Digital Intelligent Design of Interior Solutions: Exploring Embedded Systems for SketchUp Modeling

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Abstract. From the perspective of urban memory, the design is based on the old Chinese brand "Shenlin" rice wine experience hall in Xiaogan, Hubei Province, with SketchUp 3D design media software as the main modeling tool and AutoCAD/CorelDRAW and other computer-aided software to achieve the overall digital intelligence of the program. This paper studies the implementation process of building and interior 3D model building by importing the determined architectural AutoCAD plan DWG files into SketchUp software, and then the rendered effect, analysis, and structure drawings are arranged in full plan layout by CorelDRAW/Photoshop, which process can enhance the logical, holistic, artistic, and digital intelligence performance of the design plan. We analyzed the trend of the graduation design modeling software of 172 environmental design students in the last 6 classes; evaluated the effect of SketchUp modeling through multi-dimensional design feedback; and discussed the problems and shortcomings in the process of SketchUp used for modeling architectural and interior design solutions.

Keywords: SketchUp 3D modeling; digital intelligence; "Shen Lin" rice wine; experience hall design; design logic expression; Exploring Embedded Systems
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1   INTRODUCTION

In the context of the epidemic, higher education has developed course design with online, offline and hybrid teaching methods, fully mobilizing the flexibility of environmental design in terms of programmatic expression [3]. The current teaching and learning environment also provide patients

opportunities for the digital intelligence of the environmental design profession. Environmental design in virtual space and physical space "real and virtual" [4]. Students design solutions from the traditional paper drawing as the medium of expression, to the use of AutoCAD/SketchUpCorelDRAW/Photoshop/ and other computer-aided design software, the visualization of design solutions for collaborative innovation.

From the advent of the first computer in 1946 to today's program design with the help of computer software such as Ecotect/COMSOL/Phoenics for data analysis of the physical building environment to obtain data on energy efficiency and environmental protection for green buildings, to the use of BIM [16][6][4][7] (Building information Modeling) technology for building design management The focus is on the use of digital media to provide data information that can be used in real projects for architectural design solutions through virtual building 3D models, which enhance the efficiency of design performance and provide more possibilities for design solutions [17],[11],[15],[12],[19].

This paper selects the "Shen Lin" rice wine culture experience hall as a design case, from the perspective of urban memory, guided by market demand, with SketchUp as the main computer 3D modeling tool, to achieve the overall digital intelligence performance of the architectural and interior design program, by organizing the design logic of the entire program, while completing the interface with AutoCAD, CorelDRAW and other software collaborative design, to complete the entire design process to summarize the problems that arise, in the hope of providing reference for the digital intelligence performance of the architectural and design program.

2   SKETCHUP SOFTWARE INTRODUCTION

SketchUp is a computer modeling software that can embed 3D design solutions into the Google Earth environment and present the design solutions by matching with satellite maps to accurately present the real environment of that geographical location [8]. SketchUp, also known as Sketch Master, is fast to model and easy to learn to master in a short time.

2.1   Sketchup Graphics Drawing

In SketchUp faces are the basis for drawing graphics, and are automatically generated for each closed line, and are modeled through a sequence of performance from line to face to 3D body block. Figure 1 shows the initial design screen after the registration is completed. At the top and right side of the interface, there are toolbars for modeling commands. The basic drawing tools are selection, erase, line, arc, shape (rectangle, rotated rectangle, circle, polygon), push and pull, offset, move, rotate, scale, measure, text, material, wrap-around view, pan, etc. in that order. In 3D Warehouse there are model materials for downloading, which can be used in the overall solution by downloading directly or editing again. Through the window option in the toolbar, you can show and hide the default panel in the display window; meanwhile, you can freely combine the options in the dialog box (source information, material, component, style, marker, scene, shadow, fog, photo match, soften border, tool wizard, etc.) through the management panel.

The 3D presentation in SketchUp is achieved through three axes: red, green, and blue, and the corresponding axes can be found for lines, surfaces, and body blocks in the modeling process. Software through the imported AutoCAD drawing of graphic design dwg file, will be directly in the red axis and green axis formed by the horizontal plane display, dwg file formed in the closed line, in the import SketchUp software directly in the form of surface display (Figure 2) [21].
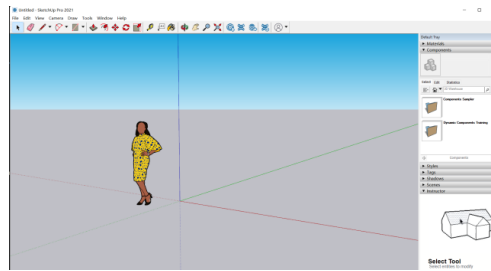
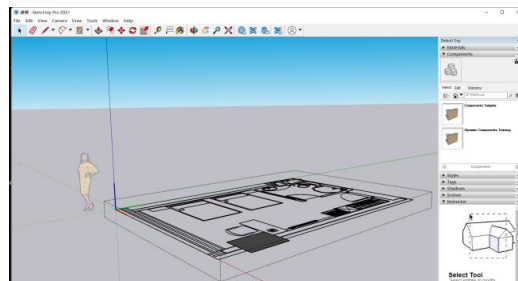**Figure 1:** The Initial Design Screen After Registration is Completed.

Figure 2: The Display Screen After Importing Dwg Files.

2.2   3d Model Generation

The push and pull tool in SketchUp (Figure 3) enable the creation of a 3D model in terms of faces, and allows the input of specific dimensions to achieve standard digital model generation according to the actual needs of the design. In a further step, the details can be modeled on the completed 3D block with the faces in the block. The system design in the window allows you to set shortcut keys. The use of shortcut keys in three views (top view, side view and front view) will greatly improve the speed of modeling.
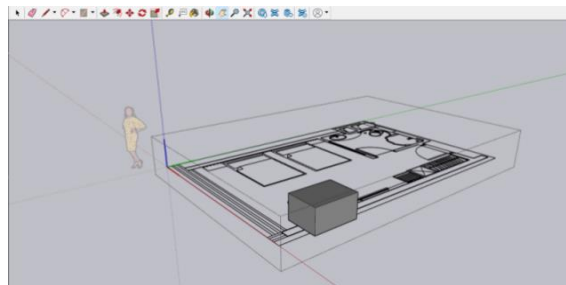

Figure 3: Generation from Faces to 3D Blocks.

