Integration of Environmental Sustainability Issues into the “Game Design Theory and Practice” Design Course

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Abstract: International and Taiwanese research has suggested that education for sustainable development (ESD) requires interdisciplinary research and teaching. There is a lack of sustainable art and design courses in the field of humanities. We have learned that design students have neither a concern for the surrounding environment nor the ability to resolve social issues when teaching design. This study is intended to integrate sustainable development issues into design courses and apply design to resolve issues so that students can develop the ability to think creatively and solve environmental sustainability issues. This study aimed to examine the effectiveness of integrating sustainable development issues into “Game Design Theory and Practice” design course and to construct a model of “design course on environmental sustainability.” This study applied the action research method and incorporated the PBL (problem-based learning) and ADDIE (analysis, design, development, implementation, evaluation) modes. Ultimately, based on the results of course planning and implementation, we proposed the model of “design course on environmental sustainability,” with priorities given to: (1) The introduction of environmental sustainability issues; (2) the introduction of design methods by teachers; (3) the promotion of students’ participation in design thinking and discussion; (4) students’ adjustments to the design according to players’ feedback; and (5) interaction and communication between different characters. The results demonstrated that the integration of sustainable development issues into the planning and implementation of the “Game Design Theory and Practice” design course had positive effects. Game design could be used as a method and tool to encourage students and players to assume sustainable citizenship and to generate a concern for sustainable development in interesting game contexts. These findings can contribute to the future development of design education at colleges and universities.

Keywords: sustainable development issues; game design; design patterns

1. Introduction

UNESCO [1] has defined education for sustainable development (ESD) as a type of education for social transformation that aims to create a more sustainable society. ESD touches on every aspect of education, including planning, application of program, course, teaching, learning, evaluation, and administration, and is dedicated to achieving uniformity among education, public awareness, and training, thereby creating a more sustainable future. Thus, ESD is more than sharing knowledge and principles about sustainability [1]. Sterling [2] suggested that sustainability is not just another issue imposed on crowded courses, but rather a gateway to courses, pedagogy, organizational changes, and policies with different perspectives, and more importantly, to the transformation of ethos. Filho et al. [3] and Moore [4] implied that when applying the principles of sustainable development to education, transdisciplinary practice is inadequate, and interdisciplinary research and
teaching are requisites. Taiwanese researcher Wang [5] indicated that most universities stress scientific implementation in Taiwan’s ESD, such as climate, architecture, and traffic engineering, and that there is a general lack of sustainable courses in history, culture, and art and design in the field of humanities. Such courses are related to environmental ethics and moral education and can facilitate students to develop sustainable values, but they have always been unavailable in universities. How to integrate sustainable courses into the classroom of art and design is a direction of future development. Subsequently, Ho [6] stated that it is an urgent requirement to develop and conduct ESD at colleges and universities. To attain the goal of ESD, the biggest challenge is to enable students to internalize “changes in brain” and achieve overt “changes in action.”

Taiwanese design scholar and educator Guang [7] revealed that design education in Taiwan places great emphasis on the transfer of professional skills. Students have been trained to be professional in design disciplines, but they lack the ability to integrate social and environmental issues into the design process from multiple perspectives, resulting in the absence of connection between themselves and their living environment and falling into vague concepts. As design educators, we are concerned about the overall development trend of ESD in Taiwan and worldwide. We have learned that design students have neither a concern for the surrounding environment nor the ability to resolve social issues during design teaching. Therefore, this study is intended to integrate sustainable development issues into design courses and apply design to resolve issues, so that students can develop the ability to think creatively and solve sustainability issues.

1.1. Aims

1. To incorporate environmental sustainability issues into the “Game Design Theory and Practice” design course so that students will understand environmental issues and be concerned for environmental sustainability.
2. To investigate the effectiveness of integrating environmental sustainability issues into the “Game Design Theory and Practice” design course.
3. To apply the action research of the “Game Design Theory and Practice” course to attain the Sustainable Development Goals adopted by the United Nations, and to construct the core model of “design courses on environmental sustainability.”

