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Innovative Practice of Sustainable Landscape Architecture Education—Parametric-Aided Design and Application

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Abstract: The traditional teaching model of landscape architecture education is teacher-centered classroom lectures, which cannot effectively satisfy students' curiosity and stimulate their creative thinking and computational thinking skills, resulting in students' low willingness to learn, inattentiveness, and lack of participation in discussions and interactions. This study attempts to combine the BOPPPS teaching structure and Design-Based Learning model to innovate the teaching design, construct the knowledge chain of landscape architecture design modeling and inspire the logic of thinking, with visual programming language, virtual reality parametric modeling and 3D printing hands-on activities while integrating sustainable development goals and related thematic issues to develop practical skills and problem-solving abilities. Through collecting students' learning performance, examining the quality and effectiveness of teaching and learning, reflecting on the revised teaching content and methods and establishing a practical teaching plan for sustainable landscape architecture education. The results of the study show that the combination of innovative teaching and learning models with SDG-related thematic issues and collaborative group discussions with teaching activities helps to enhance students' learning effectiveness and bring the learning performances of different learners closer together. In addition, the analysis of learning satisfaction shows that it enhances students' interest and motivation in learning.

Keywords: BOPPPS; design-based learning; virtual reality; 3D printing; sustainable development goals; sustainable landscape architecture education

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Citation: Hsu, C.-Y.; Ou, S.-J. Innovative Practice of Sustainable Landscape Architecture Education—Parametric-Aided Design and Application. *Sustainability* **2022**, *14*, 4627. https://doi.org/10.3390/su14084627

Academic Editors: Teen-Hang Meen, Charles Tijus, Ming-Shyan Wang, Barbara Motyl and Marc A. Rosen

Received: 15 March 2022
Accepted: 8 April 2022
Published: 13 April 2022

1. Introduction

With the rapid economic development and urban expansion in recent years, not only are the ecological environment and natural resources being overused, but the waste and pollutants emitted by factories and automobiles have also seriously damaged the environmental climate, resulting in ozone layer depletion, greenhouse effect, urban heat islands and acid rain, which have caused serious pollution and damages to the environment [1]. For this reason, the United Nations Educational, Scientific and Cultural Organization (UNESCO) has proposed the concept of urban ecological planning principles in its Man and the Biosphere Programme since 1971. In addition, at the United Nations Conference on Environment and Development (UNCED, Earth Summit) held in Rio de Janeiro, Brazil, in 1992, the participating countries jointly proposed Agenda 21, which set out the principles of sustainable development and proposed "building inclusive, safe, and sustainable cities" as one of the goals for improvement [2]. Today, international conferences on urban and environmental issues have been held, and it has been established that the future of cities must develop in the direction of sustainability, ecology, the environment and health [3]. Although industrial development has brought civilization and a comfortable life, it has also led to a loss of balance between the landscape and the natural ecology. The massive concentration of populations and industries, energy consumption, overuse of resources and environmental problems caused by massive pollution emissions, as well as climate change and environmental changes, are the challenges of modern landscape architectural design. The issue of sustainable development is one of the most important challenges that people must understand and face today.

At the 2002 World Summit on Sustainable Development, former UN Secretary General Annan said, "Education is the key to sustainable development. Education must provide students with skills, perspectives, values, and knowledge relevant to the sustainable development and lives of communities. This must be an interdisciplinary integration of concepts and analytical approaches from different disciplines." [4] In the current social climate, most people may not feel the backlash of nature's destruction of the environment, but it is possible that the future pillars of the nation, the students of today, will have to face an even more severe environment in the future. In addition to limiting and reviewing the damage done to the environment, future generations must also be aware of the environment, making education for sustainable development important and indispensable. Education for sustainability emphasizes a change in attitude and values that must be translated into practical action.

In this regard, the training of future design talents for the digital generation requires not only the training of original design skills but also the development of logical and computational thinking and cross-disciplinary skills. This study aims to integrate the BOPPPS teaching structure and the Design-Based Learning (DBL) model to develop a new teaching approach that introduces Mobile learning and flipped classroom platforms, visual programming language, virtual reality parametric modeling and 3D printing activities and incorporates SDG-related thematic issues to enhance students' interest in learning and to revitalize teaching. The following is an introduction to the relevant literature.

2. Theoretical Framework

2.1. BOPPPS

The BOPPPS Model is to divide the content into small units, and each small unit has its own "sequence" for segmented learning to maintain students' concentration, and then all units are combined to form a course [5–7]. The BOPPPS Model was first proposed by Douglas Kerr at the University of British Columbia, Canada, in 1978. The core of this model is to emphasize teacher–student interaction through Bridge-in, Objective or Outcome, Pre-assessment, Participatory Learning, Post-assessment and Summary. It provides teachers with a complete framework and theoretical support for all aspects of on-site teaching, making the arrangement of classroom teaching more structured and effective (As shown in Figure 1). With the evolution of the times, the module has gradually evolved from a traditional face-to-face course to a student-centered, web-based one. After asking questions and obtaining resources, students can collaborate with others to complete their work and solve problems online to achieve the teaching objectives [7]. Therefore, with limited time, manpower, material resources and space to invest, the BOPPPS teaching structure can be used in conjunction with SDG-related thematic issues to achieve effective, efficient and effective teaching [8] to enhance the effectiveness of this study.