3   IMPLEMENTATION OF THE PROGRAM

We selected the design of Shen Lin Rice Wine Culture Experience Hall as a case study, based on the concept of urban memory and sharing of the times. The design goal is to realize the 3D modeling of the program with the help of SketchUp, and the program will be displayed in a more direct and

realistic visual image of the experience space [23][18]. The design solution is based on the process of summarizing the problems of the existing rice taverns and then solving them [13]. The realization of the program includes pre-study, data integration, floor plan drawing, colorful floor plan functional layout drawing, 3D modeling, effect rendering, program integration, layout design, etc. (Figure 4).
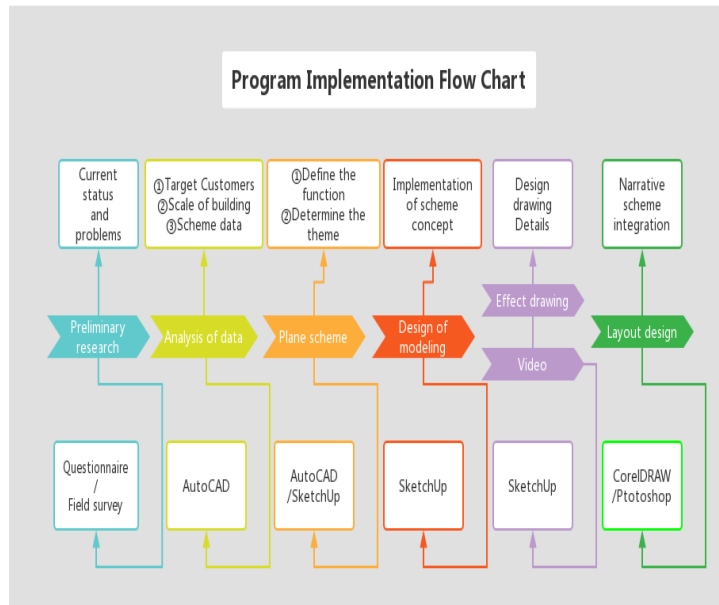

Figure 4: Flow Chart of Program Implementation.

In the context of telling the Chinese story, "Chinese old brands" have brought overall positive effects to the city because of their rich cultural connotation and become a kind of tourism and cultural resources with unique charm. Inherited in innovation, the new way of playing "old brands" will show colorful vitality. People need memory, and cities need memory. Barriers and countermeasures for the development of old enterprises (Table 1)

Serial number	Obstacles	Coping strategies	Concept Solution
1	Outdated brand environment	Innovation according to market consumption patterns	Program incorporates live, experiential marketing space
	Lack of innovation of the times	Realize the combination of shopping and experience	
2	Business model solidification	Break the deadlock by learning from the experience of successful companies	Design to include shared spaces

	Slow to respond to market changes	*Improve market feedback acumen*	
3	*Human resources dilemma*	*Grasp the era of traffic opportunities*	*Space to add multifunctional elements*
	No successful use of Internet resources	*Combining traditional business with the Internet model*	
4	*Confusion in product development*	*Strict quality control of products*	*The program provides space for comprehensive display (product materials, production processing, finished products)*
		Extensive user input	
5	*Unsystematic mining of corporate culture*	*a Systematic combing of brand IP*	*Space gives venue for corporate culture*
		b Focus on the construction of enterprise hardware environment	
	Insufficient publicity	*c Winning brand social trust*	

Table 1: Obstacles and countermeasures to the development of long-established enterprises.

The study of the "Shen Lin" rice wine cultural exhibition space was chosen to explore the application of innovation in the local "old Chinese brand" product culture and promotion space. Rice wine is a prominent local food in Xiaogan, and after a thousand years of development and inheritance, it has its own rice wine culture. Through the experience space design, we spread and show the rice wine culture, so that people can understand its production process and cultural heritage.

The spatial design of environmental design is essentially the design of human behavior in space. The integration of interior design and spiritual reconstruction is the future direction of interior design [1]. The project "Shenlin" Rice Wine Culture Experience Hall is a thematic and functional experience space with rice wine display and exchange space and rice wine culture as the background. By increasing the storytelling of the space to enhance visitors' understanding and observation of the space, while extracting rice wine elements throughout the overall space and forming a story theme through the scenes to enhance the experience of the space, integrating the storyline and the space to bring its fresh sense of experience and cultural awareness to the consumer groups [9]. The solution is modeled with the help of computer software to realize the conceptual design representation.

3.1 Solution Data Integration

3.1.1. Research findings on the local rice wine market and product marketing space

1) The existing rice wine culture museum is not open to the public, and there is no rice wine exhibition hall or experience space at the social level.

2) Xiaogan "Shen Lin" rice wine brand IP has matured and ranks third in the country among hundreds of rice wine products nationwide.

3) Most of Xiaogan's local rice wine restaurants exist as breakfast stores, with vacancies in the construction of comprehensive spaces for making, selling, exhibiting, and experiencing. We are looking for innovative workshop design for a cultural experience space for rice wine in Xiaogan.

4) Through questionnaires and field research, we divided the target groups of the design program into local clientele and tourists, with the local clientele dominated by nearby residents with daily grinding time and office workers with fast food consumption, and the student group with purchase and product study. The design space is centered on the stage of the local cultural Chu opera, while providing a space for innovative workshops for enterprises and university student groups, and taking into account the need to standardize the production and storage of rice wine; The visitor group accounts for 10% of the overall proportion, with the main demands being purchase, visit and experience of production. The program fully considers the spatial demands of experience shaping, corporate culture display, consumer purchase, and traditional craft inheritance (Table 2).

