frac{\binom{d_iL_i}{k}\binom{d_i-d_iL_i}{s_i-k}}{\binom{d_i}{s_i}} \tag{15}$$

A plausible sample of data is drawn for the data provider P_i:

$$Y_{S_i} = \left[0,0,\cdots,y_1,\cdots,y_2,\cdots,y_{S_i},\cdots,0\right] \tag{16}$$

Let the detected dataset be $G_{d_i} = \left[x_1,x_2,\cdots,x_{d_i}\right]$, and the committee detects the non-recombination rate of the data that has the same location index as that of the sampled data h in lieu of the error rate of the data so that the theoretical amount of false data is hd_i. Considering the original $b(x,n,p) = C_n^x p^x (1-p)^{n-x}$ for differential privacy, the probability that the amount of false data, i.e., the amount of noisy data, is u is:

$$b\left(\left(u,d_i,p_i\right) = C_{d_i}^u p_i^u \left(1-p_i\right)^{d_i-u} \tag{17}$$

where the data perturbation probability p_i is:

$$p_i = \frac{e^{\varepsilon_i}}{e^{\varepsilon_i} + d_i - 1} \tag{18}$$

The probability that the false data is greater than u is given by Eq:

$$Z = 1 - \sum_{x=u}^{d_i} b\left(u, d_i, p_i\right) \tag{19}$$

The smaller the Z, the less trustworthy the measured data set is. By setting the value of Z, the maximum value of theoretical false data W can be calculated, and the reputation value of the data provider with false data equal to W is set to a passing score of 60, and the larger the false data, the lower the reputation value. Finally, the committee excludes the nodes with failing reputation value and determines the final data provider node.

(3) Security Analysis

Data security collection mainly refers to the authenticity of the data, and since the original data is local to the IoT users, the scheme in this paper adopts the reputation assessment theory that can withstand most attacks.

The scheme in this paper can still determine whether a data node is a malicious node under probability p. Assuming that the privacy budget of the data provider p_i is ε_i, from the above equation, the probability that the noisy data is larger than u is $Z = 1 - \sum_{x=u}^{d_i} b\left(u, d_i, p_i\right)$, the value of Z decreases as u increases. Therefore, it is possible to determine whether a node is a malicious node or not based on the amount of erroneous data detected in the sampled data; the higher the amount of erroneous data, the higher the likelihood that the node is a malicious node, and accordingly the lower the reputation value is assigned to it.

The reputation assessment algorithm in this paper is based on credibly sampled data, and extracting data locally at the data source may jeopardize privacy security. In order to protect privacy, the scheme considers dividing the data into ordinary data and private data.

Reputation value security plays a decisive role in the reputation assessment scheme, and the scheme will lose its meaning if the reputation value is tampered with. To ensure the security of reputation value, the scheme sets up a committee to evaluate the reputation value and uploads the result to the blockchain. The blockchain is a chain structure consisting of one block after another, and each block contains a certain amount of transaction data as well as the hash value of the previous block. The data from each block is calculated by a hash function to obtain a hash value that is included in the next block, forming a tamper-proof data structure.

III. Security analysis and application promotion of meta-universe learning scenarios

III. A. Optimization of reputation assessment algorithm under blockchain technology

(1) Simulation experiment and experimental environment description

The hardware platform for the simulation experiment is a PC with Intel T430 3.6 GHz dual-core processor, 4GRAM and Windows Server 2020R2 operating system.

The software platform is a peer-to-peer network file sharing system based on Gnutella protocol implemented using Peersim 1.0.5 simulation platform and based on Java coding.

The global simulation parameters are shown in Table 2, where a selfish node is a node that increases its reputation value by decreasing the reputation value of other nodes, while a malicious node is a node that provides wrong reputation value.

(2) Simulation results

The classification of the algorithms based on the transfer mode of reputation value (TMR) can be discussed for four different scenarios based on full node recommendation, partial node recommendation, single step trust transfer and multi-step trust transfer.