2.2. Design-Based Learning, DBL

Design-Based Learning is an emerging form of cross-disciplinary, inquiry-based learning that integrates design processes and design thinking, while learning activities focus on solving complex tasks and iteratively generating solutions to unknown problems [9]. The DBL model was developed by Nelson (2004) under the concepts of integrated learning, innovative mental change, and hands-on knowledge, giving the design-based curriculum a concrete and clear way to operate [10]. The model emphasizes that the highest level of learning is to discover the common principles hidden in the curriculum and that these principles need to be experienced and integrated by students through contextual design, manual and mental operations and encouraging creative problem solving. In addition, DBL is an emerging cross-disciplinary, inquiry-based learning approach that allows students to explore and solve real-life design problems through a hands-on, reflective learning process [11] (as shown in Figure 2). The DBL curriculum is structured around design as the main axis, on the one hand using design to guide and encourage students to learn scientific knowledge [12] and, on the other hand, through design to expose students to practical design methods [13]. Practical DBL tasks in which students construct physical works can enhance high-level thinking; demonstrate creative, design and decision-making thinking; and meet the qualities of critical thinking, communication, cooperation and creativity required in the 21st century [14]. Such a learning process, combined with SDG-related thematic issues, can enhance students' reasoning, self-direction and teamwork skills for learning in a way that can be implemented in the Department of Design program.

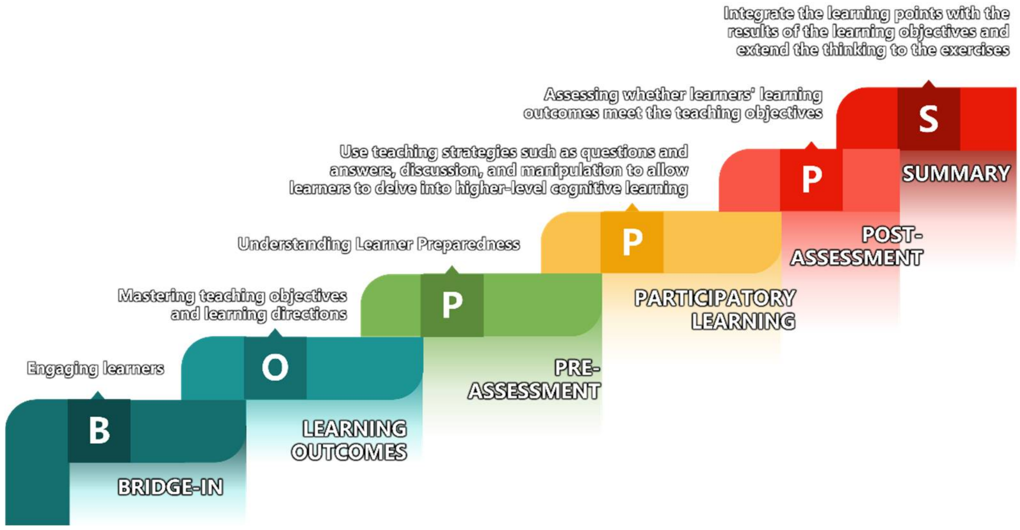

Figure 1. BOPPPS teaching mode.

Figure 2. Design-Based Learning teaching model.

2.3. Virtual Reality, VR

Virtual Reality is the use of a computer analogy to generate a three-dimensional virtual world, providing users with visual and other sensory analogies that allow them to feel as if they are there and to observe things in three-dimensional space in real time and without restriction. The term virtual reality was first coined and defined by Jaron Lanier in 1989, and it is still a wave of VR that has gained many applications in the entertainment and film industries [15]. In addition, because virtual reality environments provide simulated scenes that are close to the real visual experience, the architectural field has also incorporated computer technology and developed many computer-aided design tools to assist in design. However, due to early equipment limitations, computer-aided design software mainly uses non-immersive desktop virtual reality to present digital models, and today, computer-aided design software is still used in this form as the mainstream, with the emergence of virtual reality computer-aided design tools making the architectural design process more efficient [16]. Traditionally, 2D drawings can only be produced by hand, but with virtual-reality-assisted design tools, switching the various viewing angles of the digital model can produce a flat drawing set, and connecting the digital model to digital fabrication tools can be used for 3D printing the physical model. Therefore, in addition to the field of architecture and industrial design, VR-aided design is also suitable for application in the field of landscape architecture design (As shown in Figure 3).

Figure 3. Application of virtual reality in landscape architecture design.

2.4. Parameter Design

The origin of parametric design can be traced back to 1962, when Dr. Ivan Sutherland of MIT published his Sketchpad paper, which first introduced the concept of computer-aided design by modifying the parameter values to obtain different design components through the designed interface; later on, with the emergence of surface and solid modeling software, and even later, from unconventional Bezier curves to parametric modeling software, computers started to become a tool to assist designers [17,18]. However, parametric design functions were incorporated into commercial computer-aided design software decades later, and by the 1980s, many designers tried to use parametric features to develop their designs and conduct related application research [19]. Most of the parametric software exists in the form of plug-ins, and depending on the interface operation, it can be divided into programming language and visual programming language. It is much more intuitive than programming language and more acceptable to students. With the advanced technological capacity to compute, calculate and simulate, contemporary landscape architecture should no longer be directed only towards aesthetic and functional aspects but should also consider habitability, self-sufficiency and sustainability [20,21]. Unlike previous landscape architecture designs, which were mainly built on subjective intuitive judgment, traditional aesthetics and institutional experience, the parametric design method is based on a set of interactive rules and computational mechanisms, and through the designer's translation of design concepts, the rules and correlations of relevant parameters are defined as the basis for landscape architecture design changes. Not only can the geometry of the scheme be produced, evaluated and adjusted in real time, but the repetitive and large amount of data can be also processed in real time by a computer at any stage, allowing the designer to fully integrate their knowledge of environmental factors in the design concept and construct the corresponding visual model, provide the relevant area calculation and material costing in the shortest possible time [22]. Such a dynamic feedback mechanism and landscape architecture design process not only helps the design unit to integrate the subjective and objective design conditions but also provides control over the operating costs and the feasibility and accuracy of future construction drawings at the early stage of design, inspiring students to apply in the landscape architecture workplace in the future (As shown in Figure 4).

