Scholar Publishing Group
International Journal of Educational Innovation and Science
https://doi.org/10.38007/IJEIS.2020.010404
ISSN 2789-7184 Vol. 1, Issue 4: 30-46

Ecological Concept in Interior Design Teaching under the Background of Internet of Things

Lisha Yang*

School of Economics and Management, Chongqing Youth Vocational and Technical College, Chongqing 401320, Chongqing, China

**corresponding author*

Keywords: Internet of Things, Ecological Concept, Interior Design, Virtual Reality

Abstract: From black and white to color, from one-dimensional to multi-dimensional, from real to virtual, design creation is closely related to nature, human beings and society, and design teaching also involves all aspects. Exploding amount of information, rapidly iterating new technologies, and constantly developing new theories, these new characteristics of the big data era have brought new challenges to design teaching, and also brought new opportunities to design teaching. This paper takes the improvement of the design teaching system and the training of comprehensive design talents as the direction, based on the guidance of the relevant theories of the Internet of Things, and discusses the application scenarios and application principles of virtual reality technology in design teaching practice. On the basis of mining the Internet of Things technology, this paper combines the laws and status quo of inquiry-based learning. This paper designs an inquiry-based learning activity model based on the Internet of Things platform and guided by inquiry-based learning, with the participation of students, teachers, parents, and social participants. At the same time, in order to verify the correctness and reality of the model, this paper compares it with the current application practice of the "perceptual education" project based on the Internet of Things technology. The experiment shows the distribution of the weights of each sensor after the algorithm fusion. The estimated value of the real value at the current time point is 24, the fusion value can be calculated to be 23.9, and the error with the estimated value is 0.0041. The comparison shows that the fusion algorithm in this paper is more accurate than the arithmetic mean method, and the fusion result is closer to the real value, which can achieve the purpose of improving the accuracy of the data.

1. Introduction

In today's era of big data, the cultivation of comprehensive design talents is an important goal of art and design education. In order to achieve the goal of cultivating comprehensive design talents, it is necessary to focus on how to cultivate students' integration ability. Facing the training needs of comprehensive design talents, this paper designs teaching as a systematic project. It should be under the guidance of scientific theory, using advanced teaching technology, through analysis and research in the process of designing teaching, how the various parts are related to each other and interact with each other. Designing problems and needs in teaching, finding ways to solve these problems and needs, achieving the best teaching effect, and establishing a more perfect design teaching system.

The digital application research of interior design teaching is based on the researcher's nearly twenty years of interior design engineering practice and first-line teaching practice. The forward-looking teaching concepts, new teaching models and scientific training methods provided by digital application research for interior design teaching have strong practical significance. From the perspective of learning content, the Internet of Things technology has changed the traditional mode of simplification and textbook-based learning content. Students can use the characteristics of the Internet of Things, such as perception and long-distance transmission, to choose the learning content that they are more interested in and need to explore, and get rid of the time and space constraints of the learning content to a greater extent.

The innovation of this paper is that (1) this paper breaks through the previous researchers' perspective, trying to systematically analyze inquiry-based learning from a more mesoscopic level and from the perspective of pedagogy. This paper will make a more systematic discussion on the content, inquiry relationship, inquiry evaluation and other factors involved in inquiry learning. (2) On the basis of theoretical research and practical investigation, combined with the advantages of Internet of Things technology, this paper proposes to design an inquiry-based learning model from an ecological perspective. It is expected that by introducing family factors and social factors that have not participated in the process of inquiry learning in traditional situations, a pan-inquiry learning circle centered on students and assisted by teachers, parents, and social counselors can be established.

2. Related Work

The concept of environmental design is interrelated with the concepts of emotional design, engineering, design for pleasure, etc. Over the past two decades, Tynynyka AS has become increasingly interested in the emotional response of consumers to the idea of introducing environmental design. This enables him to highlight some new trends related to the emotional composition and perception of design objects [1]. Although he tries to analyze the influence of eco-design thinking on interior design to maintain the stability of human factors and follow ergonomic systems, there are still gaps in the experimental results. Technology not only gives us more information, it also empowers us to communicate, organize and manage time. The research objective of Rajebhosale S is to design secure home automation systems accessible from a global location. In this proposed system, the Raspberry Pi is used as a gateway between the web dashboard and the actual system devices and sensors [2]. Although a faster communication perspective is achieved in this system, sensor data and devices are still inaccessible from anywhere in the world using the MQTT protocol. Powered by IoT technology, they provide homes with safety, comfort, entertainment, assisted living, and efficient management to enhance consumers' quality of life. Sequeiros H developed a research model combining hedonic and well-being motivation with a unified theory of technology acceptance and use to assess the impact on well-being. Results suggest that hedonic motives associated with adopting certain smart home services moderate continued use [3]. 3D solid modeling, global illumination effect levels, and real-time rendering methods have laid the foundation for practical applications. Rendering quality and speed are paradoxes for 3D scene visualization. Zhang H explored the ideas and methods of realizing realistic indoor scenes based on the interactive real-time rendering of the open source project MNRT. He designed the commercial design of interior design software using NVIDIA's powerful application engine, ray tracing engine Opti X, scene management engine SceniX and PhysX engine [4]. Although his experimental direction is forward-looking, there are still shortcomings. When it comes to interior design projects, architects, owners, and suppliers rely on specialized contracts to manage the risks associated with these relationships—risks that vary based on each party's role in the project. Koger M works with architects from the hospitality, residential and commercial sectors to understand the complexities and risks associated with their project relationships. For example, interior design projects often involve direct interaction between architects and suppliers and are complicated by varying degrees of contract negotiation and purchasing power [5]. Aiming at the characteristics of significant color difference and rich colors between regions in interior design, Fang L proposed an interior design color transfer algorithm based on topology information region matching. First, he introduced the segmentation of interior design images, and then proposed to calculate the topological information of each region to determine the matching relationship between regions, thereby improving the accuracy of color transfer between images. Second, in order to improve the integrity of color transfer, he not only introduces color transfer between matching regions, but also color adjustment for regions without corresponding target regions. Finally, a color harmony algorithm is introduced to reduce the effect of unexpected colors generated during color transfer, thereby improving the harmony of the final image [6]. Although his interior design color transfer algorithm is highly practical, the experimental process is still incomplete.

3. The Integration of IoT and Design Teaching

3.1. Internet of Things

The communication layer is built on the basis of modern communication technology. It is the bridge for the flow of information throughout the model. Relying on technologies such as wireless networks, wired networks, and the Internet, the information in the Internet of Things can be transmitted and shared. The structure of the Internet of Things is shown in Figure 1.