It is noticed that the optimized reputation assessment algorithm (Reputation Assessment Algorithm based on Sampled Data) does not perform normalization but reduces the degree of damage to the node contribution volume information through LERV while identifying malicious node behavior.

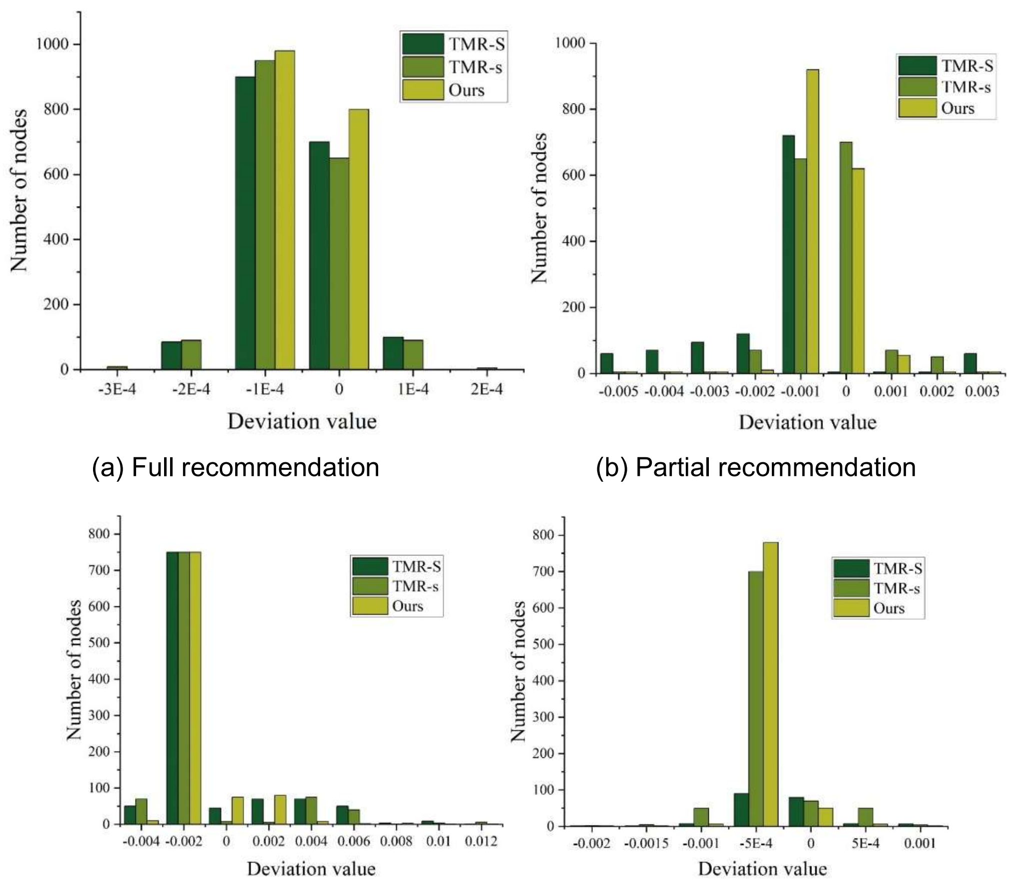
For different situations, the reputation assessment algorithms are further normalized (TMR-S) and non-normalized (TMR-s) algorithms. In view of this, while performing the simulation validation, the concern is the closeness of the reputation values calculated by different algorithms to the ideal value, and with reference to the relative value of the node's contribution to the system in the ideal case, the closer the calculated GRV value is to the ideal value, the better the algorithm is.