Serial number	Crowd	Overall consumption share	Space Appeal
1	Local clientele	(90%)	Purchase / daily food / visit / punch card / study / making storage / experience making / parent-child communication
2	Students	5%	√ Purchase √ Visit √ Study √ Experience making
3	Residents	45%	√ Purchase √ Daily food √ Production and storage √ Cultural polishing
4	Commuters	40%	√ Purchase √ Daily diet √ Production and storage √ Parent-child communication
5	Visitors	10%	√ Purchase √ Visit √ Punch card √ Experience making

Table 2: Design Target Group Analysis and Corresponding Space Requirements.

3.1.2. Software performance-based design tasks

Students can find real local projects through school-enterprise cooperation, and have the advantage of conducting field research when they start their program design. This project takes the graduation design topic of the fourth-year university students as an opportunity to focus on the students' use of SketchUp and other software in the design process. We hope to summarize the strengths and weaknesses of students' scientific and logical expression of design thinking by studying the process of computer software-based representation of design solutions, which will be used to adjust the course project design, software coordination, and improvement of logical expression of solutions.

- Task 1: Integrate the current dilemma of the project through research, propose a reasonable floor plan design, use AutoCAD to draw dwg files, draw colorful floor plans in SketchUp

software, build 3D scheme models, make model axonometric drawings, exploded drawings, and multiple styles of effect drawings. Designing the layout of the scheme in CorelDRAW/Photoshop software by taking the completed scheme drawings in SU and the pre-analysis data;

- Task 2: To test the results of the designs by entering them into professional design competitions;

- Task 3: Teacher-led, student-centered review of the program to summarize the experience, including satisfaction with the use of the software, tasks not achieved in the program, etc.

- Task 4: The design work is evaluated by "five dimensions" (student self-evaluation, professional teacher evaluation, design competition evaluation, enterprise representative evaluation, community user evaluation).

3.2 Spatial Three-Dimensional Scene Construction

3.2.1. Site Selection

Figure 5: Programsite Map.

Through social research, we selected the Daitianqiao Rice Tavern in downtown Xiaogan City as the project base site (Figure 5) and made specific data analysis of its surrounding food, coffee, scenic spots, entertainment, handicraft workshops and grocery stores with the help of computer software (Table 3).

Serial number	Crowd	Overall consumption share
1	Gourmet	40%
2	Coffee	16%

3	Scenic spots	9%
4	Entertainment	15%
5	Handicraft Workshops	8%
6	Grocery Supermarket	12%

Table 3: Design Target Group Analysis and Corresponding Space Requirements.

3.2.2. Modeling

A model is an abstract representation of a solid object, and it is only by modeling a building in three dimensions that a realistic representation of it in three dimensions can be made, and thus it is possible to simulate, model and analyze the building in a computer" [22].

1)   After having clear data on the dimensions of the original site through field measurements, the obtained data were converted into dwg and dxf files by using AutoCAD, and the sketches of the concept plan (Figure 6) integrated through research were drawn in dwg and dxf formats, and then imported into SketchUp to model and design the walls, homes, barsand partitions by drawing closed lines. Transform the graphics of walls, homes, bars and partitions into surfaces by drawing closed lines, then assign different material maps to the surfaces representing different functional areas and distinguish them by color, and enter the numerical codes of the partitions by corresponding colors with the text tool to complete the colorful functional layout drawing (Figure 7a) [25]; The 3D modeling of each color block through the push-pull tool provides a visual representation of the dynamic partitioning of the scheme (Figure 7b); The previously completed 3D body block was implemented with the help of Photoshop tools to analyze the pedestrian flow of employees and customers, which allows the observer to have a more intuitive feeling (Figure 7c).
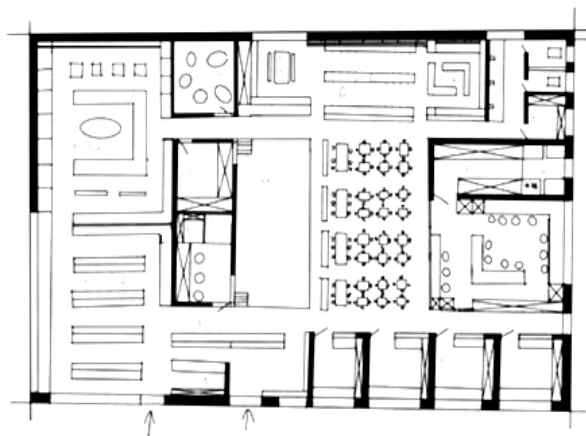

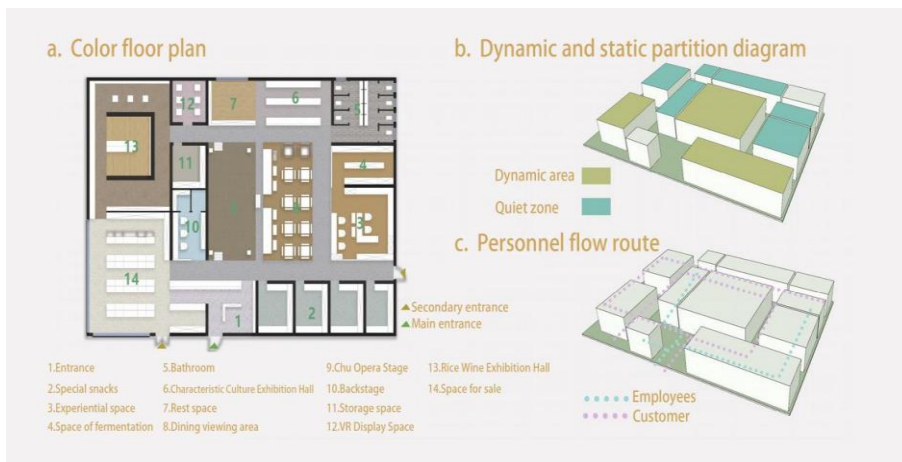**Figure 6:** Sketch of Conceptual Design Scheme.