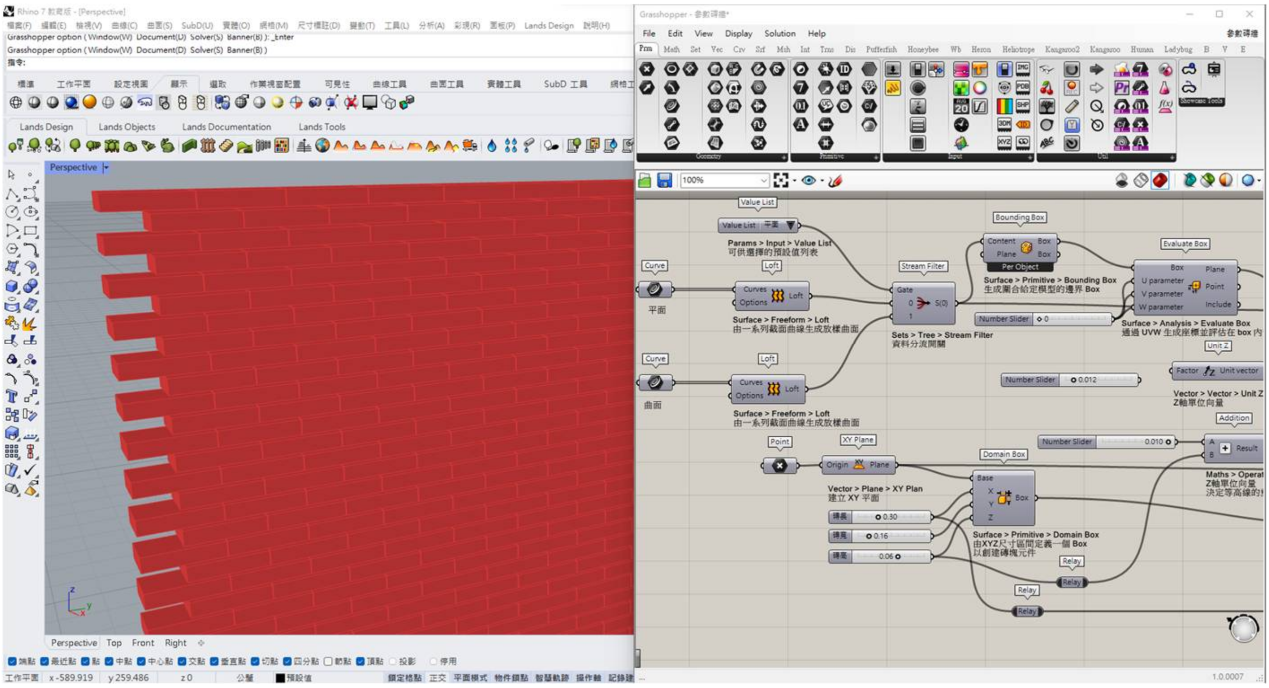

Figure 4. Application of parametric design in landscape architecture.

The principle of 3D printing requires the creation of a digital 3D model, which is then processed through digital cut layers and output in a g-code file to allow the 3D printer to output the solid. It has a wide range of applications, including aerospace, construction, automotive, defense, dental, food, shoes, art and education [23]. In the course of their teaching practice, the researcher found that students who learned to draw 3D images and operate 3D printers on computer software were able to render three-dimensional objects better than those who usually drew by hand with pencil and paper or sculpted with clay. Students can also use their familiar software as a tool, their imaginative ideas can be more easily shaped and teachers can see the development of more creative and expressive works [24]. Three-dimensional printing learning activities help to highlight the design implications in engineering, where the final and critical step in engineering design is modeling, and the development of models helps to develop students' understanding of important high-level concepts in engineering [25]. Kaiser & Sriraman (2006) also believe that students must be able to apply knowledge from different areas of science and mathematics in the modeling process to solve the real-world problems they face [26]. Therefore, during the learning process of 3D printing, students can learn 3D printing and modeling-related techniques and use them to evaluate the feasibility of their design ideas, thus reducing the potential problems of subsequent real-life production. In addition, using the current 3D printing technology to supplement teaching, the 3D printing machine allows the curriculum to be integrated into the teaching as a supplementary teaching tool or model to enhance students' learning motivation and also increases students' interaction with the classroom learning, focuses their attention and increases the learning effect. It also increases students' interaction with classroom learning, focuses their attention, increases the learning effect and inspires students' thinking ability. It also allows students to learn about the operation of new technology and design concepts [27] (as shown in Figure 5).

Based on the above literature analysis, this study adopts the BOPPPS teaching structure and Design-Based Learning model, supplemented by Visual Programming Language and Virtual Reality parameter control modeling, and 3D prints the results to facilitate students' mastery of landscape architecture design learning direction. It provides teachers with a basis for structuring the various parts of the classroom, making the teaching site more structured and attractive by using segmented teaching arrangements to enhance classroom participation and promote interaction between teachers and students [27], solving the problem of students being easily distracted in class, cultivating students' ability to think and analyze and further promoting the teaching and learning of the course.