Table 2: Global simulation parameter

Parameter	Full node recommendation	2 % recommendation	Single-step trust transmission	Multi-step trust transmission
Number of system nodes	1000	1000	1000	300
Business volume	100000	100000	100000	20000
High active node	20% of the high activity nodes account for 50% of the business			
Secondary active node	60% of the secondary activity nodes account for 40% of the business			
Low active node	20% of low activity nodes account for 10% of business			
Malicious node ratio	20%			
Simulation number	20			
Evaluation standard deviation	±20%			
Evaluate path length	1<5			

The simulation results are shown in Fig. 2, where the degree of deviation of the GRV values computed with TMR-S, TMR-s, and the reputation assessment algorithms based on sampled data from the ideal values are counted and compared in the case of full node recommendation (a), partial node recommendation (b), single-step trust transfer (c), and multistep trust transfer (d), respectively.

The results of the simulation experiments show that the global reputation value calculated by the reputation assessment algorithm based on sampled data is closer to the ideal value and improves the ability to identify malicious nodes.



(a) Full recommendation (b) Partial recommendation

(c) Single step trust recommendation (d) Multi-step trust recommendations

Figure 2: Simulation result

In order to compare the degree of deviation of the GRV from the ideal value for the TMR-S algorithm, the TMR-s algorithm, and the reputation assessment algorithm based on sampled data, the Euclidean distance model is used to measure the correlation coefficient between the GRV series calculated by these three algorithms and the ideal value. The distribution is shown in Fig. 3.

From the figure, it is easy to see that the correlation coefficient of the reputation assessment algorithm based on sampling data proposed in this paper is closer to 0, which is obviously better than that of TMR-S and TMR-s algorithms, indicating that the global reputation value calculated by the reputation assessment algorithm based on sampling data is closer to the ideal value. It has certain rationality and accuracy.

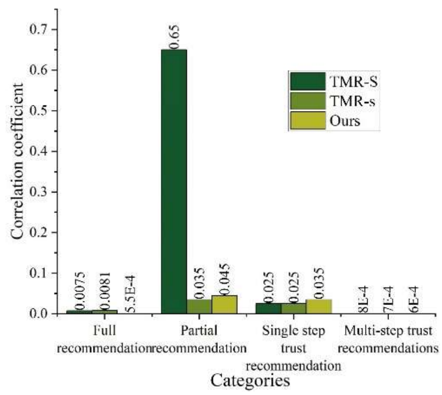


Figure 3: The comparison graph of correlation coefficient

III. B. Meta-universe Learning Scene Communication Practices

(1) Scenario-based communication practices

With the promotion of digital teaching, many digital teaching resources and online learning platforms have been further integrated into traditional educational practices through developed network technologies, promoting the change of traditional classroom teaching structure. The blending of reality and virtual reality is one of the core features of the mobile Internet era, and the contact time and space of teachers and students, due to the development and application of online learning platforms, includes the offline real teaching environment and online virtual cyberspace online platform environment, for example, the teacher can arrange assignments and after-school tasks through online learning platforms, such as "nail", so that students can clock in and out. For example, the teacher can arrange homework and after-school tasks in online learning platforms such as "Nail", let the students punch the card to complete, and upload to the platform, with the help of the online platform to connect the traditional behavior of handing over and receiving homework to the online, and at the same time, it also saves the time cost of receiving homework and correcting the homework offline and the operation steps, and this function is very good to connect the function of the online platform with the real scenario.

Taking a meta-universe learning platform as an example, users can upload local files of smart mobile terminals on the platform, and can also choose files stored in other platforms such as QQ or chat records, and at the same time, they are also able to share the files of the reverse selection platform to QZone and so on.

(2) Data Analysis

This paper uses the electronic questionnaire online platform "Questionnaire Star" to conduct research, and a total of 670 questionnaires were issued. Excluding 33 invalid questionnaires that did not use the meta-universe learning platform for online learning, a total of 637 questionnaires were finally recovered in line with this study, and the data obtained were used as the official research data of this paper. And a database was set up through SPSS for statistical analysis.

Among the data obtained from the questionnaires distributed in this study, the proportion of males is 48.5% and the proportion of females is 51.5%. The percentage of respondent users' grade level is 36% for senior year, 44% for sophomore year, and 20% for junior year. The percentage of respondent users' geographic city grades in first-tier cities was 28%, in new first-tier cities was 35%, in second-tier cities was 25%, and in third-tier cities and below was 12%.