Figure 7: (a) Color Floor Plan, (b) Dynamic and Static Analysis, (c) Pedestrian Flow Analysis.

2) Based on the surface of the plan, the detailed modeling of the plan can be carried out to enrich the specific details of size, material, decal, height, shape, color, finishing details, etc. The locations that need to be modeled in detail are such as building exterior wall, interior wall, entrance, bar, experience space, product making space, bathroom, cultural showroom, dining area, stage, storage space, vending space, ceiling, etc. After the modeling is completed, the 3D model of the solution can be presented as an axonometric drawing (Figure 8a). Exploded drawing is the process of disassembling the model in SketchUp, splitting the model into several layer and playing groups for each layer according to the design purpose, with building walls, home soft furnishings, and ceiling structure as independent model sections, presented in a top-down list according to the superimposed spatial structure (Figure 8b).
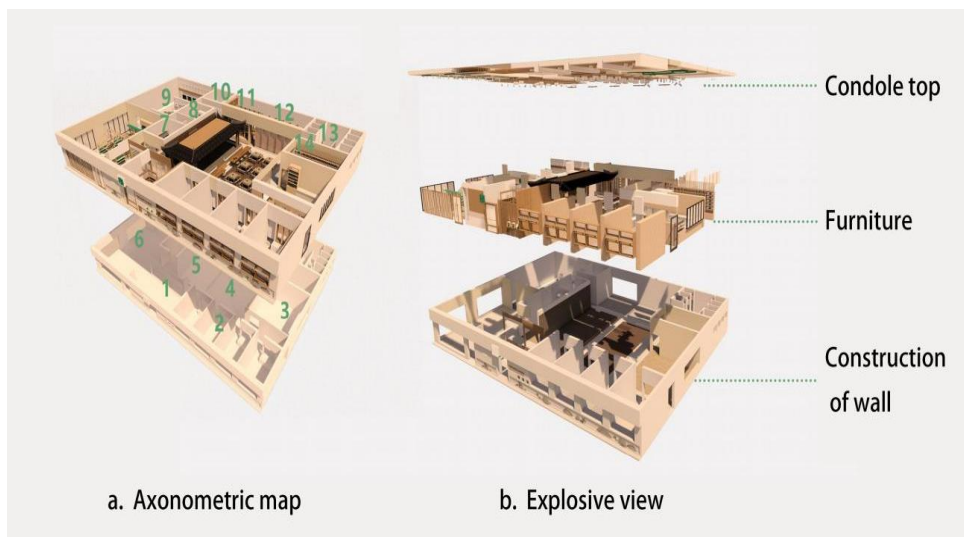

Figure 8: (a) Axonometric Drawing,(b) Exploded View.

3) The optimization design process of the model can change the details of the local modeling and mapping at any time, and the overall program focuses on the proportion, color, texture, style and other laws of formal beauty when choosing to download the model for the overall program, so that the form serves the function and makes the overall space image harmonious and consistent with the goal of the overall program. Directly downloaded models in most cases do not match the cultural and styling requirements of the program, and need to be disassembled structurally and then modeled twice to guide compliance with the overall requirements. For difficult modeling cases of design solutions in terms of cultural elements and patterns, we can assist with CorelDRAW/Photoshop in post-production. It is with the whole that the theme of the program is established.

4) After the completion of the SU 3D model, the program can be further enriched by material texture mapping, adding lighting links [20]. When adding the camera, you can make appropriate adjustments to the angle, composition, and display content of the screen. You can render and export the effect at any time, and choose the optimal visual angle to present the design plan by checking the effect, and at the same time, if you find a deficient position, you can enter the model again to make the adjustments to the plan. In the process of modeling large volumes, making local modifications can reduce software calculations and improve software operation speed by hiding all models other than the objects to be edited.

4   MODELING RESULTS DEMONSTRATION AND ANALYSIS

In SketchUp detailing modeling, the design image of each space from the program facade to the interior was completed, with enscape renderer for parameter setting, mapping, lighting, rendering and other links to obtain the effect of each scene (Table 4).

4.1   Effect Showing and Analysis

The rendering is the most direct response to the main body of the design scheme. The visual image, organization, spatial architecture, proportional relationship, color and light, design details, material style and other details of the scheme can be shown. The drawing of rendering is the most important part of the whole program, according to the design requirements, corresponding to provide space details to solve the spatial requirements of the solution. The rendering export can export line drawing, shadow drawing, solid color drawing, white mold drawing and other picture styles respectively according to the design performance requirements.

For the design of "Shenlin" rice wine culture experience hall, we determined the functions of the program from various aspects such as cultural display, traditional craft experience, visualmarketing and business development, and extracted the design theme, the detail and color of the program modeling from two levels of digging rice wine culture and regional culture, and drew out the program in three-dimensional form with the help of SketchUp.

The design of this scheme is remarkable by simulating real scenes. The design intention was expressed in terms of light and shadow, color, and structural details, which solved the problems in the preconceived scheme and fully demonstrated the advantages of SketchUp software in 3D modeling. However, because of the model material, lighting parameters design and other issues, some of the effects also have poor results, can be post-processed through Photoshop software for contrast, tone, curve, etc. on the effects.

Effect name	Renderings	Effect name	Renderings
01 Restaurant space		*02 Chu Opera Exhibition Stage*	
03 Cashier space		*04 Front lobby waiting space*	
05 Production experience space		*06 Sale experience space*	
07 Product fermentation display space		*08 Sitting space*	
09 Cultural Exhibition Hall		*10 Showroom aisle space*	
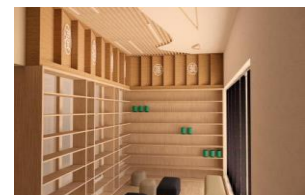
11 Main entrance elevation of the building		*12 street vending windows*	
13 Building facade			

Table 4: Results After Modeling and Rendering with SketchUp (Jian Zhong).