1.2. Research Questions

1. Can the integration of environmental sustainability issues into the “Game Design Theory and Practice” design course create an awareness for environmental sustainability among university students?
2. What are the specific learning outcomes for students by integrating environmental sustainability issues into the “Game Design Theory and Practice” design course?
3. What is the development model for integrating environmental sustainability issues into the “Game Design Theory and Practice” design course?

2. Literature Review

This section will examine (1) the status of ESD in Taiwan and worldwide; (2) ESD and university design courses; (3) theories and practical methods of board game design in the “Game Design Theory and Practice” design course; and (4) the significance of integrating sustainable development issues into the “Game Design Theory and Practice” design course.

2.1. Current Status of Education for Sustainable Development (ESD) in Taiwan and Worldwide

The United Nations [8] has agreed on 17 Sustainable Development Goals (SDGs) and 169 targets. The 17 SDGs include: Providing quality education, providing job opportunities and promoting inclusive and sustainable economic growth, developing sustainable cities and communities, responding to
climate change and its impacts, conserving and sustainably using oceans and marine resources, and preserving and promoting terrestrial ecosystems. In the 21st century, universities are at a stage of rethinking their positioning and facing the challenge of instantly responding to social needs. The adoption of the globally recognized SDGs framework can facilitate universities worldwide to fulfill their social missions and core functions. However, there is much room for improvements in ESD. Sterling [9] specified and proposed that learning is a process of creation, reflection, and participation. Education should enable students to develop the ability to deal with ambiguity and uncertainty. In a dynamic process, learning is about embarking on sustainable living and developing the ability to adapt to the environment. Filho et al. [3] and Moore [4] mentioned that when applying the principles of sustainable development to education, one of the obstacles encountered is a desire for synergy across various learning areas in the school system. ESD requires interdisciplinary research and teaching. It is one of the essential educational activities in university education to design sustainable courses to trigger and foster students’ awareness of sustainability. Filho [10] put forward the direction of ESD and emphasized the significance of local contexts and cultural particularities. Each geographical area and society encounters different environmental and resource crises, and the local humanistic values and cultures involved also vary. As a result, when designing an ESD course, it is necessary to consider the uniqueness of the society in which a higher education institution is located and focus on solving local problems. Such courses prioritizing local cultural context are close to the daily lives of students and can also support and develop together with the local community.

The implementation of ESD in Taiwan’s universities is centered on the establishment of centers, departments, institutes, and academic programs. Most of its content is scientifically oriented, such as environmental engineering, architecture, energy, and green technology. However, there is a lack of sustainable learning in the field of humanities. Taiwanese scholar Ho [6] suggested that colleges and universities are academic hubs for the transmission and innovation of knowledge and the nurturing of promising youths. If students are trained to work for sustainability, the environment, economy, and society will continue to flourish, which not only meets the needs of this generation but also does not jeopardize the well-being of future generations [11].

2.2. ESD and Future Development of University Design Courses—Application of Problem-Based Learning Theory

In terms of the international and Taiwanese higher education trends under the abovementioned SDGs, there are three aspects that need improvements. First, transdisciplinary research and teaching are required when applying the principles of sustainable development to education [3,4]. Second, when designing an ESD course, it is necessary to underline the significance of local contexts and cultural particularities, consider the uniqueness of the society in which a higher education institution is located, and focus on solving local problems [10]. Third, Taiwanese universities are lacking in sustainable learning in the field of humanities, and Taiwan’s arrangements for ESD rarely think about learning among learners, such as the cultivation of global, world, and sustainable citizenship. As design educators, we have also reflected on the fact that previous design courses tend to concentrate on the transfer of professional design knowledge and skills and lack the connection to sustainable issues about the local living environment. Many scholars have recently focused and expressed their views on university design courses. Liao [12] argued that university art and design courses should attach importance to the living environment and explore relevant issues, with the living environment as the theme of design courses. Design educators Hwang and Su [13] suggested that when academics step out of the classroom and face environmental conditions, the problem awareness will be further extended, generating a mindset that strives to clarify knowledge but also confronts the challenge of “how to help solve environmental problems.” The abovementioned literature shows the importance of connecting design courses with the social living environment. Therefore, in addition to teaching design principles and professional skills, we need to think about how to break through the original framework and guide students to care about local contexts and the reality of environmental sustainability. By dealing
with practical problems in the living environment, students can propose solutions, turn them into
design, and perform the design integration of interdisciplinary “sustainable development in practice,”
thus reexamining the connection between design courses and society.