Before analyzing the model, SPSS software was used to first validate and analyze the differences in demographic variables, and the data results were obtained as shown in Table 3.

Male students scored 3.42 ± 0.96 and 3.45 ± 1.01 on the dimensions of Platform Accompaniment and Sense of Classroom Engagement, respectively, which were higher than their female counterparts. The p-value of each dimension of the survey is greater than 0.05, and there is no difference between genders. Therefore gender will not be a factor affecting the variables in this paper.

Table 3: Data survey results

Type	Man	Female	T	P
Platform engagement	3.42 ± 0.96	3.39 ± 0.85	0.526	0.657
Use convenience	3.55 ± 0.99	3.58 ± 0.79	1.236	0.213
Study immersion	3.46 ± 0.98	3.61 ± 0.91	0.826	0.404
Resource effect	3.57 ± 1.03	3.64 ± 0.95	0.499	0.628
Platform interactivity	3.21 ± 1.04	3.35 ± 0.98	0.304	0.721
Classroom participation	3.45 ± 1.01	3.37 ± 0.99	-0.427	0.331
Usage attitude	3.64 ± 0.91	3.67 ± 1.02	0.892	0.758
Behavioral intention	3.57 ± 0.95	3.60 ± 1.15	1.234	0.091

(3) Correlation analysis

After completing the reliability effect test, SPSS was used to conduct correlation analysis to test whether there is a significant correlation between each independent variable and the mediator variable, and the mediator variable and the dependent variable.

The specific data results of correlation analysis are shown in Table 4.

According to the results in the table, there is a significant correlation between each independent variable and the mediator variable, and between the mediator variable and the dependent variable. According to the range of the correlation coefficient, the correlation coefficient of this test is greater than 0, so there is a positive correlation between each independent variable and the mediator variable, and the mediator variable and the dependent variable.

Table 4: Specific data results of correlation analysis

		Usage attitude	Behavioral intention
Platform engagement	Pearson-related	0.785	0.791
	Significance	0.000	0.000
	N	637	637
Use convenience	Pearson-related	0.715	0.760
	Significance	0.000	0.000
	N	637	637
Study immersion	Pearson-related	0.747	804
	Significance	0.000	0.000
	N	637	637
Resource effect	Pearson-related	0.793	813
	Significance	0.000	0.000
	N	637	637
Platform interactivity	Pearson-related	0.825	836
	Significance	0.000	0.000
	N	637	637
Classroom participation	Pearson-related	0.813	854
	Significance	0.000	0.000
	N	637	637
Usage attitude	Pearson-related	1.000	0.812
	Significance	0.000	0.000
	N	637	637
Behavioral intention	Pearson-related	0.801	1.000
	Significance	0.000	0.000
	N	637	637

Each variable in this paper has 2 question terms. In order to ensure the reliability of the research results, this paper uses the method of averaging to replace the variables involved in the analysis, and then uses linear regression analysis to verify the relationship between each independent variable and the dependent variable in order to test the research hypotheses.

The model summary data are shown in Table 5. Independent variables: (constant), classroom engagement, platform interactivity, resource effectiveness, platform accompaniment, learning immersion, platform convenience. Dependent variable: attitude.

The adjusted R^2 is 0.714, indicating that 71.4% of the users' attitudes toward use are related to the above dependent variables.

Table 5: Model summary data

Model	R	R^2	After adjustment R^2	Standard bias error	Durbin-Watson
1	0.825*	0.726	0.714	0.468	3.251

The effects of usefulness, ease of use, and autonomy on user attitudes are shown in Table 6.