4.2 Video Rendering

The finished model created in SketchUp, using the enscape renderer. First, adjust the rendering preset parameters, set the lighting in the scene and adjust the light atmosphere to the right level; Then give each object the corresponding material, and adjust the material; next, select the most appropriate viewpoint, set the scene lens; Finally, each scene is rendered into a video segment by segment through enscape's video rendering. The video will be video post-processing through pr video editing software, a segment of the video into a video and add music, and then export the video to obtain the design of the complete video.

5 NARRATIVE LAYOUT DESIGN

Layout design is an important part of the scientific and logical display and modification of the program. The basic information, construction vision, conception, conceptual design, central idea, overall image and detailed content of the whole program can be displayed through the exhibition board design. The exhibition board usually starts from the title of the project, and the structure of the whole layout is reasonably laid out, dealing with the location analysis map, traffic analysis map, development status structure map, plan scheme map, space generation map, axonometric map, explosion map, effect map, elevation map, section map, etc.

Excellent layout design that will automatically lead the viewer to information in order [20][2][24]. With the help of Photoshop/CorelDRAW software, we design the layout of the program, arrange it in the same logical order of storytelling, echo the overall program in terms of headlines, fonts, color and other detail, highlight the focus of the layout, echo the first and last, and form a logical closed loop of the program. The program exhibition board (Figure 9).
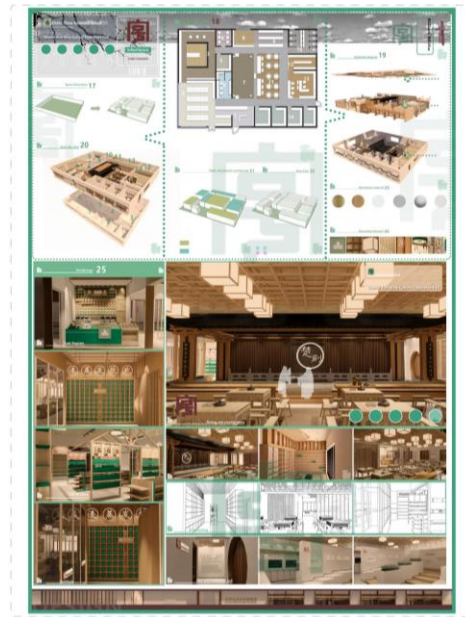
Figure 9: Program Exhibit.

6   DESIGN EVALUATION

We tried to evaluate the completed design solutions through five dimensions: students' self-evaluation, professional teachers' evaluation, design competition evaluation, enterprise representatives' evaluation, and community users' evaluation, Figure 10.
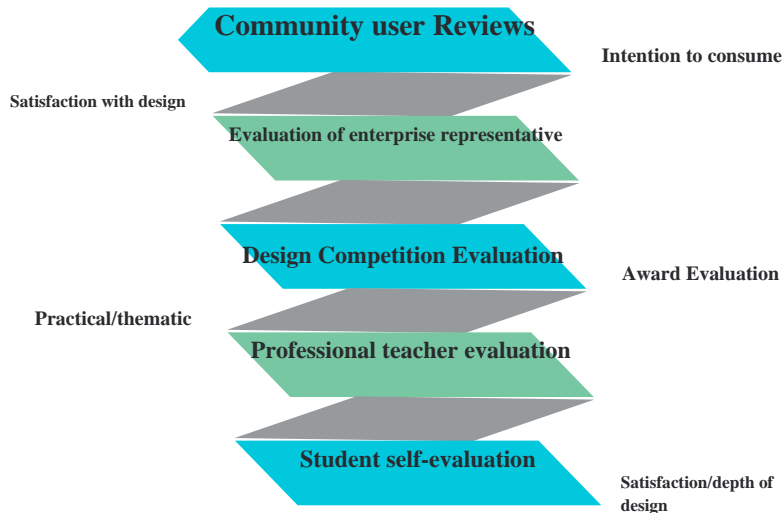

Figure 10: Design evaluation logic diagram.

6.1 Student Self-Evaluation

After completing the design, the students reviewed the whole solution in three aspects: design depth, software usage, and the degree of improvement of their own design logic.

At the design depth level, from the beginning of the design positioning excavation to the theme setting, and then to the modeling and rendering of the design scheme, in terms of the bright space of the scheme, the practicality of the scheme is fully considered, and the design is basically completed in solving the needs of enterprise product promotion and display, marketing and selling, providing space for consumer groups to experience, daily consumption and daily communication, etc. However, in the specific details of the design, including the control of space scale and material selection, due to the lack of practical experience, the lack of sufficient confidence in their design performance, especially in the storage space, bathroom, and other service auxiliary space of the design scheme, the design depth is not sufficient. [5].

The students made their own summary of the use of the software. Students say the software is easy to learn to get started, but it's still not easy to do well. Especially in modeling, mapping, rendering, and software lag when the scene becomes larger, students can feel helpless, and in the progressively more advanced modeling stage they also need to learn to complete their design tasks through more plug-ins. Students indicated that if they had a faculty member to lead and guide them in their projects, and students had the opportunity to work on real-world projects, they would have had an earlier opportunity to learn the software in depth and would have been better able to perform the software for the program. In the learning process of the software course, the modular design training is significant, and more importantly, the opportunity to coordinate the various software in combat is essential to improve the expression of students' program skills.