Liao [12] implied that the recently emerging problem-based learning (PBL) strategy meets the
requirements of innovative teaching in university education and is suitable for integration into design
teaching. Many scholars [14–16] have also argued that the PBL strategy can place learners in meaningful
learning scenarios where problem solving in real-life scenarios is the main learning focus, while teachers
provide guidance to enable learners to acquire knowledge and develop problem-solving capabilities.
According to a study by Chen [17], there are six steps in the implementation of PBL teaching strategies:
(1) Learners are assigned to solve a practical problem; (2) group members discuss and analyze the
problem; (3) learners gather and share relevant information; (4) learners devise solutions; (5) group
members submit a problem report; and, (6) learning evaluation and reflection. The present study
integrates the above academic theories and practical design principles and applies PBL teaching theory
to the teaching process of the “Game Design Theory and Practice” course. The six steps are as follows:

The first step is to identify the problem: Students are assigned to solve a local environmental
problem, which is a motivation for learning. After identifying and focusing on problems in the living
environment, they are asked to devise solutions step by step.

The second step is to discuss and analyze the problem: The emphasis is on interactive discussion
among learners to analyze the problem and gather and share information. The course adopts a
grouping method to form a team for brainstorming and practical creation.

The third step is to devise solutions: Learners devise possible solutions to the outstanding
problem. Besides encouraging group members to think about the problem, importance is also attached
to dialogue and interaction among group members, teachers, and students to stimulate more reflection.

The fourth step is to evaluate the solutions: Learners learn to evaluate and reflect, apply the
knowledge and skills learned to problem solving, and develop the wisdom and critical thinking ability
to solve the problem.

The fifth step is solution visualization: After the members brainstorm, conceive conflicts, and
reach a consensus, they choose a solution to present its design concept in visual images.

The sixth step is to publish and display the results: Two formats are used in the course—a
classroom design report and a public exhibition at the end of the semester so that students will learn
about how their peers use design to solve problems.

2.3. Table Game Design and Design Practice

The two main elements of game design in the “Game Design Theory and Practice” design
course are “game elements” and “game mechanics.” “Game elements” refer to the basic elements that
constitute the game and are the basis that guides the whole game process, while “game mechanics” are
designed to optimize and reinforce game elements [18]. Hunicke, LeBlanc, and Zubek [19] proposed
the mechanics-dynamics-aesthetics (MDA) game framework. In the framework, the mechanics in
question are the rules that guide the game, namely the rules and goals of the game, dynamics is the
interactive behavior derived from game mechanics, and aesthetic refers to the feelings and experiences
of the player during the process. This MDA game framework is primarily used in the present study
because its framework is complete and covers the main concepts of game design. There are three
practical methods of board game design for the “Game Design Theory and Practice” course, which are
as follows:

2.3.1. Iterative Design Pattern

According to Zichermann [20], the iterative design process should include the following four
steps: Prototype design, prototype testing, results analysis, and corrections, then repeating the process.
2.3.2. Analysis, Design, Development, Implementation, Evaluation (ADDIE) Mode

ADDIE represents the five stages of analysis, design, development, implementation, and evaluation. ADDIE mode is an effective instructional system design for developing board game designs, which is described below. (1) Analysis: The designer should list the development information of the issue and analyze the issue and the player’s prior knowledge and needs [21]. (2) Design: The designer should describe the specific details of the finished products, including goals, design concepts, content, interface design, and game process design [22]. (3) Development: The designer should combine all the designs, including board game components, game manuals, and game rules [23]. (4) Implementation: Design peers test the game so that the designer can make corrections and improvements from the feedback given [24,25]. (5) Evaluation: The summative evaluation should consider the consistency of the content and goal, the completeness of the content, applicability, and the satisfaction of players [26].