In the linear regression model, the β regression coefficients of Platform Accompaniment, Ease of Use, Learning Immersion, Resource Effectiveness, Platform Interactivity, and Classroom Engagement are 0.467, 0.513, 0.363, 0.392, 0.336, 0.319, respectively, and the values of β are all greater than zero, so that all of these independent variables have a positive influence. Among them, the β value of ease of use is the largest, 0.513, which shows that ease of use has the greatest influence on attitude toward use. The next are platform accompaniment, resource effectiveness, learning immersion, platform interactivity, and classroom engagement, respectively. In addition, the significance p-value of all independent variables in the linear regression is less than 0.05, thus indicating that the above independent variables are relatively significant when it comes to the influence on the attitude of use.

In summary, in the construction and application of the meta-universe learning scene, the scene specialization of the meta-universe learning platform can be improved to create a scene learning platform that is easy to use and highly portable. This leads to the promotion of meta-universe learning scenarios.

Table 6: The effect of usefulness, ease of use and autonomy on user attitude

Model	Unnormalized coefficient		Normalization factor	T	Significance
	B	Standard error	Beta		
1 (constant)	0.312	0.115		3.521	0.005
Platform engagement	0.467	0.062	0.359	7.158	0.001
Use convenience	0.513	0.051	0.485	8.261	0.003
Study immersion	0.363	0.074	0.375	3.425	0.001
Resource effect	0.392	0.082	0.164	2.595	0.000
Platform interactivity	0.336	0.043	0.199	2.778	0.008
Classroom participation	0.319	0.069	0.253	3.984	0.025

IV. Conclusion

In this paper, blockchain technology is utilized to be responsible for the security management of meta-universe learning scenarios, and a blockchain-based IoT data security collection scheme is proposed, and as a result, a reputation assessment algorithm based on sampled data is proposed. Simulation experiments are done on the reputation assessment algorithm on the dataset and the effectiveness of the algorithm is analyzed.

The global reputation value of the reputation assessment algorithm based on sampled data is closer to the ideal value under four different scenarios: all node recommendation, partial node recommendation, single-step trust transfer and multi-step trust transfer.

Learning scenarios constructed using meta-universe technology can be used in practical applications to improve user satisfaction by adjusting several factors: portability of use, platform accompaniment, resource effectiveness, learning immersion, platform interactivity, and classroom participation.

Funding

This research was supported by the Collaborative Education Project of Industry-University Cooperation, Ministry of Education: "Teaching Reform and Practical Research on the Course 'Digital Special Effects and Synthesis' in the Context of Virtual Simulation" (08075748).

References

[1] Hassanzadeh, M. (2022). Metaverse, Metaversity, and the Future of Higher Education. Sciences & Techniques of Information Management, 8(2).