In the daily course training sessions, students pay little attention to the completion quality of a single design session (e.g., detail drawing of plan schemes, section drawing, etc.). In the process of integrating large schemes, the design problems of the previous session leading to the next design cannot be guaranteed, and if the drawing of plan schemes cannot be completed accurately in AutoCAD, importing them into SketchUp for modeling will lead to an increase in workload, and then it is necessary to go back to working on plan schemes until they can be successfully applied to 3D modeling. Design is the process of discovering problems and then solving them according to the design means. The program is a direct reflection of the designer's logical thinking, and each designer gradually forms his or her own design thinking through design experience or by interpreting successful design cases. Completely sorting out your design logic will help the solution to be completed successfully. The students themselves said that through this design solution training, their ability to analyze problems and solve them is clearer than ever before.

6.2 Professional Teacher Evaluation

The evaluation of the work by the professional teachers coincided with the defense of the graduation design. The defense committee consisted of one defense team leader, three defense teachers and one defense secretary, and a total of five people gave their respective evaluations of the work. The work review grade is given by the instructor and the other two teachers of the defense team according to whether the work is consistent with the chosen topic and professional training direction, as well as the completion of eight items such as design workload, work innovation, work integrity, etc. Each item is divided into ABC or ABCD four items, and the overall completeness of the work can be seen through the review table. Table 4 shows that the works received 3 A's in terms of the conformity of the chosen topic with the direction of professional training, design workload, visual aesthetics, and overall evaluation of the design; 2 A's and a B each in terms of completeness and functionality of the work, which is also mentioned in the student's self-evaluation section in agreement with it; And only 1 A (significant improvement or unique insight) and 2 Bs (some

improvement or new insight) were earned in the Innovative section of the work, which also provides a clear direction for design improvement. All three teachers gave a review score of 90 or above, which shows the recognition of the design effect of this project with SketchUp modeling. The above is the overall evaluation of the design by the professional teachers. (Table 5 Teacher Review Form).

Serial number	Topic selection and professional training direction	Design Work Attitude	Design workload	Innovative works	Work integrity	Functionality of the work	Visual aesthetics	Overall design evaluation	Review Results
Instructor	A B C	A B C D	A B C D	A B C	A B C D	A B C	A B C	A B C D	95
Reviewing teachers (I)	A B C	□	A B C D	A **B** C	A **B** C D	A B C	A B C	A B C D	90
Reviewing teachers (II)	A B C	□	A B C D	A **B** C	A B C D	A **B** C	A B C	A B C D	92

Table 5: Teacher Review Form.

The student's overall grade (overall grade) consists of the three reviewers' grades and the defense grade, each with a different weighted score, and the instructor's grade (weighted at 50%); Two additional reviewers each (15% weighting). The defense score is composed of 5 scores from 5 teachers who defended on site and 5 scores from 5 teachers who gave 5 scores to the work exhibition board, and the average score of 10 scores (weight 20%) is taken to obtain the final overall score. (Table 6: Comprehensive performance evaluation table).

Instructor Rating Results (50% weighting)	Reviewing Teacher I Rating Results (15% weighting)	Reviewing Teacher II Rating Results (15% weighting)	Answer grade (20% weighting) 5 defense results and 5 exhibition board achievements Average value	Overall evaluation results
95	90	92	93	93

Table 6: Overall Performance Evaluation Table.

6.3 Design Competition Evaluation

Students' design works were submitted to the professional design competition, in the 2022 10th Future Designer National College Digital Art and Design Competition (NCDA), which has been held

for 10 years since 2012, attracting nearly 1 million college students from more than 1,500 colleges and universities across the country to participate each year, with fierce competition, the competition system through the selection of "five rounds of three double publicity" system, in accordance with the three-tier system of school-level competition, provincial competition (regional competition) and national competition, after "school-level competition" - "qualification" - "provincial preliminary competition" - "provincial final (publicity)" - "national finals (publicity)" five rounds of competition two rounds of works publicity. In the end, the design won the "Provincial First Prize" and "National Second Prize", and won the "Provincial Excellent Graduation Design", which reflect the recognition and affirmation of the environmental design works designed with the help of computer software in the professional field.

6.4 Business Representative Evaluation

We will program effects with video, with 1 enterprise representatives and 1 Xiaogan Jaggery and Rice Wine Museum Museum interpreter exchange, they think this program design, landing is very strong, through the design effects of the space, atmosphere, image of the experience museum has a very deep feeling; At the same time, the conceptual scheme, if turned into a real space, will add to the experiential space of the Xiaogan Rice Tavern, a commercial space that the company wants to create; Of course, in terms of the materials of the program, street windows, and storage space, there is still a need to only push the program.

6.5 Community User Reviews

The user's evaluation is the most intuitive and effective evaluation of the program. We expected to do a concept design feedback evaluation of the consumers of the existing rice tavern, but because of the epidemic this semester, we did not successfully conduct this research, so we hope to fill this regret in the later concept design.

7 SOFTWARE APPLICATIONS

7.1 Software Selection Research

We conducted statistics on the software used for graduation design in the last 6 years in the Guangdong University of Petrochemical Technology and New College of Technology of Hubei Engineering University (Table 7). The period includes the performance tools for the graduation design of 539 students, and the students choose the graduation design performance forms mainly include SketchUp modeling, 3DS MAX modeling, Cool Home design software, hand-drawn effect drawings, and hand model making. (Fig. 11 Distribution of student graduation design modeling tools in the past 6 years).