2.3.3. Cyclic Mode

Lin and Lai [27] put forward a cyclic mode for board game design which divides board game design into the following five stages. (1) Task analysis needs to gather information required for creative issues, background knowledge about design, technology, and player needs. (2) Design concept: Relate the observed material to the elements related to the theme, adopt methods such as brainstorming and mind mapping to create and ultimately share creative ideas with members. (3) Mechanics creation defines the four decisive features of the game: Goals, rules, feedback system, and voluntary participation. (4) Prototype implementation refers to making prototypes of board games for internal testing. (5) Testing is conducted on a board game prototype, and subjective and objective feedback is collected from general players after trial play.

This study used the ADDIE mode as the main practical design method, which was supplemented by the cyclic mode for educational board game design proposed by Lin and Lai [27].

2.4. The Significance of Integrating Environmental Sustainability Issues into the “Game Design Theory and Practice” Design Course

In view of the shortcomings in previous studies, this study adopts a transdisciplinary approach and focuses on Taiwan’s local context and cultural particularities. To solve local problems, we will lay emphasis on local cultural context and make up for sustainable learning in the field of humanities and arts at colleges and universities in Taiwan, while taking into consideration the cultivation of world citizenship. This study argues that university design education should be concerned with the sustainability of the living environment in the process of fostering education, and, from the standpoint of educators and researchers, think about how to inspire students to care about the pulse of the sustainable development of the Earth through the guidance and planning of design courses. Moreover, the issues surrounding local environmental sustainability can be integrated with the design majors at colleges and universities so that students can adopt design as a strategy to care for the sustainable development of the Earth and fulfill their responsibilities as world citizens.

Yamazaki [28] pointed out that “design” is the process and method of problem solving, through which people plan and design together to solve the issues of and care for the living environment. Keller and Sandlin [29] also indicated that design education is a type of collaborative participation in which the engagement and interaction of participants will affect the creation. In line with the abovementioned studies, this study suggests that the extension and implementation of design courses can be introduced and deepened from the issues of living environment, thus developing learners’ positive attitudes towards the sustainability of the living environment and changing their behavior to practice environmental sustainability. The design content focuses on the problems encountered by Taiwan’s local environment which can be regarded as a starting point. Through learning and interaction, environmental sustainability issues can be transformed and presented in design creation. Through the implementation of the “Game Design Theory and Practice” design course, this study aims
to solve various problems in daily life and guide students to understand and confront environmental sustainability issues together.

3. Research Method and Process

3.1. Methods

Following the action research method, this study focuses on solving practical problems in the social environment and the completion of practice through participation in practical creation, constructs a collaborative and synergistic relationship among group members, and emphasizes phased reflection and response. Using action research, this course uses the constant “raising” of questions as the impetus for course improvement and spiral dialogue, refines reflective knowledge, expands the horizon of course practice, and places course issues in the context of environmental sustainability. The researcher, who is also a teacher, intends to use the course planning of “Game Design Theory and Practice” design course to motivate students to explore “environmental sustainability issues” and use the course as a strategy to help solve environmental sustainability issues. In this way, learners are able to look into and address problems, use a wide range of solutions to communicate and interact with problems arising from the social environment, participate in the social living environment, and learn to deal with the diversity of the social living environment. The action research is described in detail below.