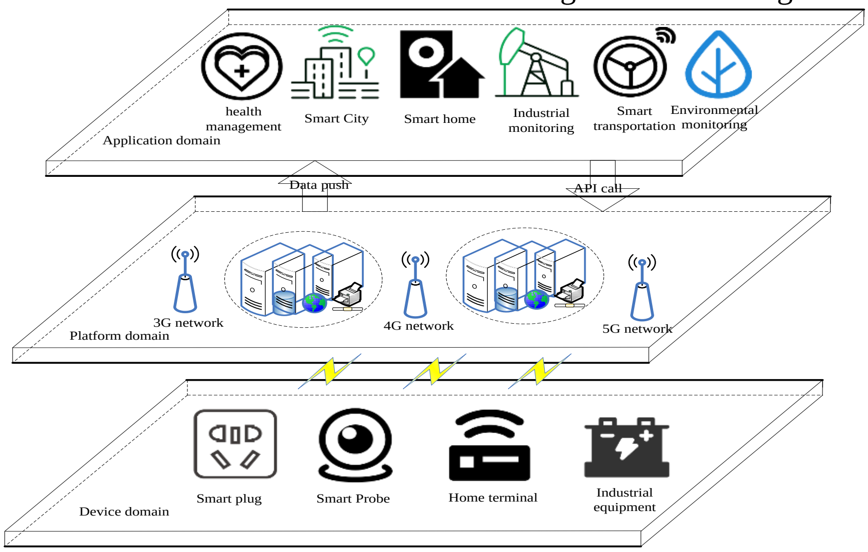


Figure 1. The structure of the Internet of Things

As can be seen from Figure 1, through modern communication technology, inquiry-based learning can break through the limitations of time and space. Users can access the corresponding network at any time and any place to obtain the required inquiry information and carry out inquiry-based learning [7]. Moreover, the current Internet of Things system is integrating communication network and cloud storage technology, and the information collected through the Internet of Things can be uploaded to the cloud for storage through information communication. Therefore, users can more conveniently extract and analyze information [8].

3.2. Traditional Interior Design Teaching Concept

Originating from the traditional interior design teaching for the purpose of beautifying and decorating the six faces of the single enclosed building, it is based on patterns. Therefore, the traditional concept of interior design teaching is based on the two-dimensional patterned plane teaching method, emphasizing students' hand-painted expression ability [9]. Teaching and learning is a process in which teachers' theories and experiences are combined with students' imaginations through description and comprehension. Design training is done through plane sketching, then repeated copying and modification with transparent sketch paper and sulfuric acid paper. Therefore, the training of hand-painting skills has always accounted for a large proportion of traditional interior design courses. In addition to the basic hand-painted expression training of design, professional hand-painting skills training also has a wide variety of types and a huge system. Hand-painting ability is the focus of traditional teaching training, and it is also an important criterion for evaluating teaching achievements [10-11]. For a long time before digital technology intervened in design expression, there was a misunderstanding in the industry: that strong hand-painting ability means strong design ability. This misunderstanding causes more students to spend more time on the practice of hand-painting skills and even the selection of hand-painting tools. The horizontal structure of the inquiry learning model based on the Internet of Things is shown in Figure 2.

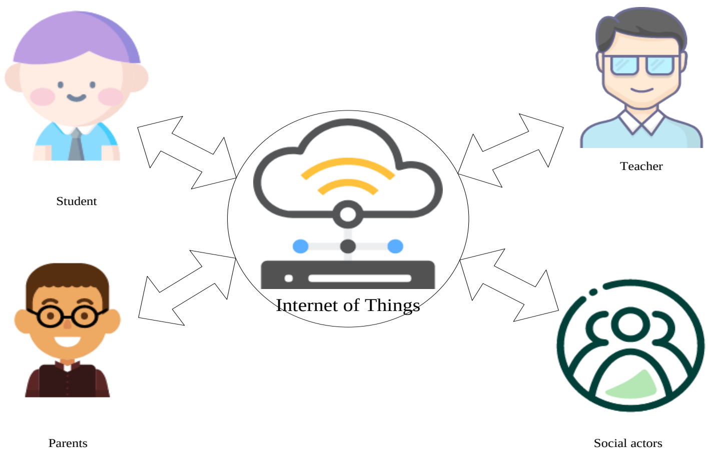


Figure 2. Horizontal structure of the inquiry-based learning model based on the Internet of Things

As can be seen from Figure 2, inquiry-based learning is a learning behavior that simulates the process of scientific research. Regardless of the teaching mode of inquiry-based learning, the position of teachers and students in the mode of inquiry-based learning. In essence, the core of all inquiry-based learning is to help students build a behavioral model of "exploring problems - getting concepts - applying concepts - exploring new problems". In this mode of behavior, students can not only acquire new knowledge and improve their cognitive level, but also cultivate their interest and emotion in scientific inquiry [12]. At the same time, such a mode of discovering and solving problems is also a behavioral mode that students must have in their future production and life.

3.3. Building a Fuzzy Neural Network Model

This chapter is to complete the evaluation of TS fuzzy neural network on the comfort of interior design environment, so this section first introduces the development history of neural network and fuzzy logic theory and their respective characteristics. Then this paper expounds the mathematical concept model of T-S neural network, learning simulation algorithm, and then constructs the framework of fuzzy neural network. It provides a theoretical basis for the evaluation of the db (database) data of the indoor smart home system in the next section and the improvement of the indoor environment.

(1) Artificial neuron model

Biological neurons generally include cell bodies, axons, dendrites and synapses, which complete the reception and processing of information and map within a certain interval (usually zero to one or minus one to one). This refers to activation function functions, such as step function, linear partition function and threshold function, etc. [13-14]. It is represented by Formula (1).

$$\mu_k = \sum_{j=1}^{p} w_{kj} x_j, v_k = net_k = u_k - \theta_k, y_k = \varphi(v_k) \tag{1}$$

(2) Training of artificial neural network

The training steps of the neural network are to generate sample data, determine the network type and structure, and train and test [15]. The collection and preprocessing of smart home environment information is a key part of the successful development of neural networks. The first step is to determine the input quantity, that is, to test the correlation between the input quantities (when there are two input quantities with strong correlation, one of them needs to be selected as the input after statistical analysis of the data). If it set up more nodes at the beginning, it need to use the error cost function after the network is trained:

$$J_f = \frac{1}{2}\sum_{p=1}^{p}\sum_{i=1}^{N_q}(t_{pi} - x_{pi})^2 + \varepsilon\sum_{q=1}^{q}\sum_{i=1}^{N_q}\sum_{i=1}^{N_{q-1}}|w_{ij}^{(q)}| = J + \varepsilon\sum_{q,i,j}|w_{ij}^{(q)}| \tag{2}$$