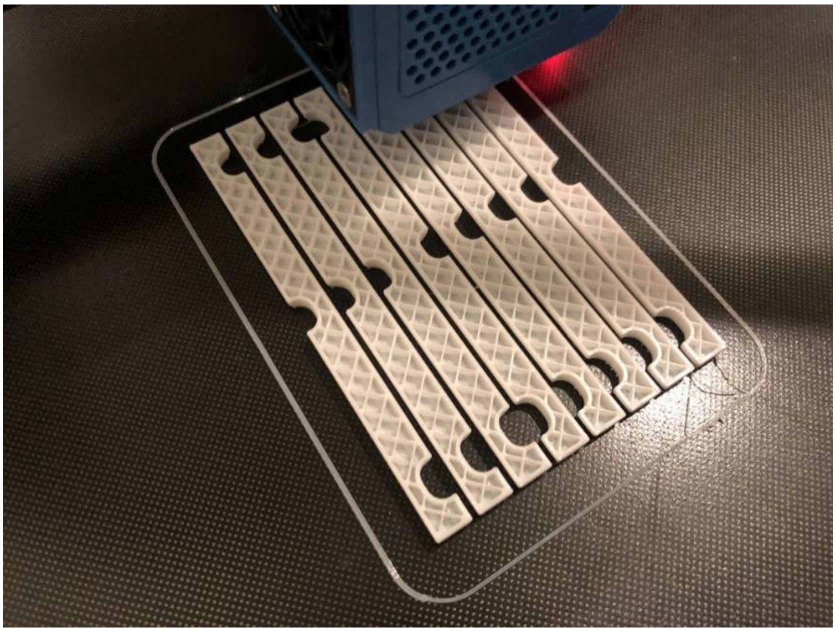

Figure 5. Application of 3D printing in landscape architecture.

3. Materials and Methods

This study constructs a knowledge chain of sustainable development and inspires design logic through innovative teaching and learning design. It designs teaching activities with teaching experience, develops practical skills and problem-solving abilities and examines teaching quality and learning effectiveness by collecting students' learning performance, learning questionnaires and teaching interviews, and then reflects on the teaching model to establish a practicable teaching program for sustainable landscape architecture.

The specific research objectives of this study are as follows:

1. To investigate the feasibility of the BOPPPS teaching structure and Design-Based Learning model in the design and implementation of a sustainable landscape architecture design curriculum;
2. To understand the impact of adopting the BOPPPS teaching structure and Design-Based Learning model on students' professional knowledge and learning outcomes;
3. The changes and perceptions of students with different learning achievements in the design and implementation of innovative sustainable landscape architecture design teaching programs

3.1. Participants and Context

The research field is a teaching program for sustainable landscape architecture education at a university of science and technology in central Taiwan. This course is a semester-long experimental research study designed to ensure that the content and delivery methods are appropriate to the students' level. In order to ensure that the content and teaching methods were appropriate for the students, we took into account the students' familiarity with 3D modeling, their busy schedules and the limitations of equipment and space. We selected a three-credit, three-hour Landscape and Urban Planning senior elective course as the implementation target. The course was taught in a small class size, with 11 males and 13 females, for a total of 24 senior students.

3.2. Course Scope and Thematic Unit Design

The scope of the course is parametric modelling, incorporating "SDG 11—Goal 11Make cities and human settlements inclusive, safe, resilient and sustainable", "SDG 13—Take urgent action to combat climate change and its impacts", "SDG 15—Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss" and other related goals. The visual programming language (VPL) through the Rhino plug-in program Grasshopper connects the designed components with relational models and graphical interfaces to indirectly achieve the effect of automated scripting, allowing students who are not familiar with writing computer programs to perform parametric design through virtual reality (VR).There are 16 thematic unit in the course, including "Basic concepts of parametric design", "Introduction and operation of parametric software", " Component set parameters and applications", "Introduction and analysis of sustainable landscape cases", "Case studies of sustainable landscape integration and extension", "Application of virtual reality integration", "Landform design", "Permeable pavement design", "Timber floor design", "Green corridor design", "Green wall design", "Trellis pavilion design", "Bamboo tunnel design", "Pergola design", "Sustainable environmental design and analysis" and "Applications of 3D printing". Students were able to develop parametric models based on different design requirements, provide optimal designs under different design conditions and constraints and 3D print the results for evaluation (As shown in Figure 6).

Figure 6. Course scope.

3.3. Teaching Practice Processes

In this study, we used teaching observation, learning effectiveness assessment and qualitative analysis to understand the feedback of the participating students on the overall effectiveness of the learning objectives, steps and results set in the curriculum. In order to present the quality of teachers' teaching, the teaching implementation procedure was divided into three stages: the pre-teaching preparation stage, the classroom teaching application stage and the effectiveness evaluation and feedback stage, and each stage is shown in Figure 7.