3.2. Subjects

The subjects were junior students in the department of creative life design. The “Game Design Theory and Practice” design course was an elective course for junior students in the first semester of 2019 with 45 students enrolled. The course action research was divided into five stages which are shown in Table 1—Course Framework. All students had the ability to construct shapes, modeling skills, and 3D computer graphics skills and were grouped in fives.

| Table 1. Course framework of “Game Design Theory and Practice”. |
|---------------------------------------------------------------|
| **Course Content Planning**                                  | **Course Content and Cyclic Experience** |
| Phase 1 (Weeks 1–5)                                          | • Introduction to game design theory |
| 1. Lectures on game design theory                            | • Description of United Nations’ SDGs |
| 2. Teaching instructions on United Nations’ Sustainable      | • Discover the real-life problems of local environmental sustainability issues in Taiwan |
| Development Goals (SDGs)                                     | • Discuss and analyze the problems |
| 3. Current status and analysis of local environmental         | • Development of game design concept |
| sustainability issues in Taiwan                             | • Produce possible solutions |
| 4. The designer should observe and raise questions about     | • Evaluate design solutions |
| local environmental sustainability in Taiwan                  |                                           |
| 5. The designer identifies issues, needs, and the player’s   |                                           |
| prior knowledge                                              |                                           |
| Phase 2 (Weeks 6–10)                                         |                                           |
| 1. Teaching and case analysis of design methods               |                                           |
| 2. The designer should describe the specific details of the  |                                           |
| finished product                                             |                                           |
| 3. The designer should design game rules                      |                                           |
| 4. The designer should design game maps, characters, and     |                                           |
| objects                                                      |                                           |
| Phase 3 (Weeks 11–15)                                        | • Game design implementation |
| 1. The designer assembles all the designs according to the   | • Solution visualization |
| blueprint                                                    |                                           |
| 2. The designer develops board game components and game     |                                           |
| teaching manuals                                             |                                           |
### Table 1. Cont.

| Course Content Planning | Course Content and Cyclic Experience |
|-------------------------|--------------------------------------|
|                         | First cycle                          |
| 1. The designer guides design peers to test | 1. Identify real-life problems in sustainable development |
| 2. Make corrections and improvements from the feedback given by design peers | 2. Discuss and analyze problems |
|                         | 3. Produce possible solutions |
|                         | 4. Evaluate design solutions |
|                         | 5. Solution visualization |
|                         | 6. Achievements publication and exhibition |
|                         | 7. Feeling feedback from each other |
|                         | 8. Be the basis for the next action |
| Phase 4 (Weeks 16–17)  |                                      |
| Teacher’s reflection    |                                      |
| 1. This is a preliminary test |                                      |
| 2. Return to Phase 2 and Phase 3 to make adjustments and corrections after discovering problems in this test phase |                                      |
| 3. Guide students to make design corrections based on peer feedback |                                      |
|                         | Second cycle                         |
| 1. Teachers should disclose knowledge and hold evaluation exhibitions | 1. Identify real-life problems in sustainable development |
| 2. Make corrections and improvements from the feedback from players | 2. Discuss and analyze problems |
| 3. The summative evaluation of the course should consider the consistency of the teaching content and objectives as well as the completeness of the teaching content | 3. Produce possible solutions |
|                         | 4. Evaluate design solutions |
|                         | 5. Solution visualization |
|                         | 6. Achievements publication and exhibition |
|                         | 7. Feeling feedback from each other |
|                         | 8. Be the basis for the next action |
| Phase 5 (Week 18)       |                                      |
| Teacher’s reflection    |                                      |
| 1. Return to Phase 2 and Phase 3 to make adjustments and corrections after discovering problems in this test phase |                                      |
| 2. Game design is a cyclic, spiral journey |                                      |
| 3. The summative evaluation results and the problems found will be used as a basis for improvement in the next phase of teaching |                                      |

### 3.3. Process

The process of this study is as follows: Identify and define problems in the previous “Game Design Theory and Practice” design course; draw up a feasible action plan; plan after adjustments; take action to implement the plan and integrate PBL learning theory and the ADDIE method into the course framework and content; observe and reflect after the implementation of the plan; and ultimately, disclose the knowledge.