In the Formula, J_f is the sum of the squares of the error output, and the second term is generally called the "forgetting term" in order to minimize the connection weight coefficient after training, and the learning algorithm is obtained by letting J_f calculate the gradient of w_{ij}. The role of the learning algorithm is to attenuate unnecessary or less influential connection weights to zero and remove the corresponding nodes to make the resulting overall neural network scale appropriately. The gradient is as follows:

$$\frac{\partial J_f}{\partial w_{ij}^{(q)}} = \frac{\partial J}{\partial w_{ij}^{(q)}} + \varepsilon \mathrm{sgn}(w_{ij}^{(q)}) \tag{3}$$

If only a single hidden layer is included in the forward network, the relationship between the number of neurons in the input layer M and the number of nodes in the layer q is approximately:

$$q = 2M + 1 \tag{4}$$

The performance of a network is mainly measured by its generalization ability, which is tested and verified with a set of independent data [16].

(3) Fuzzy controller

For the MISO (multiple input single output) structure, a set of m fuzzy rules can be used to represent its discrete-time model, and the jth fuzzy rule is as follows:

$$R^i: \text{if } x_1 \text{ is } A_1^i, x_2 \text{ is } A_2^i, \ldots, x_m \text{ is } A_m^i \text{ then } y^i = p_0^i + p_1^i x_1 + p_2^i x_2 + \ldots + p_m^i x_m \quad (5)$$

Among them, X_j becomes the generalized input variable of the model, and the membership function of the fuzzy subset is a convex set composed of pieces [17-18]. Given a generalized input variable $(x_{10}, x_{20}, \ldots, x_{m0})$, the output $\bar{y}$ can be obtained from the weighted average of the outputs of the rulesy^i(i=1,2, ..,n):

$$\bar{y} = \frac{\sum_{i=1}^{n} G^i y^i}{\sum_{i=1}^{n} G^i} \quad (6)$$

n is the number of fuzzy rules; y^i is obtained by the conclusion Formula of the ith rule; weight G^i represents the truth value of the ith rule corresponding to this generalized input vector, which is determined by the following Formula:

$$G^i = \prod_{j=1}^{m} A_j^i (x_{j0}) \quad (7)$$

Here Π is a fuzzy operator, usually using a small operation or a product operation [19].

(4) MIMO system structure

Compared with the structure principle of MISO, the MIMO system structure is a further deduction of the principle of the MISO system. Each node of the first layer of the former network is connected to each component x_i of the input $\bar{x} = [x_1, x_2, \ldots, x_n]^T$ vector. This layer is used as the input layer to transmit the input value to the mentioned second layer. The second layer mainly completes the membership degree μ_i^j of each component x_i of the input quantity, that is,

$$\mu_i^j = \mu_{A_i^j}(X_i) \text{ or } \mu_i^j = e^{\frac{(x_i - c_{ij})^2}{\sigma_{ij}^2}} \quad (8)$$

where c_{ij} and σ_{ij} are the center and width of the function, respectively;

$$\alpha_j = \mu_1^{i1} \mu_2^{i2} \ldots \mu_n^{in} \quad (9)$$

where ∈{1,2,...,},∈{1,2,...,}...∈{1,2,...,},j=1,2,... ,m,m=$\prod_{i=1}^{n} m_i$, the function of the fourth layer is to normalize the calculation, namely:

$$\overline{\alpha_j} = \frac{\alpha_j}{\sum_{i=1}^{m} \alpha_i} \text{ (j=1,2,...,m)} \quad (10)$$

The first layer of the postware network is also the input layer, and its zeroth node mainly provides the constant term of the network, so its value is 1. The second layer handles the consequent of each rule, namely:

$$y_{ij} = p_{j0}^i + p_{j1}^i x_1 + \ldots + p_{jn}^i x_n = \sum_{l=0}^{n} p_{jl}^i x_l \ (j = 1,2,\ldots,m; i = 1,2,\ldots,r) \quad (11)$$

The calculation output of the network is realized in the third layer. When calculating the output, the output of the antecedent network is used as the weighting coefficient, and the output value is the weighted sum. At this point, the MIMO system structure model is realized, namely:

$$y_i = \sum_{j=1}^{m} \overline{\alpha_j} y_{ij} \quad (i = 1,2\ldots,r) \quad (12)$$

(5) Build a T-S network model

Through the previous introduction to the development history of neural network, artificial neural network model and unit training, and in-depth analysis of the learning algorithm of fuzzy control theory. When the T-S fuzzy neural network is initialized, the coefficients and parameters of the membership function are determined according to the indoor environment data required for training, and then the MapMinMax function is used to normalize the training data, such as:

$$y = (y_{max} - y_{min}) * (x - x_{min})/(x_{max} - x_{min}) + y_{min} \quad (13)$$

In the Formula, y_{max} is generally 1, y_{min} is -1, and x_{max} and x_{min} are the maximum and minimum values of the input, respectively. Let the error cost function be $E=\frac{1}{2}\sum_{i=1}^{r}(t_i - y_i)^2$, t_i and y_i represent the expected output and the actual output, respectively. The following is the parameter p_{ij}^{l} learning algorithm:

$$\frac{\partial E}{\partial p_{ij}^{l}} = \frac{\partial E}{\partial y_1}\frac{\partial y_1}{\partial y_{lj}}\frac{\partial y_{lj}}{\partial p_{ij}^{l}} = -(t_1 - y_1)\overline{\alpha_i}x_i \quad (14)$$

$$p_{ij}^{l}(k+1) = p_{ij}^{l}(k) - \beta\frac{\partial E}{\partial p_{ij}^{l}} = p_{ij}^{l}(k) + \beta(t_1 - y_1)\overline{\alpha_i}x_i \quad (15)$$

At this point, the parameter p_{ij}^{l} can fix the T-S fuzzy neural network structure, as shown in Figure 3:

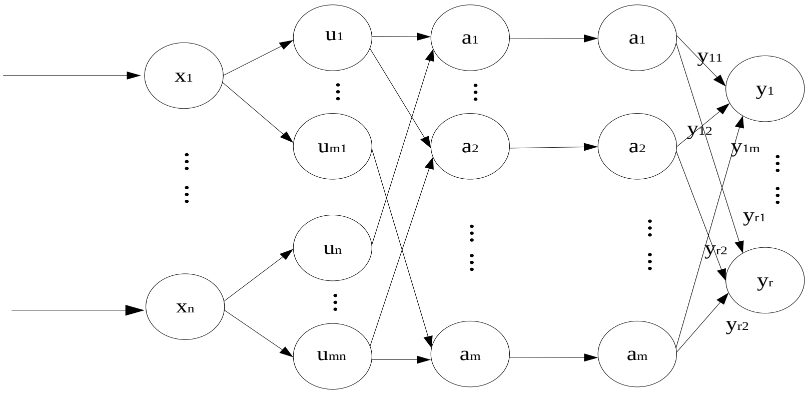


Figure 3 Simplified diagram of T-S network

For the learning problems of c_{ij} and σ_{ij}, the simplified structure is similar to the Mamdani type neural network, that is, if y_{ij} $=w_{ij}$, it can fully rely on the results obtained earlier, namely:

$$\sigma_i^{(5)} = t_i - y_i \quad (i=1,2,\ldots,n) \quad (16)$$

$$\sigma_i^{(4)} = \sum_{i=1}^{r}\sigma_i^{(5)}y_{ij} \quad (j=1,2,\ldots,m) \quad (17)$$

$$\sigma_i^{(3)} = \sigma_i^{(4)}\sum_{\substack{i=1\\ i\neq j}}^{m}\alpha_i/(\sum_{i=1}^{m}\alpha_i)^2 \quad (j=1,2,\ldots,m) \quad (18)$$

$$\sigma_{ij}^{(2)} = \sum_{k=1}^{m}\sigma_i^{(3)}s_{ij}e^{-\frac{(x_i-c_{ij})^2}{\sigma_{ij}^2}} \quad (i=1,2,\ldots,n;\ j=1,2,\ldots,m) \quad (19)$$

Finally got:

$$\frac{\partial E}{\partial c_{ij}} = -\sigma_{ij}^{(2)}\frac{2(x_i-c_{ij})}{\sigma_{ij}};\frac{\partial E}{\partial \sigma_{ij}} = -\sigma_{ij}^{(2)}\frac{2(x_i-c_{ij})^2}{\sigma_{ij}^{(3)}}$$

$$c_{ij}(k+1) = c_{ij}(k) - \beta\frac{\partial E}{\partial \sigma_{ij}};\ \sigma_{ij}(k+1) = \sigma_{ij}(k) - \beta\frac{\partial E}{\partial \sigma_{ij}} \quad (20)$$

In the Formula, β>0 is the learning rate, i=1,2,...,n; j=1,2,...,m.

4. Spatial Atmosphere Digital Teaching and Training Module Scheme

4.1. Teaching Purpose and Expected Results

The digital teaching and training module of space atmosphere takes a functional system as an example, and presents it in the form of a digital interactive teaching program. It conducts participatory interactive learning and experience of design elements in a three-dimensional virtual scene. Taking the living space system as an example, the interactive teaching program is to establish a living space system in a three-dimensional space model. It uses an automatic roaming path to simulate the connection between functional moving lines and spaces, and can manually operate the moving line paths in the form of games and interactive participation. It switches the roaming mode by clicking the corresponding button. In the 3D scene, different styles such as "classical" and "modern" can be presented as a whole, and local design styles can be switched and compared for a certain room by clicking the corresponding button. It can also have a more in-depth experience of design elements such as color and material, and perform material replacement and color adjustment for a certain space interface or furniture. It enables students to understand the influence of different materials and colors on the shaping of space atmosphere through interaction.

4.2. Teaching Content

After digital thinking training and multi-angle and multi-level creative practice experience, students will complete a profound understanding of spatial form, spatial sense, spatial form attributes and spatial emotional expression. And students have mastered the logic of creative design, and have the ability and means of creative thinking. On this basis, the abstract concept of space atmosphere has the basis of visualization and visualization. In the three-dimensional virtual living scene, the spatial atmosphere teaching simulates the living environment system in a way of visual comprehensive presentation. It reproduces different style trends and spatial atmospheres with different spatial forms, colors, materials, and light environments. Students can participate in the shaping of the space atmosphere in an interactive way. By experimenting with changing colors and materials, experiencing style is not a concept. Style is a consistent and distinctive creative logic and modeling method. It is a comprehensive environmental system composed of design elements such as form, color, material, and light environment under the same attributes. Changing the properties of design elements would break the logic of this design.

5. Digital Application Practice of Interior Design Teaching

5.1. Quantification of the Results of Digital Thinking Training

Interior design is a process of thinking activities, thinking training is a very important link in interior design teaching. These contents are not only completely abstract, but also need to be experienced in person before they can be understood and perceived. Digital technology provides a broad platform for different stages of thinking training, as well as digital training methods with new concepts. The digital training method is also the digital design method for students to enter the design creation in the future. Entering this platform, a strong visual experience can arouse students' curiosity, and the process of self-exploration and discovery can arouse students' thirst for knowledge, which is the best state of learning. Thinking training relies on the quantification of visual digital results, as shown in Figure 4.

Figure 4. Thinking training

Visualization is one of the most impactful sensory experiences that digital technology brings to us. Multisensory stimulation also brings about changes in perception and aesthetics. A large number of abstract forms that cannot exist, cannot be seen, or cannot be established in the real world are created by computers, forming new combination relationships, and obtaining experiences and gains beyond experience through virtual means. The abstract performance of computer design software in the virtual environment is infinitely rich. These abstract forms exist beyond the experience and concepts of the real world, but they stimulate a certain emotional experience of people with real and rich textures. The experience of emotions is similar between people and can resonate, so understanding arises.

5.2. Recording of Design Paths

In the early stage of visual thinking training, a large number of visual elements can be constructed with the help of digital design methods, and inspiration comes from the continuous discovery and exploration of the combination relationship between space and elements. The moment of inspiration is very short, and the interference of other information will make it disappear quickly. When traditional means such as writing and sketching have not had time to record, it has disappeared or been replaced by new inspiration. However, thinking training is based on a digital platform. Digital technology can completely record the design path, and the thinking process is completely preserved. It can not only backtrack but also perform point-to-point comparisons.

The sparks generated in each stage of thinking training are very important, and the excitement points represent the epiphany or turning point when the thinking process has obtained a certain enlightenment at a certain stage. With the deepening of thinking, this series of logical excitement constitutes the prototype of design logic. With the help of the digital platform, according to certain training themes, students can explore, try and discover themselves in the visual perceptual experience, so as to personally experience and recognize the development process of very abstract design thinking and the process of design logic in theoretical descriptions. This is exactly what we set up different stages of digital thinking training in teaching practice.