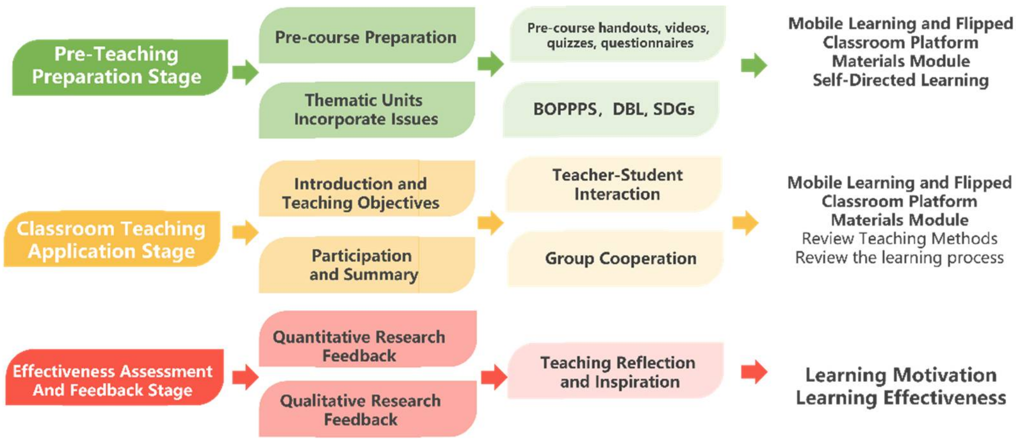

Figure 7. Teaching practice processes.

3.3.1. Pre-Teaching Preparation Stage

The video was recorded for each topic unit, and digital handouts and quizzes were created before class. The video contained an overview of the course and the steps for each thematic unit. The digital teaching materials and videos were uploaded to the mobile learning and flipped classroom platforms so that students could obtain a grasp of the learning direction before the class. The digital handouts included detailed illustrations of the different thematic units, operational explanations and brainstorming exercises. Presentations were created for each thematic unit to be used in the classroom. In addition, various types of questions were set up on the mobile learning and flipped classroom platforms to serve as topics for classroom discussions and pre-test quizzes.

3.3.2. Classroom Teaching Application Stage

The BOPPS teaching model and the Design-Based Learning model were used as segmented approaches to teaching and learning, and the 16 thematic units mentioned above were developed into digital materials. After the teacher explains the teaching objectives, students were allowed to log in to the mobile learning and flipped classroom platforms to take pre-quizzes and design assignments. Finally, the post-test results were used to review the content and students' understanding, integrate learning points and clarify modeling misconceptions and problem modeling skills (As shown in Table 1).

3.3.3. Effectiveness Assessment and Feedback Stage

To understand the effectiveness of student learning in the BOPPPS teaching model and Design-Based Learning models, we measured the effectiveness of teaching and learning. Through the mobile learning and flipped classroom platforms, students' learning ability was assessed by reviewing their learning history and providing immediate feedback. Students were first categorized into high (Top 25%), medium and low (Bottom 25%) achievers based on their scores in the first semester of the initial course. In the quantitative study, each thematic unit was administered with a platform to collect data from pre-tests and post-tests to understand the perception of professional competence and the learning effectiveness of different academic achievers [28]. At the middle and end of the semester, questionnaires were administered to evaluate the course learning awareness, and course learning satisfaction. The questionnaire was designed using a 5-point Likert scale, with scores from "1" to "5" representing "very non-conforming" to "very conforming", and the higher the score, the higher the learning awareness and learning satisfaction. The questionnaire contained 7 questions on learning awareness and 6 questions on learning satisfaction, totaling 13 questions. In terms of qualitative research, qualitative feedback was collected through end-of-semester interviews that asked questions such as "What did you learn in this course? and "What are your learning experiences and recommendations in this course?" to identify potential problems and provide reference for teachers to adjust teaching materials and methods.

Table 1. BOPPPS teaching model combined with DBL learning model for classroom teaching procedures.

BOPPPS Teaching Model	Teaching Procedures	DBL Learning Mode	Teaching Method
B Introduction to the theme unit.	Topic-related issues to attract students' attention and arouse their interest in learning.	Learning about the lesson topics and concepts.	Watch online teaching videos.
O Instructional objectives.	Explain the relevance of the teaching objectives to the learning content so that students understand the direction of learning.	Understand the main axes of the course, think about the questions and prepare for design challenges Teacher's notes.	Teacher instructions.
P1 Pre-test.	Check students' mastery of the material and their independent learning status.	Conduct pre-test learning assessment.	Quizzes.
P2 Participatory learning.	With digital teaching materials and digital media applications, group discussions are used to help students understand design principles and hardware and software operating guidelines and to deepen the teaching process.	Discuss with the group how to design and produce? Why use the parameters for design? Try to combine visual language and parametric virtual reality for thematic design challenges and build preliminary 3D models.	Group discussion and learning, teacher guidance.
P3 Post-test.	Review the content of thematic modules to assess students' understanding and grasp learning dynamics.	Conduct post-test learning assessment	Quizzes and explanations.
S Abstract/ Integration Summary.	Integrate the teaching points and learning outcomes and extend the homework exercises after class.	Evaluate the learning process, apply what they have learned and make design corrections. Extend past experience, redesign and build 3D models according to the assignment content, and 3D print the design models to publish for feedback.	Student presentation and teacher explanation.

3.3.4. Data Processing and Analysis

In order to understand the impact of BOPPPS teaching structure and Design-Based Learning model on the curriculum, the students were first divided into high, medium and low achievers according to the distribution of student achievement. For the 16 thematic units, learning sheets and quizzes questions were created and pre-tests were conducted on the mobile learning and flipped classroom platforms to check the effectiveness of independent learning. Secondly, through innovative teaching, learning activities and discussions, the students were given a post-test on the mobile learning and flipped classroom platform to evaluate the effectiveness of the teaching and learning of the thematic units. Finally, before the midterm and final examinations of the semester, questionnaires and interviews were conducted on the teaching of the course (As shown in Table 2), including learning awareness, learning satisfaction and experience suggestions. The data were collected and analyzed using paired sample *t*-tests, one-way ANOVA and qualitative analysis.