[2] Shu, X., & Gu, X. (2023). An empirical study of A smart education model enabled by the edu-metaverse to enhance better learning outcomes for students. Systems, 11(2), 75.
[3] Lala, R., Jeuring, J., Van Dortmont, J., & Van Geest, M. (2017). Scenarios in virtual learning environments for one-to-one communication skills training. International Journal of Educational Technology in Higher Education, 14, 1-15.
[4] Luis, R. M. M. F., Llamas-Nistal, M., & Iglesias, M. J. F. (2017, June). Enhancing learners' experience in e-learning based scenarios using Intelligent Tutoring Systems and Learning Analytics: First results from a perception survey. In 2017 12th Iberian Conference on Information Systems and Technologies (CISTI) (pp. 1-4). IEEE.
[5] Zifan, C., & Haiyan, Y. (2023). Evolution of Artificial Intelligence Generated Content (AIGC) and Its Application Scenario of Library Intelligent Service. Libraly Journal, 42(384), 34.
[6] Yáñez, C. (2015). New learning scenarios for the 21st century related to Education, Culture and Technology. RUSC, 12(2), 87-102.
[7] Tomashevskiy, V., Pohrebniuk, I., Kunanets, N., Pasichnyk, V., & Veretennikova, N. (2021). Construction of individual learning scenarios. In Advances in Computer Science for Engineering and Education III 3 (pp. 609-620). Springer International Publishing.
[8] de Brito Lima, F., Lautert, S. L., & Gomes, A. S. (2022). Learner behaviors associated with uses of resources and learning pathways in blended learning scenarios. Computers & Education, 191, 104625.
[9] Scholze, A., Potkonjak, S., Marcel, F., Folinazzo, G., & Townend, N. (2022). Scenarios for learning–scenarios as learning: A design-based research process. In Activating Linguistic and Cultural Diversity in the Language Classroom (pp. 113-139). Cham: Springer International Publishing.
[10] Kundu, A., & Dey, K. N. (2018). A contemporary study on the flourishing E-learning scenarios in India. International Journal of Creative Research Thoughts, 6(2), 384-390.
[11] Ramos, B., & Condotta, R. (2024). Enhancing learning and collaboration in a unit operations course: Using AI as a catalyst to create engaging problem-based learning scenarios. Journal of Chemical Education, 101(8), 3246-3254.
[12] Di Natale, A. F., Repetto, C., Costantini, G., Riva, G., Bricolo, E., & Villani, D. (2024). Learning in the metaverse: Are university students willing to learn in immersive virtual reality?. Cyberpsychology, Behavior, and Social Networking, 27(1), 28-36.
[13] Marini, A., Nafisah, S., Sekaringtyas, T., Safitri, D., Lestari, I., Suntari, Y., ... & Iskandar, R. (2022). Mobile augmented reality learning media with Metaverse to improve student learning outcomes in science class. International Journal of Interactive Mobile Technologies, 16(7).
[14] Lee, C. S., Wang, M. H., Reformat, M., & Huang, S. H. (2023). Human intelligence-based Metaverse for co-learning of students and smart machines. Journal of ambient intelligence and humanized computing, 14(6), 7695-7718.
[15] Nizamuddin, N., & Shuhaiber, A. (2024, November). Blockchain and the Metaverse: Personalized Learning for a Digital Future. In 2024 6th International Conference on Blockchain Computing and Applications (BCCA) (pp. 271-278). IEEE.
[16] Singh, M., Sun, D., & Zheng, Z. (2024). Enhancing university students' learning performance in a metaverse-enabled immersive learning environment for STEM education: A community of inquiry approach. Future in Educational Research, 2(3), 288-309.
[17] Sá, M. J., & Serpa, S. (2023). Metaverse as a learning environment: Some considerations. Sustainability, 15(3), 2186.
[18] Sakka, S., Liagkou, V., Stylios, C., & Ferreira, A. (2024, May). On the privacy and security for e-education metaverse. In 2024 IEEE Global Engineering Education Conference (EDUCON) (pp. 1-10). IEEE.
[19] Singh, D., Mohan, S., & Dubey, P. (2024). Identifying Cyber Threats in Metaverse Learning Environment using Explainable Deep Neural Networks. International Journal of Performability Engineering, 20(12).
[20] Al-kfairy, M., Sendaba, O., & Alfandi, O. (2025). Understanding trust in educational Metaverse: the role of social cognitive theory constructs and perceived risks. Kybernetes.
[21] Yang, E., & Ryu, J. (2024, March). Learners' Cognition and Emotions in Metaverse Learning Environments: A Multimodal Analysis. In Society for Information Technology & Teacher Education International Conference (pp. 986-990). Association for the Advancement of Computing in Education (AACE).
[22] Jia, J., Wang, T., Zhang, Y., & Wang, G. (2024). The comparison of general tips for mathematical problem solving generated by generative AI with those generated by human teachers. Asia Pacific Journal of Education, 44(1), 8-28.
[23] Garon, J. M. (2023). Legal considerations for offering metaverse-based education. JL & Educ., 52, 53.
[24] Al-kfairy, M., & Alfandi, O. (2024). The ethical dilemma of educational metaverse. Recent advances in Evolution of Education and Outreach, 1(1), 006-016.
[25] C H Fang,X W Wu & P A Heng. (2024). .. Zhonghua wai ke za zhi ,62(11),981-983.
[26] Valeria Malyavina. (2023). Intellectual Property and the Metauniverse. Journal of Social Science and Humanities,5(7).