5.3. Visualization of Design Logic

Digital technology has disrupted the conventional human perspective, and we have seen what the naked eye world cannot. Perspectives on the world are completely different, people's concepts have also undergone tremendous changes, and aesthetic consciousness and aesthetic categories have been greatly expanded. The beauty of the abstract world that we have never seen, can only be seen through the virtual. With the help of digital technology, it is possible to walk into it, into a world that can only be understood and unspeakable in the past, which has become a scientific world today. Virtual technology realizes the visualization of abstract concepts, and the digital platform can reveal the laws and logic of design. People can intuitively approach theories, ideas, concepts, and even touch. It can thus also be quickly recognized and easily understood.

5.4. Digital Design Expression

Digital technology has made a great change in the creative method of interior design, which is reflected in the powerful means of digital design expression. In the era of hand-painting, it is "intention to write first", think first and then write. What comes to mind is usually what has been seen, a representation of experience. The huge advantages of digital technology in design expression provide a new digital design method with technology and software platforms in different stages and aspects. It can make design thinking and logic manifest in the most intuitive and real way in a visual way. The digital design expression is shown in Figure 5.

Figure 5. Digital design expression

As can be seen from Figure 5, the accuracy, applicability and aesthetics of the perspective effect require the accumulation of experience in the systematic learning of detailed perspective relationships and a large number of rulers and gauges "finding the vanishing point" drawing training in the previous teaching. It cost countless rework and repaints. Because it is often only when the drawing is completed that it can see where the error is or whether the angle is appropriate. And the accuracy of writing is the accumulation of experience that requires repeated labor in years.

5.5. Evaluation of Interior Design Environmental Data

(1) T-S network preprocessing

When initializing the T-S fuzzy neural network, first clear the environment variables. The coefficients and parameters of the membership function are determined according to the indoor environment data required for training, that is, the coefficients and parameters are initialized. It is established that I=4. (the number of four input nodes), M=12 (the number of twelve implicit nodes), 0=1 (the number of one output node), and the number of cyclic learning training is 500. The training data is then normalized with the MapMinMax dependent variable.

(2) T-S network sample training

The indoor environment is greatly affected by geographical location and climatic conditions. The high temperature difference between the north and the south in summer is not very obvious, mainly because the temperature difference is large. The temperature difference between the seaside and the south is small, while the temperature difference between the north and the inland is large. The humidity varies from place to place, and the comfort level for the human body is roughly in the range of 40 to 60 percent. Indoor CO2 concentration ≤0.10% is normal, 0.10%-1.0% concentration range is harmful to human body, 4%-5% can cause asthma and dizziness, and 210% concentration can cause people to suffocate and die. The illuminance varies with different rooms in the room. The human eye needs 2001ux for reading a book during the day, while most of the illuminance at night requires 250-5001ux. The standard illuminance of the living room and living room is 150-3001ux. The indoor environment information can be trained and tested by using the T-S network model. The indoor design environment data T-S network test is shown in Figure 6.

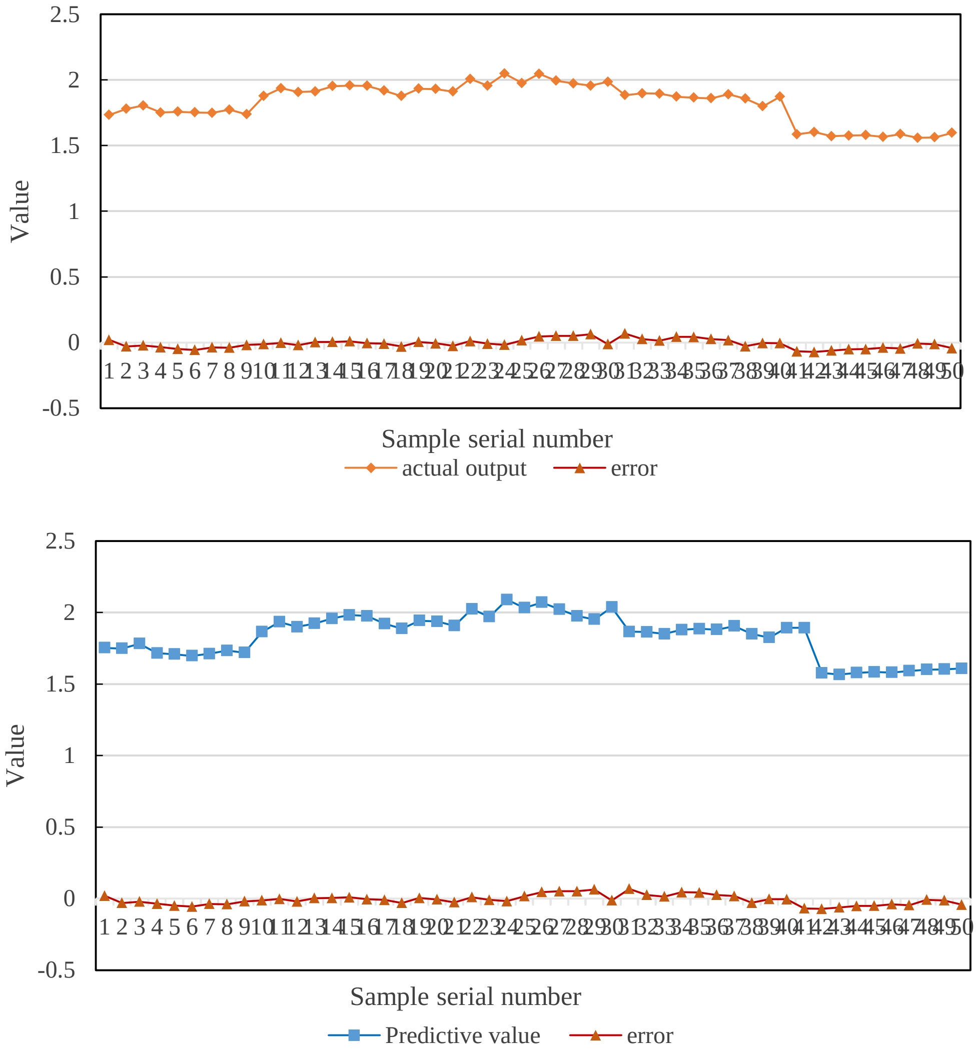


Figure 6. T-S network test of indoor design environment data

It can be seen from Figure 6 that during the data test, the difference between the two outputs results in the error of the data test, and the result shows that the error meets the test accuracy requirements. The indoor environment data T-S network training is shown in Figure 7.