Table 2. Survey on Learning Awareness, Learning Satisfaction and experience suggestions.

Questionnaires—Learning Awareness
A1 I think it is easy to learn this teaching activity unit. A2 I think it is necessary to learn this module. A3 I think the learning of this teaching activity module helps me to improve my design skills. A4 I think that learning this activity unit will help me to go to higher education. A5 I think that learning this activity module will help me to finish my homework faster A6 I think the learning of this teaching activity module can increase my professional knowledge. A7 I feel that learning this module will increase my professional confidence.
Questionnaires—Learning Satisfaction
S1 I think this teaching activity unit is a fun thing to do. S2 I will devote time to learning about this activity S3 I am willing to participate in the activities that the teacher of this activity wants us to do. S4 I feel that I have made progress in my performance or learning in this activity S5 I can understand the learning content of the activity or material S6 I am confident in my learning ability in this activity
Interviews—Experience Suggestions
ES1 What did you learn in this course? ES2 What are your learning experiences and recommendations in this course?

4. Results and Discussion

The results of the study were first analyzed by using the formative assessment of the pre-test and post-test of the action learning and flipped classroom platform system as a learning effectiveness analysis. Secondly, the results of the pre-test and post-test descriptive statistics were used to understand the learning situation of the learners with different learning achievements in different thematic units. Finally, a questionnaire survey on learning awareness, learning satisfaction as well as a qualitative interview feedback survey were conducted.

4.1. Learning Effectiveness Analysis

After the students' independent learning through the pre-course materials, the students were tested with an action learning and flipped classroom platform system, which was used as a pre-test to benchmark the students' learning. This test was used as a pre-test to benchmark student learning. After the classroom instruction and group discussion, a post-test was conducted with the platform system to examine the effects of BOPPPS teaching structure and Design-Based Learning model on learning outcomes (As shown in Table 3).

As can be seen from Table 3, the students' pre-test scores indicate that students did not read the pre-course materials or were unable to master the core knowledge of learning: Comparing the pre-test and post-test scores of each topic unit, the average score of Unit 1 improved from 40 to 81.67 with an improvement of 41.67 points, while the average score of Unit 2 improved from 47.5 to 85 with an improvement of 37.5 points. The average score of Unit 3 improved from 25.83 to 84.173 with an improvement of 58.33 points. The average score of Unit 4 improved from 66.67 to 85.83 with an improvement of 19.17 points. The average score of Unit 5 improved from 74.77 to 90 with an improvement of 15.83 points. The average score of Unit 6 improved from 59.17 to 95 with an improvement of 35.83 points. The average score of Unit 7 improved from 50 to 79.17 with an improvement of 29.17 points, and the average score of Unit 8 improved from 50 to 79.17 with an improvement of 29.17 points. The average score of Unit 8 increased from 62.5 to 88.33 with an improvement of 25.83 points. The average score of Unit 9 increased from 72.5 to 94.17 with an improvement of 21.67 points. The average score of Unit 10 increased from 45.83 to 75.83 with an improvement of 30 points. The average score of Unit 11 increased from 67.5 to 86.67 with an improvement of 19.17 points. The average score of Unit 12 improved from 47.5 to 78.33 with an improvement of 30.83 points. The average score of Unit 13 improved from 76.67

to 89.17 with an improvement of 12.5 points. The average score of Unit 14 improved from 82.5 to 95.83 with an improvement of 13.33 points. The average score of Unit 15 improved from 75 to 91.67 with an improvement of 16.67 points, and the average score of Unit 16 improved from 82.5 to 75.83 with an improvement of 30 points. The average score of Unit 16 improved from 82.5 to 93.33 with an improvement of 10.83 points. Unit 3 "Component set parameters and applications" has the most advanced score, followed by Unit 1 "Basic concepts of parametric design" and Unit 2 "Introduction and operation of parametric software". There were 13 thematic units with an average score of 80 or more in the post-test, and 5 of them had an average score of 90. The results of the study showed that the post-test scores of the 16 thematic modules were significantly higher than the pre-test scores by more than 10 points, with a significant difference and a gradual increase in the mean scores, indicating that the innovative curriculum really helps students' learning effectiveness.

Table 3. Analysis of a sample of 24 senior students in a thematic unit with paired sample *t*-test.

Thematic Units	Pre-Test		Post-Test		Paired Difference	*t*
	M	SD	M	SD		
1. Basic concepts of parametric design	40.00	22.07	81.67	16.59	41.67	−15.61 ***
2. Introduction and operation of parametric software	47.50	18.47	85.00	14.74	37.50	−13.51 ***
3. Component set parameters and applications	25.83	16.13	84.17	14.42	58.33	−19.92 ***
4. Introduction and analysis of sustainable landscape cases	66.67	12.74	85.83	13.81	19.17	−10.11 ***
5. Case studies of sustainable landscape integration and extension	74.17	16.13	90.00	14.45	15.83	−7.62 ***
6. Application of virtual reality integration	59.17	13.81	95.00	8.85	35.83	−14.92 ***
7. Landform design	50.00	19.56	79.17	12.48	29.17	−12.15 ***
8. Permeable pavement design	62.50	14.82	88.33	11.67	25.83	−11.50 ***
9. Timber floor design	72.50	11.52	94.17	11.00	21.67	−13.00 ***
10. Green corridor design	45.83	17.17	75.83	14.42	30.00	−12.46 ***
11. Green wall design	67.50	11.52	86.67	11.29	19.17	−8.54 ***
12. Trellis pavilion design	50.83	21..25	78.33	15.51	30.83	−12.84 ***
13. Bamboo tunnel design	68.33	20.36	84.17	13.16	12.50	−5.32 ***
14. Pergola design	72.5	19.39	88.33	14.35	13.33	−6.78 ***
15. Sustainable environmental design and analysis	75.00	14.74	91.67	9.29	10.07	−8.48 ***
16. Applications of 3D printing	82.50	10.73	93.33	9.63	10.83	−5.21 ***