Expression Tools	Number of students/total number of classes Percentage	Class of 2017	Class of 2019	Class of 2020	Class of 2021	Class of 2022	Class of 2023
	Number of students/tota	54/104	52/97	49/81	45/78	62/95	57/84

SketchU p	*l number of classes*						
	Percentage	*51.9%*	*53.6%*	*60.5%*	*57.7%*	*65.3%*	*67.8%*
3DSMAX	*Number of students/tota l number of classes*	*41/104*	*40/97*	*32/81*	*31/78*	*33/95*	*23/84*
	Percentage	*39.4%*	*41.2%*	*39.5%*	*39.7%*	*34.7%*	*27.4%*
Hand-painted	*Number of students/tota l number of classes*	*8/104*	*0/97*	*0/81*	*0/78*	*0/95*	*0/84*
	Percentage	*7.8%*	*0%*	*0%*	*0%*	*0%*	*0%*
Cool Home	*Number of students/tota l number of classes*	*1/104*	*5/97*	*0/81*	*2/78*	*0/95*	*4/84*
	Percentage	*0.9%*	*5.2%*	*0%*	*2.6%*	*0%*	*4.8%*

Table 7: Statistics on the Percentage of Performance Tools in the Last 6 Years.
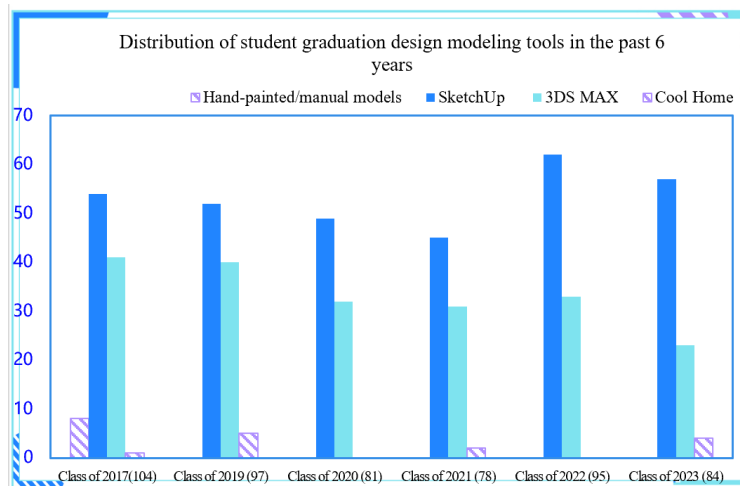

Figure 11. The Distribution of Students' Graduation Design Modeling Tools in the Past 6 Years.

We made an analytical trend graph of the percentage of students using software such as SketchUp. (Figure 12 Trend graph of student modeling tools for the last 6 years).

1) SketchUp topped the list by a wide margin as the most popular design modeling software among students. The most important design modeling software since 2017 to date;

2) Results showing the absence of hand-drawn, manual modeling as the main form of presentation for five consecutive years.

3) The use of 3DS MAX modelling software has also been decreasing.

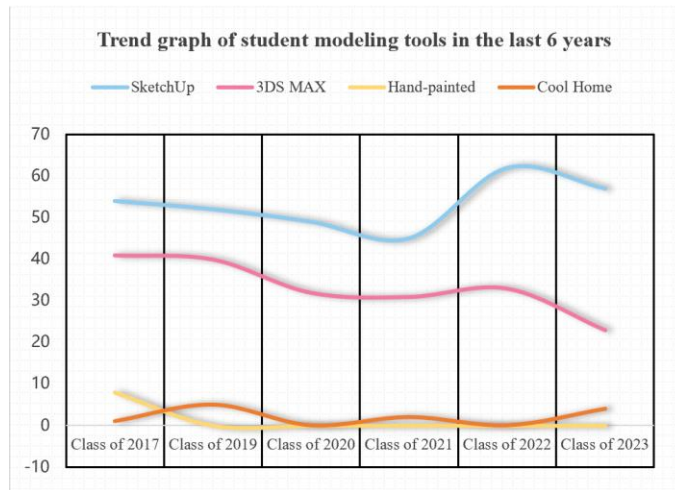4) The total number of users of Cool Home design software is small, with a slight upward trend.

Figure 12: Trend Graph of Student Modeling Tools in the Last 6 Years.

7.2 Sample Survey Of Graduates On Teaching Sessions During Their School Years

In 2022, 54 students were randomly selected from the five graduating classes of environmental design students in two universities from 2017-2021 to evaluate the most useful teaching sessions during their own school years, including five sessions including basic theory, professional theory, design practice training, extracurricular academic activities, and others. The results obtained show that 49.8% of the graduates found the various (project) practical training at the school to be most helpful; 27.8% for professional knowledge; and 11.1% for basic theory; Extracurricular academic activities 2%; other 9.3%. The above data, to some extent, suggest guidelines for teaching our courses. This value must fluctuate with time and practice specifics, and we need to adjust our teaching plan according to the specific situation.

8 CONCLUSION

The global epidemic of higher education online and offline hybrid teaching methods are changing, traditional paper design has quietly retired, with new technology digital intelligence design performance is on the rise. The study combined the design of "Shenlin" rice wine experience hall with the modeling software effects of 539 students, showing that the main reason for the popularity of SketchUp-based 3D modeling is its simplicity and ease of learning, and the ability to quickly master the operating system. In the case of the Guangdong University of Petrochemical Technology and New College of Technology of Hubei Engineering University, for example, the 3DS MAX modeling course offered by the school was not the best choice for students. Unfortunately, there is no way to know how effective the design solutions are on the ground, but student self-evaluation, teacher

evaluation, and design competition evaluation show that 3D modeling of the solutions using SketchUp software is effective and is one of the effective means to achieve digital intelligence of environmental design solutions.Though the effectiveness of design solutions utilizing Embedded Systems cannot be precisely measured without on-the-ground implementation, evaluations from students, teachers, and design competitions indicate that 3D modeling solutions with SketchUp software prove to be effective. Consequently, the integration of Embedded Systems and digital intelligence emerges as a promising approach to achieving efficient and innovative environmental design solutions in higher education.

The unstoppable software performance of Digital Intelligence, based on SketchUp software for 3D modeling, enables the process from line to surface to block, helping students to present their design solutions in a more realistic virtual three-dimensional space. SketchUp software is applicable in all environmental design fields of interior, the architecture and landscape.

What the findings tell us: Combine things so that we can add SketchUp/Kookaburra and other software instruction to the original modeling curriculum; The design profession is set up in the form of modular design and the quality assessment of each module is strengthened; The course design can be enhanced with AutoCAD/SketchUp/CorelDRAW/Photoshop software coordination course section to enhance the design expression of the complete solution.