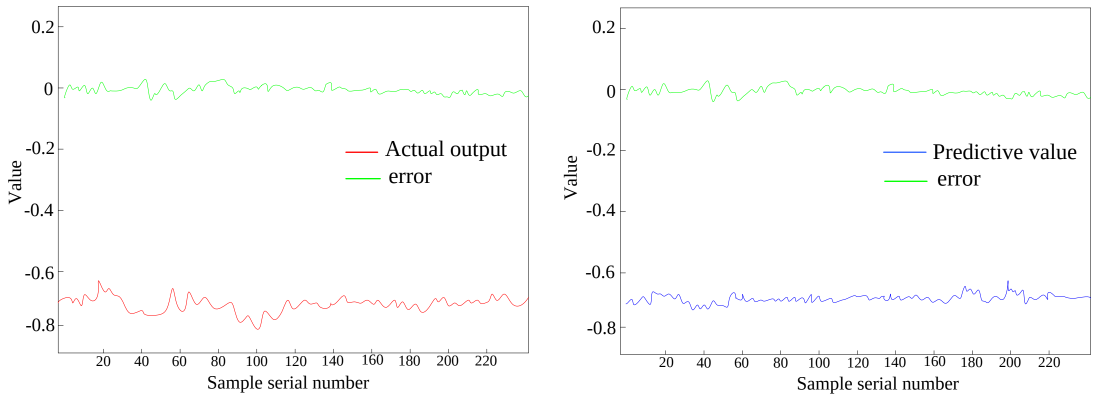


Figure 7. Indoor environment data T-S network training

As shown in Figure 7, the input and output structures obtained after learning and training normalization include the maximum value, the minimum value and the mean value, which are used for normalization and denormalization of test data.

In order to verify the effectiveness of the data first-level fusion algorithm, the humidity values collected by 6 nodes at the same time are used as the experimental data, and the measured value of the hygrometer is used as the estimated value of the real value at the time of data collection. The estimated value of the true value at the current time point is 24. It can be calculated that the fusion value is 23.9, and the error with the estimated value is |23.9-24|/24=0.0041. The result obtained by the arithmetic mean fusion is 23.6, and the error with the estimated value is |23.6-24|/24=0.0167. The comparison shows that the first-level data fusion algorithm in this paper is more accurate than the arithmetic average method, and the fusion result is closer to the real value, which can achieve the purpose of improving the data accuracy. Table 1 shows the distribution of the weights of each sensor after the fusion of the first-level data fusion algorithm.

Table 1. Sensor weight assignment

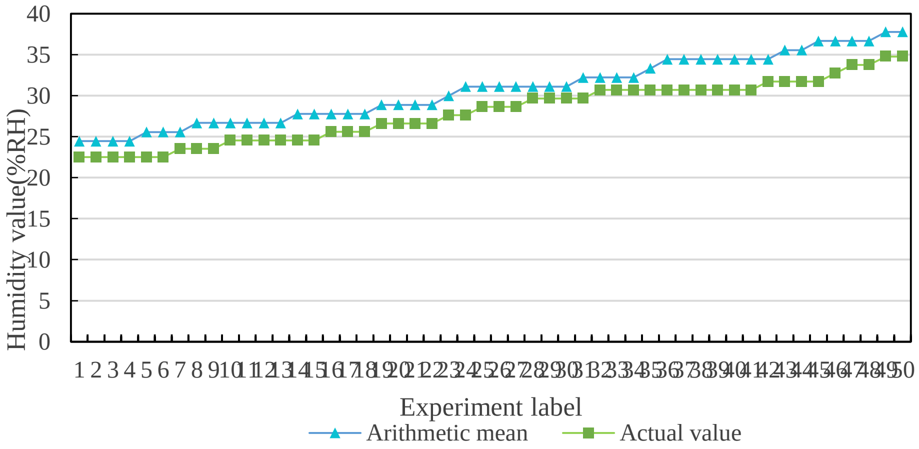
Sensor serial number	Measured value at a point in time	Trusted ratio	Fuzzy closeness	Sensor weight
1	25.4	6/6	0.0034	0.0026
2	22.4	6/6	0.1094	0.0841
3	25.0	6/6	0.0421	0.0324
4	22.4	6/6	0.1094	0.0841
5	24.3	6/6	0.9830	0.7558
6	22.3	6/6	0.0533	0.0410

It can be seen from Table 1 that the sensors with lower fuzzy proximity are given smaller weights, and conversely, the sensors with higher fuzzy proximity are given larger weights. In order to further verify the algorithm's ability to suppress outliers, the No. 3 sensor is interfered to generate outliers. Table 2 shows the distribution of weights when there are outliers.

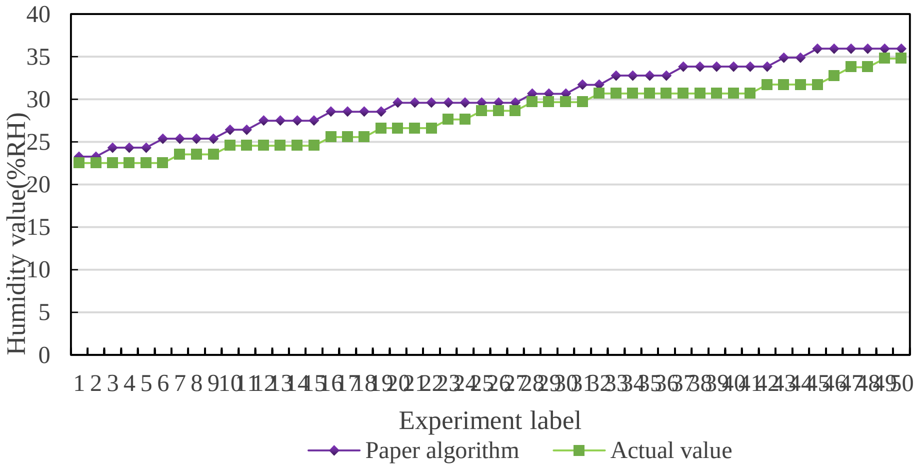
It can be seen from Table 2 that the measured value of No. 3 sensor has a large deviation compared with other sensors. According to the first-level fusion algorithm of data in this paper, the fuzzy closeness is very small, and the assigned weights are also not small. The calculated fusion value is 22.9, and the error with the estimated value is |22.9-24|/24=0.0458. The result obtained by the arithmetic mean fusion is 28.7, and the error with the estimated value is |28.7-24|/24=0.1958. The comparison shows that the fusion results calculated by the data first-level fusion algorithm in this paper are less affected by outliers, and the fusion results are closer to the real values. In order to better verify the effectiveness of the data first-level fusion algorithm, this paper selects 50 groups of humidity data collected at different time points, and the fusion results are shown in Figure 8.