***: $p < 0.001$.

Based on the results of the descriptive statistical analysis, it was found that, overall, the low and middle achievers showed more improvement than the high achievers (as shown in Table 4). The initial reason for this is that through the innovative teaching design of the BOPPPS and Design-Based Learning model, group discussions were combined with teaching activities, and the teacher encouraged each student to share the teaching content on the stage, so the high achievers led the learning and motivated the middle and low achievers to learn.

At the end of the semester, a learning cognition and learning satisfaction questionnaire was conducted to understand learners' wishes, feelings and attitudes towards learning activities. It can reflect the students' enjoyment of learning activities or the extent to which their personal desires and needs are met or goals are achieved [24]. The specific results of the survey are shown in Table 5.

Table 4. Pre-test and post-test performance of 24 senior students with different learning achievements in thematic lesson.

Learning Achievements		Thematic Lessons	Pre-Test		Post-Test		Thematic Lessons	Pre-Test		Post-Test	
Group	N		M	SD	M	SD		M	SD	M	SD
High	7	1. Basic concepts of parametric design	65.71	15.12	94.29	9.76	9. Timber floor design	80.00	0.00	97.14	7.56
Middle	10		38.00	6.32	84.00	12.65		70.00	10.54	94.00	9.66
Low	7		17.14	13.80	65.71	15.12		68.57	15.74	91.43	15.74
Total	24		40.00	22.07	81.67	16.59		72.50	11.52	94.17	11.00
High	7	2. Introduction and operation of parametric software	65.71	15.12	97.14	7.56	10. Green corridor design	62.86	13.80	85.71	15.12
Middle	10		46.00	9.66	88.00	10.33		44.00	12.65	76.00	8.43
Low	7		31.43	15.74	68.57	10.69		31.43	10.69	65.71	15.12
Total	24		47.50	18.47	85.00	14.74		45.83	17.17	75.83	14.42
High	7	3. Component set parameters and applications	40.00	16.33	94.29	9.76	11. Green wall design	77.14	13.80	97.14	7.56
Middle	10		22.00	6.32	84.00	12.65		66.00	9.66	84.00	12.65
Low	7		17.14	17.99	74.29	15.12		60.00	0.00	80.00	0.00
Total	24		25.83	16.13	84.17	14.42		67.50	11.52	86.67	11.29
High	7	4. Introduction and analysis of sustainable landscape cases	74.29	9.76	97.14	7.56	12. Trellis pavilion design	77.14	7.56	97.14	7.56
Middle	10		68.00	10.33	86.00	9.66		46.00	13.50	76.00	8.43
Low	7		57.14	13.80	74.29	15.12		31.43	10.69	62.86	7.56
Total	24		66.67	12.74	85.83	13.81		50.83	21.25	78.33	15.51
High	7	5. Case studies of sustainable landscape integration and extension	85.71	9.76	100.00	0.00	13.Bamboo tunnel design	88.57	10.69	100.00	0.00
Middle	10		76.00	12.65	92.00	10.33		70.00	14.14	82.00	6.32
Low	7		60.00	16.33	77.14	17.99		45.71	9.76	71.43	10.69
Total	24		74.17	16.13	90.00	14.45		68.33	20.36	84.17	13.16
High	7	6. Application of virtual reality integration	71.43	10.69	100.00	0.00	14. Pergola design	91.43	10.69	100.00	0.00
Middle	10		60.00	0.00	98.00	6.32		76.00	8.43	90.00	10.54
Low	7		45.71	15.12	85.71	9.76		48.57	10.69	74.29	15.12
Total	24		59.17	13.81	95.00	8.85		72.50	19.39	88.33	14.35
High	7	7. Landform design	65.71	15.12	91.43	10.69	15. Sustainable environmental design and analysis	91.43	10.69	100.00	0.00
Middle	10		52.00	13.98	78.00	6.32		72.00	10.33	92.00	10.33
Low	7		31.43	15.74	68.57	10.69		62.86	7.56	82.86	7.56
Total	24		50.00	19.56	79.17	12.48		75.00	14.74	91.67	10.07
High	7	8. Permeable pavement design	71.43	10.69	97.14	7.56	16. Applications of 3D printing	94.29	9.76	97.14	7.56
Middle	10		64.00	12.65	88.00	10.33		80.00	0.00	96.00	8.43
Low	7		51.43	15.74	80.00	11.55		74.29	9.76	85.71	9.76
Total	24		62.50	14.82	88.33	11.67		82.50	10.73	93.33	9.63

Students are categorized into high (Top 25%), medium and low (Bottom 25%) achievers based on their scores in the first semester of the initial course.

Table 5 shows that in terms of course learning awareness, "A6 I think the learning of this teaching activity module can increase my professional knowledge" has the highest rating, followed by "A2 I think it is necessary to learn this module" and "A7I feel that learning this module will increase my professional confidence". In terms of course learning satisfaction, "S3 I am willing to participate in the activities that the teacher of this activity wants us to do" and "S5 I can understand the learning content of the activity or material" had the highest ratings, followed by "I feel that the next highest rating was '1. I think this teaching activity unit is a fun thing to do'". The general perception of learning and satisfaction with learning of the students in the course was positive.