In the future, more design tools may appear for our design expression, but the convenience and efficiency of the tools will not change the purpose of the service.

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REFERENCES

[1]   Bo, W.: Interior Decoration Design and Ecological Reconstruction Based on Ecological Energy Saving Technology, Energy Reports, 7(7), 2021, 49-61. https://doi.org/10.1016/j.egyr.2021.10.054
[2]   Cui, F.: Research on the Relationship Between Layout Arrangement and Human Visual Habits in Graphic Design, Shandong Light Industry College, 2012.
[3]   Enrique, C.M.;Juan A. A.B.;José M.C.D.: Future Teachers' Perception of the Usefulness of SketchUp for Understanding the Space and Geometry,Domain,Heliyon, 7(10), 2021, e08206. https://doi.org/10.1016/j.heliyon.2021.e08206
[4]   He, Q.; Qian, L.; Duan, Y.; Li, Y.: The Current Situation and Obstacles of BIM Application at Home and Abroad, Journal of Engineering Management, 26(01), 2012, 12-16.
[5]   Kennon, M.; Smith.: Conditions Influencing the Development of Design Expertise: As Identified in Interior Design Student Accounts.Design Studies, 36, 2015, 77-98. https://doi.org/10.1016/j.destud.2014.09.001
[6]   Kymmell,w.: Building Information Modeling: Planning and Managing Construction Projects With 4d CAD and Simulations, New York:2008, Mcgraw-Hill.
[7]   Li, Y.: Research on Optimization of Construction Site Layout Based on BIM Technology, Beijing University of Architecture, 2019.

[8] Liu, X.;Zhang, J.: Design and Implementation of a Three-Dimensional Campus Virtual Reality Platform, Hubei Agricultural Science, 53(12), 2014, 2909-2912+2922. 10.14088/j.cnki.issn0439-8114.2014.12.053.

[9] Lv, W.: Huang, Y.; Liu, F.: A Preliminary Investigation on the "Project-Based" Teaching Reform Mode of Environmental Art Design Majors - Taking Interior Design as an Example, https://doi.org/10.16272/j.cnki.cn11-1392/j.2011.02.025.

[10] Ma, J.: The Visual Flow in Layout Design, Packaging Engineering, (06), 2008,191-193.

[11] Meng, J.: The Application and Prospect of SketchUp in Curatorial Practice, Art Education, (10), 2022, 244-247.

[12] Nisrine,K.;Nicole,D.;M..;Laila,S.;Stephanie,H.;Malcolm,M.:Opportunities Stemming from Retrofitting Low-Resource East African Dwellings By Introducing Passive Cooling and Daylighting Measures,Energy for Sustainable Development, 69, 2022, 179-191. https://doi.org/10.1016/j.esd.2022.06.007

[13] Ozge Sever, I.; Kubra, O. D.:The Location of Computer Aided Drawing and Hand Drawing on Design and Presentation in the Interior Design Education,Procedia - Social and Behavioral Sciences, 182, 2015, 607-612. https://doi.org/10.1016/j.sbspro.2015.04.792

[14] Song, L.: Environmental design: Professional Community and Disciplinary Orientation, Design, 33(11), 2020, 98-100.

[15] Su, Y.: The use of Virtual Reality in Landscape Garden Planning and Design and Optimization of Hierarchical Details, Modern Electronics Technology, 42(09), 2019, 115-117+122. https://doi.org/10.16652/j.issn.1004-373x.2019.09.027.

[16] Sun, C.; Cheng, X.: SketchUp-Based 3D Structure Generation for Building Interiors in Firefighting, Highway Traffic Technology, 34(S2), 2017, 105-109.

[17] Wan, B.: Experimental Comparative Analysis of 3D City Modeling Technology Between 3DSMAX and SketchUp, Mapping and Geographic Information, 40(02), 2015, 23-25. https://doi.org/10.14188/j.2095-6045.2015.02.006.

[18] Xu, D.; Fang, X.; Ren, J.; Fan, X.: SketchUp-Based Urban 3D Modeling Technology, Mapping Science, 36(01), 2011, 213-214+189. https://doi.org/10.16251/j.cnki.1009-2307.2011.01.039.

[19] Xu, X.: Interior Design Decoration Simulation Based on wireless sensors, Microprocessors andMicrosystems, 82,2021,103813. https://doi.org/10.1016/j.micpro.2020.103813

[20] Xu, H.W.; Fang,X.; Ren, J.Y.et al: 3-D Modeling Technology of Digital City Based on SketchUp, Science of Surveying and Mapping, 36(1), 2011, 213-215. .

[21] Yang, C.; Ji, Y.;Hu, Q.;Zhang, F. Y.:3D Modeling and Design of Underground Pipe Network with the Support of SketchUp Software, Survey and Mapping Bulletin, (05), 2018, 126-130. https://doi.org/10.13474/j.cnki.11-2246.2018.0158.

[22] Yang, L.; Sheng, Y.; Wang, B.: Research on the Method of Indoor and Outdoor Integrated Modeling of Buildings Using 3D Laser Scanning Technology, Survey and Mapping Bulletin (07), 2014, 27-30. https://doi.org/10.13474/j.cnki.11-2246.2014.0218.

[23] Yao, X.:Zhou, Y.;Gasong,Z. W..: Implementation Method and Application of Inverse Modeling of Buildings Based on 3D Laser Scanning, Industrial Architecture, 50(03), 2020, 178-181+189. https://doi.org/10.13204/j.gyjz202003031.

[24] Ying, H.; Jinqi, G.: The performance of Nature Cover and the Inspiration for the Cover Design of Chinese Science and Technology JournalsTechnology and Publishing, (08), 2022, 101-106. https://doi.org/10.16510/j.cnki.kjycb.20220816.004.

[25] Zhang, H.: Research on Building Modeling Based on 3-Dimensional Laser Scanning Technology, Laser Technology, 38(03), 2014, 431-434.