Table 2. Outlier suppression ability

Sensor serial number	Measured value at a point in time	Trusted ratio	Fuzzy closeness	Sensor weight
1	25.4	5/6	0.0008	0.0004
2	25.4	5/6	0.6007	0.2717
3	25.4	1/6	0.0000	0.0000
4	25.4	5/6	0.6007	0.2717
5	25.3	5/6	0.6499	0.2940
6	25.3	5/6	0.3583	0.1621



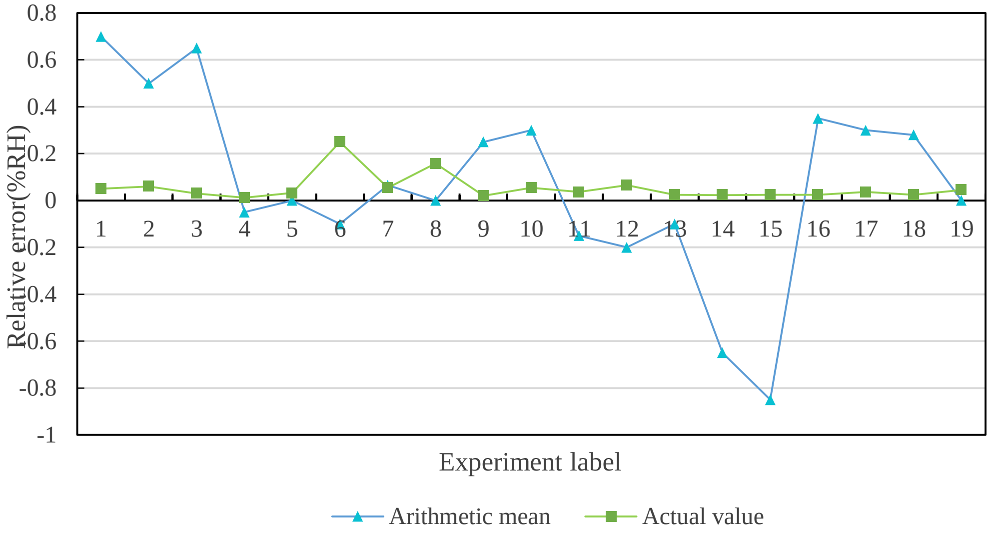
A. Comparison of arithmetic mean and true value



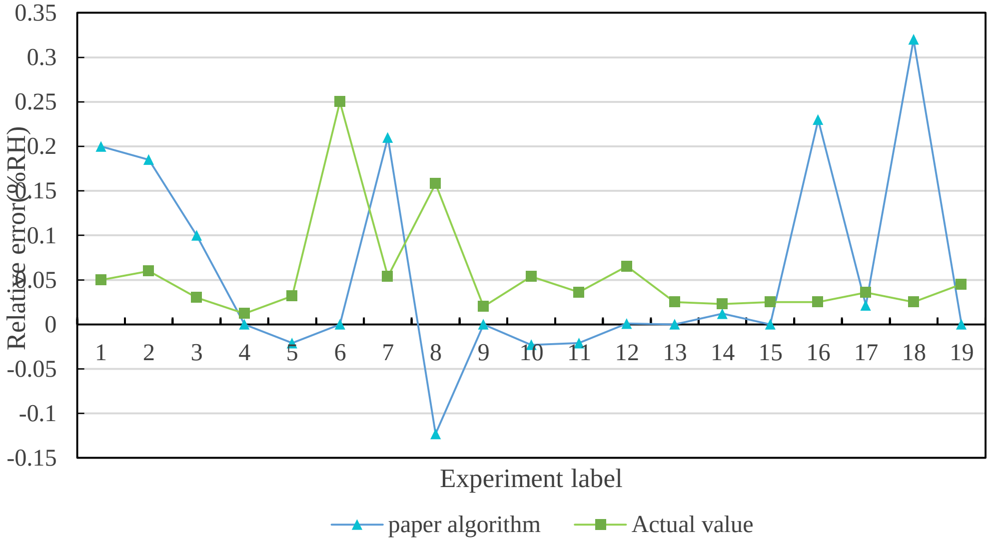
B. Comparison between the algorithm in this paper and the real value

Figure 8. Fusion result graph

It can be seen from Figure 8 that the fusion algorithm designed in this paper is closer to the true value than the arithmetic mean method. The comparison of the relative deviation between the fusion results of different algorithms and the real value is shown in Figure 9.



A. The arithmetic mean method and the relative deviation of the true value



B. The relative deviation of the algorithm in this paper and the real value

Figure 9. Relative deviation comparison

As can be seen from Figure 9, the relative deviation between the algorithm in this paper and the real value is generally lower than the algorithm average method. The first-level data fusion algorithm designed in this paper can improve the accuracy of the data, and has a good suppression effect on outliers. It can achieve the purpose of data fusion and has practical application value. The error comparison of fusion results of different algorithms is shown in Figure 10.

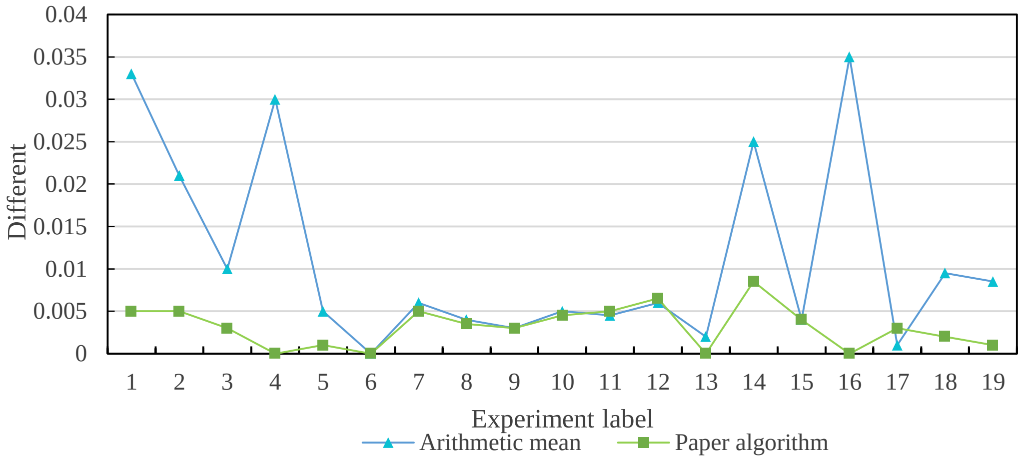


Figure 10. Error comparison

As can be seen from Figure 10, in order to compare the relative deviation more conveniently, the true value is normalized to 0. The error is also generally lower than the algorithmic averaging method. In order to verify the effectiveness of the data two-level fusion algorithm, this paper takes the data obtained under different environmental comfort levels as the input value, and uses the data two-level fusion algorithm to evaluate and calculate. Table 3 shows the data obtained when the comfort is optimal and the evaluation calculation results.