Table 5. Learning perceptions and learning satisfaction of 24 senior students.

Questions	N	MIN	MAX	M	SD
Learning Awareness A1	24	2.00	4.00	3.42	0.72
Learning Awareness A2	24	4.00	5.00	4.88	0.34
Learning Awareness A3	24	4.00	5.00	4.83	0.38
Learning Awareness A4	24	4.00	5.00	4.71	0.46
Learning Awareness A5	24	3.00	5.00	4.67	0.64
Learning Awareness A6	24	5.00	5.00	5.00	0.00
Learning Awareness A7	24	4.00	5.00	4.88	0.34
Learning Satisfaction S1	24	4.00	5.00	4.92	0.28
Learning Satisfaction S2	24	2.00	4.00	3.42	0.72
Learning Satisfaction S3	24	5.00	5.00	5.00	0.00
Learning Satisfaction S4	24	3.00	5.00	4.67	0.64
Learning Satisfaction S5	24	5.00	5.00	5.00	0.00
Learning Satisfaction S6	24	4.00	5.00	4.83	0.38

4.2. Learning Awareness, Learning Satisfaction Survey

Student feedback is one of the most important criteria to measure the effectiveness of teaching, especially through qualitative interview feedback, which can not only understand students' learning experience and suggestions but can also understand students' learning situation and needs and provide teachers with new teaching reflections, so that they can adjust the progress, teaching methods and course contents in a timely manner. In this study, focus group interviews were conducted through special reports, and the specific feedback analysis is below.

4.2.1. Integrating SDG-Related Thematic Issues with Teaching Module to Increase Interest in Learning

This study uses current news issues in the classroom to stimulate students' interest and curiosity in sustainable land use and increase their willingness to participate in the course. For example: a. The heat island effect is worsening year by year, and temperatures remain high. Through the design of permeable pavement parameters, the size of the base, topographic relief and planting characteristics, we create an optimal design to alleviate storm water runoff, reduce damage to the environment and achieve a reduction in surface temperature. b. The infinite expansion of modern cities has caused a serious impact on the urban environment, the climate and original organisms. The parameters of the island-hopping green corridor are designed to match the spatial dimensions and planting objects to create ecological island-hopping, which not only mitigates the heat island effect but also provides a place for creatures to take refuge and habitat. c. Students were deeply interested in these topics and found them useful for learning through the introductory lectures.

4.2.2. Information Integration into Inquiry Teaching to Enhance Learning Motivation

The course incorporates a variety of design software, so that students who do not know how to write programs can also use parametric design software and virtual reality to carry out a variety of landscape design. In addition, students can communicate and collaborate with each other through the online platform for digital presentation and print out the results through the 3D printer for design review and improvement. This makes students' learning faster, clearer and more interesting and has an added effect on enhancing students' motivation and conceptual learning. Students like this teaching method better than the traditional lecture method.

The results of the above analysis show that the BOPPPS teaching model and the Design-Based Learning model are both very positive. Students generally liked the integration of the curriculum with current events, learning new design software and tools, understanding the needs of the landscape profession, developing practical skills for the workplace and quickly grasping the key learning points in a relaxed and fun learning process (as shown in Figure 8).

Figure 8. Innovative teaching programs.

5. Conclusions

This study adopts the BOPPPS teaching model and Design-Based Learning model for sustainable landscape architecture education. The main conclusions are as follows:

1. The post-test scores for the thematic units were all more than 10 points higher than the pre-test scores, indicating that the incorporation of SDG-related thematic issues in the BOPPPS teaching model and Design-Based Learning model can enhance learning effectiveness.

2. The scores of both the pre-test and post-test of the thematic module were higher than those of the pre-test, indicating that the integration of the BOPPPS teaching model and the Design-Based Learning model into thematic issues related to SDGs allows students to continue to accumulate learning experiences.
3. The integration of SDG-related thematic issues in the BOPPPS and Design-Based Learning models combined with cooperative group learning reduced the gap in learning effectiveness between high, middle and low achievers in the learning modules.
4. Students′ feedback on the BOPPPS teaching model and design-oriented learning model for sustainable landscape architecture education was very positive. Students generally liked the integration of curriculum and current events, the learning of emerging design software and tools, and the ability to quickly enter into learning situations through group work, which effectively increased the quality of learning outcomes. The overall average scores for Learning Awareness and Learning Satisfaction were both above 4.6.
5. Students' qualitative feedback indicated that the use of the BOPPPS teaching model and the Design-Based Learning Model to integrate SDG-related thematic issues in the teaching site increased interest and participation in teaching activities, especially in group work, where students with different learning achievements could help each other learn together.

Overall, The BOPPPS and Design-Based Learning models integrate innovative technology and SDG-related thematic issues into teaching and learning, allowing for a variety of teaching strategies that are useful for reference in teaching related disciplines.

Author Contributions: Conceptualization, C.-Y.H. and S.-J.O.; methodology, C.-Y.H.; software, C.-Y.H.; validation, C.-Y.H.; formal analysis, C.-Y.H.; investigation, C.-Y.H.; resources, C.-Y.H.; data curation, C.-Y.H.; writing—original draft preparation, C.-Y.H.; writing—review and editing, C.-Y.H.; visualization, C.-Y.H.; supervision, S.-J.O.; project administration, C.-Y.H.; funding acquisition, C.-Y.H. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: We would like to express our special thanks to the students who participated in this study. We are very grateful to them.

Conflicts of Interest: The authors declare no conflict of interest.

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