#### 3.3.1. Identify and Define Problems

In the past, this course was limited to theoretical teaching and case analysis, with the teacher teaching in a one-way manner and students listening and practicing, lacking peer discussion and brainstorming. Although students could produce aesthetic and interesting game works, they had neither true understanding nor concern for the environment in which they grew up. Thus, we attempted to adjust the course so that students could apply the theories and practical methods they have learned to address environmental sustainability issues.

#### 3.3.2. Draw up a Feasible Action Plan

**Step 1: Develop course framework and content**

The course lasted 18 weeks. In the first stage (Weeks 1–5), the teacher guided the students to discover the current status and analyze the environmental issues in Taiwan to identify existing problems. In the second stage (Weeks 6–10), through creative thinking, the designer had to devise possible solutions, evaluate the design solutions, and set up the design concept, issue content, game map,
characters, and objects. In the third stage (Weeks 11–15), the designer assembled all the designs according to the blueprint and developed the game manual and game rules. In the fourth stage (Weeks 16–17), the designer guided peers to conduct testing and made corrections and improvements from the feedback given. In the fifth stage (Week 18), teachers were required to disclose their knowledge and conduct evaluation exhibitions. The summative evaluation should consider the consistency of the teaching content and objectives as well as the completeness of the teaching content. Table 1 shows the course framework and activities.

Step 2: Integrate the ADDIE mode into the practical design process (Stage 2–4)

First, task analysis of the integration of environmental sustainability issues into the game (analysis): Gather information required for environmental issues, background knowledge about design, technology, and player needs.

Second, design a concept of the integration of environmental sustainability issues into the game (design): Relate the observed and collected material to data on issues and design elements, adopt methods such as brainstorming and mind mapping to create, and share creative ideas with group members.

Third, mechanics design and creation of the integration of environmental sustainability issues into the game (development): Design the goals, rules, and feedback system of the game.

Fourth, prototype implementation of the integration of environmental sustainability issues into the game (implementation): Produce a prototype of the board game for internal testing.

Fifth, testing of the integration of environmental sustainability issues into the game (evaluation): Design peers test the board game prototype and give feedback after trial play so that the designer can collect subjective and objective feedback and make corrections and improvements.

3.3.3. Plan After Reflection

This study takes the four key components of spiral cyclic mode in the action research, namely planning, action, observation, and reflection, as the basis of the five-stage teaching research.

3.3.4. Take Action to Implement the Plan

The course plan in this study allows students to discuss and identify practical problems of environmental sustainability through collaboration among members, propose feasible solutions, and transform them into practical designs. The PBL mode was used to propose specific solutions, namely the implementation framework and content of the course (Table 1), whereas the ADDIE mode was applied from the second stage to the fourth stage.

3.3.5. Tools

The tools in this study include student interviews, questionnaire surveys, class photos, evaluation of students’ creations, teacher logs, and player interviews. The collected data was coded and analyzed according to attributes and viewed as a basis for course improvement.

3.3.6. Access to Knowledge and Exhibitions

A public evaluation exhibition of the course was held in the 18th week, where players, teachers, and students exchange ideas.

4. Results

Table 2 shows the coding data collected in the course; Table 3 shows the questionnaire survey result before course learning; Table 4 shows the questionnaire survey result at the end of the course learning; Table 5 shows the course practice process; and, Figure 1 shows student creations. Appendix A shows interview questions with students at the end of the course learning, and Table A1 in Appendix B shows player questionnaire design. The questionnaire was designed based on the purpose of this
study. The interview questions were designed to understand the learning effectiveness of students and players on sustainable development issues through the questionnaire after the game design course (Appendix C).