Table 3. Evaluation results of comfort

Environmental parameters	Numerical value	Membership		In conclusion
		Good	Difference	
Temperature	22.3	0.0681	0.0299	Excellent
Relative humidity	58.9	0.1687	0.0532	Excellent
Light intensity	395	0.0617	0.0276	Excellent
Formaldehyde	0.03	0.3077	0.0755	Excellent
--carbon oxide	1.5	0.1649	0.0525	Excellent
Fusion algorithm evaluation results		0.1147	0.0373	Excellent

It can be seen from Table 3 that the two-level fusion algorithm based on the fuzzy comprehensive evaluation method designed in this paper can synthesize various environmental factors and make a comprehensive evaluation of the comfort level.

6. Conclusion

Using the Internet of Things technology, the design process is visually decomposed in stages in the digital teaching, and each knowledge point is connected in series by means of thinking training.

It completes the self-construction of design logic in the creative experience, guided by digital design creation methods, and follows a certain theme direction. In the virtual space, by constructing design elements, combining design elements, and spirally observing the relationship between space and design elements. It enables students to observe, discover, break up, and reorganize the records of inspiration paths through digital technology in a visual perceptual experience. It enables students to experience and recognize the practical significance of abstract theory, as well as the development process of design thinking and the process of design logic in creation. And it promotes the accumulation of design experience and the qualitative change of design ability through the quantitative change of visual element processing.

Funding

This article is not supported by any foundation.

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

References

[1] Tynynyka A S. Influence of human emotions on the perception of residential interior ecodesign. Problems of Interaction between Arts Pedagogy and the Theory and Practice of Education. (2019) 53(53): 214-229. https://doi.org/10.34064/khnum1-53.13

[2] Rajebhosale S, Sonawane M A, Pawar M S, et al. IOT based Home Automation and Security System. IJARCCE, (2017) 6(3): 821-824. https://doi.org/10.17148/IJARCCE.2017.63193

[3] Sequeiros H, Oliveira T, Thomas M A. The Impact of IoT Smart Home Services on Psychological Well-Being. Information Systems Frontiers. (2021) 3: 1-18. https://doi.org/10.1007/s10796-021-10118-8

[4] Zhang H, Zheng H. Research on interior design based on virtual reality technology. Boletin Tecnico/Technical Bulletin. (2017) 55(6): 380-385.

[5] Koger M. Updated Interior Design Services Contract Documents Coming Soon. Engineering news-record. (2019) 282(9): 50-50.

[6] Fang L, Wang J, Lu G. Color Transfer Algorithm for Interior Design through Region Matching Based on Topological Information. Jisuanji Fuzhu Sheji Yu Tuxingxue Xuebao/Journal of Computer-Aided Design and Computer Graphics. (2017) 29(6): 1044-1051.

[7] Noweir H, Adly A, Rahman D A. The Impact of Interior Design on Autistic Behavior (Childhood Stage from 3 to 12 Years Old) "From the Perspective of Environmental Psychology". Journal of Design Sciences and Applied Arts. (2021) 2(2): 186-203. https://doi.org/10.21608/jdsaa.2021.29840.1031

[8] Baniyamin N, Din S. Rethinking Bamboo: An Asian Eco-Interior Design Language with Ecological Branding in East Asia. Cultural Syndrome. (2020) 1(2): 79-95. https://doi.org/10.30998/cs.v1i2.229

[9] Aldabbagh G, Alzafarani R, Ahmad G. Energy Efficient IoT Home Monitoring and Automation System (EE-HMA). International Journal of Recent Technology and Engineering. (2020) 8(5): 3176-3185. https://doi.org/10.35940/ijrte.D8803.018520

[10] Chung M. Influencing Factors, Resources and Implementation Status of Do-it-yourself Interior Design in Young (20s and 30s) Single-Households in Metropolitan Seoul. Korean Institute of Interior Design Journal. (2020) 29(3): 132-142. https://doi.org/10.14774/JKIID.2020.29.3.132

[11] Kim L W, Choi S S. Theoretical Myongri Study on the Perspective Drawing Ability of University Students in Interior Design Major Departments. Korean Institute of Interior Design Journal. (2020) 29(3): 143-155. https://doi.org/10.14774/JKIID.2020.29.3.143

[12] Kim J, Kim S, Jang S G. A Study on the Phases of the times and the Characteristics of Da-bang Interior Design in Korean Films in 1960s. Korean Institute of Interior Design Journal. (2020) 29(3): 112-120. https://doi.org/10.14774/JKIID.2020.29.3.112

[13] Baniyamin N, Din S. Rethinking Bamboo: An Asian Eco-Interior Design Language with Ecological Branding in East Asia. Cultural Syndrome. (2020) 1(2): 79-95. https://doi.org/10.30998/cs.v1i2.229

[14] Farooq S, Zubair F, Kamal M A, et al. Analysis of Interior Design of Restaurants with Reference to Ambience and Customer Gratification. Civil Engineering and Architecture. (2020) 8(5): 1019-1027. https://doi.org/10.13189/cea.2020.080528

[15] Sokienah Y. The Architectural and Interior Design Identity Crisis: The Case of Girne in North Cyprus. Civil Engineering and Architecture. (2021) 9(1): 124-129. https://doi.org/10.13189/cea.2021.090110

[16] Shamy N E. The impact of architectural psychology on the interior design of psychiatric hospitals. Journal of Design Sciences and Applied Arts. (2021) 2(1): 30-49. https://doi.org/10.21608/jdsaa.2021.29937.1043

[17] Kareem A T, Hameed S H. The Intellectual Luxury in the Interior Design. Review of International Geographical Education Online. (2021) 11(2): 92-104.

[18] Asojo A O, Vo H. Pedagogy + Reflection: A Problem-Based Learning Case in Interior Design. International Journal of Designs for Learning. (2021) 12(2): 1-14. https://doi.org/10.14434/ijdl.v12i2.25372

[19] Yang J. Teaching Optimization of Interior Design Based on Three-dimensional Computer-aided Simulation. Computer-Aided Design and Applications. (2021) 18(S4): 72-83. https://doi.org/10.14733/cadaps.2021.S4.72-83