Table 2. Coding data collected in the course.

| Research Tool                      | Example               | Meaning of Code                                                                 |
|------------------------------------|-----------------------|---------------------------------------------------------------------------------|
| Student interview                  | S I 01-Q1-20200105    | S 01 stands for the first student, I for interview, Q for question, and 20200105 for date. |
| Player interview                   | PI 01-Q3-20200112     | P 01 stands for the first student, I for interview, Q for question, and 20200112 for date. |
| Teacher’s reflection diary         | TD-20200115           | TD stands for teacher’s diary and 20200115 for date.                             |
| TA’s observation weekly journal    | TA-Week01-01          | TA stands for research assistant, Week01 for the week, and for the document code. |
| Students’ creation evaluation      | SC-Week03             | SC stands for students’ creation and week03 for the week.                        |

Table 3. Questionnaire survey result before course learning.

| Question                                                                 | Mean |
|--------------------------------------------------------------------------|------|
| 1. Do you comprehend Earth sustainable development goals before taking this course? | 2.50 |
| 2. Do you understand the dilemma of sustainable development encountered on the Earth? | 2.67 |
| 3. Do you understand how to apply your professional skills to transform sustainable development issues into design? | 3.00 |

Note: This is a 1–5 scale, with the larger number representing the higher agreement.

Table 4. Questionnaire survey result at the end of the course learning.

| Question                                                                 | Mean |
|--------------------------------------------------------------------------|------|
| 1. Do you comprehend Earth sustainable development goals after taking this course? | 4.57 |
| 2. Do you understand the sustainable development dilemma encountered on the Earth after the sustainability integrated course? | 4.67 |
| 3. Do you understand how to apply your professional skills to transform sustainable development issues into design after this course? | 4.81 |
**Table 4. Cont.**

| Question                                                                 | Mean |
|-------------------------------------------------------------------------|------|
| 4. Does the comprehension of United Nations’ sustainable development issues assist in your design? | 4.13 |
| 5. Do you acquire more cross-discipline knowledge from the game design with United Nations’ sustainable development as the topic? | 4.51 |
| 6. Does the use of United Nations’ sustainable development goals as the topic for solving the dilemma encountered on the Earth help you promote the integration of design practice? | 4.79 |
| 7. Do you have deeper comprehension of the dilemma of Earth sustainable development goals after this course? | 4.57 |
| 8. Do you understand your social responsibility for sustainable development after the course mapping? | 4.56 |
| 9. Do you agree that using United Nations’ sustainable development for the design could better realize the concerns about the Earth (world)? | 4.62 |
| 10. Do you receive the sense of achievement in the game design course with United Nations’ sustainable development as the topic? | 4.83 |

**Note:** This is a 1–5 scale, with the larger number representing the higher agreement.

**Table 5. Teaching assistant’s record in the course practice process.**

| Phase 1 (Week 1–5) | Eco Bridge | House Fall |
|--------------------|------------|------------|
| • Discover real-life local problems in Taiwan | 1. Issue: The construction of highways in Taiwan compresses the survival space of leopard cats. | 1. Issue: Land subsidence in Taiwan results in disasters. |
| • Discuss and analyze the problems | 2. Solution for the issue: To appeal for the original living environment of leopard cats being persecuted and compressed, this group of students concern about leopard cats through the construction of ecological bridge and integrate such an idea into the game design, expecting that players could comprehend the importance of leopard cats being protected in order to maintain ecological sustainability (TA-Week03-01) | 2. Solution for the issue: In order to deliver the disaster caused by land subsidence in Taiwan and the mutual effects among disasters, this groups of students design the game to introduce the generation, prevention, and reflection of disasters, allowing players enjoying the game and thinking of the profound damage of land subsidence on environmental sustainability (TA-Week03-06) |
| Phase 2 (Week 6–10) | Eco Bridge | House Fall |
|---------------------|------------|------------|
| • Produce possible solutions | (TA-Week06-01) | (TA-Week06-06) |
| • Evaluate design solutions | (TA-Week06-06) | |

| Phase 3 (Week 11–15) | Eco Bridge | House Fall |
|---------------------|------------|------------|
| • Solution visualization-construct prototype | (TA-Week11-01) | (TA-Week11-06) |

| Phase 4 (Week 16–17) | Eco Bridge | House Fall |
|---------------------|------------|------------|
| • The designer guides design peers to test | (TA-Week16-01) | (TA-Week16-06) |
| • Make corrections and improvements based on feedback from design peers | (TA-Week16-06) | |

| Phase 5 (Week 18) | Eco Bridge | House Fall |
|------------------|------------|------------|
| • Game design is a cyclic, spiral journey | (TA-Week18-01) | (TA-Week18-06) |
| • The summative evaluation results and the problems found will be used as a basis for improvement in the next phase of teaching | (TA-Week18-06) | |
5. Discussion

Based on Section 4, in Table 3, the mean for Question 1 is 2.50 and for Question 2, 2.67. In Table 4, the mean for Question 1 is 4.57, for Question 2, 4.67, and for Question 9, 4.62. It revealed that the students using environmental sustainability issues for design could better reflect their concern for environmental issues in Taiwan and worldwide. It also revealed that integration of environmental sustainability issues into the “Game Design Theory and Practice” design course can inspire university students to understand environmental issues and care for the environment.

Based on Section 4, in Table 4, the mean for Question 3 is 4.81 and for Question 4 is 4.53. It can be verified that the students learned how to use professional skills to transform environmental sustainability issues into design and found that knowledge on environmental issues could help with game design. In Table 4, the mean for Question 5 is 4.51 and for Question 6 is 4.79. It revealed that the students believed integration of environmental sustainability into game design could provide them with more transdisciplinary knowledge and improve the integration of design practice. Other implementation effectiveness of the course is demonstrated as follows:

Students found the interactive communication process of the design course interesting, fulfilling, and creative. Brainstorming for issues of concern is more problem-solving than in previous courses, even struggling and dealing with lots of problem and challenges in the process, there are many creative ideas hitting students in the game development process. It can be evidenced by the following interviews:

“Discussing and exchanging ideas about design with group members enabled me to come up with different creative ideas” (SI35-Q3-0111). “Initially it is difficult, but finally it is quite fulfilling to have the game design results on display in its entirety and be recognized by players”. (SI36-Q3-0112)

This course had a positive effect on students, and they were able to better understand the sustainable development of the Earth. This can be verified by the mean (4.83) for Question 10 in Table 4. Further, it can be evidenced by the following interviews:
“Incorporating sustainability issues in an interesting way is very friendly and gives a better understanding of what SDGs are all about”. (SI13-Q6-0110)

This course planning could help students to think in a multi-perspectives way, enhance their integrated design ability, and develop an international outlook. Also, transforming the ways to address the issues on the Earth into game mechanics makes the rules meaningful and is very special. It can be evidenced by the following interviews:

“Design helps me develop multi-faceted thinking and the ability of integrated game design” (SI23-Q7-0110). “During game design, I can consider the development of all dimensions and have an international outlook”. (SI32-Q7-0112)

According to the results of the interviews conducted after the student-designed games were tested by players, it revealed that players were positively affected and the effects of games on players are detailed as follows.

Players understood that arbitrary development would lead to environmental destruction and subsidence through the game participation process. Through the fun and interesting game, players learned of the composition of the stratum, the geological composition, the causes of subsidence, and the importance of the foundation. This could be evidenced by the following interview.

“We often see the subsidence of the stratum but don’t know why. It turns out that man-made development, ground water extraction, construction of high-rise buildings, and mining have caused changes in stratum structure and we really need to strike a balance between development and the environment”. (PI09-Q3-20200112)

Players understood the urgency of protecting ecological diversity through game participation. Players often see news about the killing of Taiwanese leopard cats and black bears. After players played the Eco Bridge game, they thought it was urgent and meaningful to protect migratory animals in this way. This could be evidenced by the following interview.

“Through this game, we can understand the concept of eco bridges and reflect on the serious damage to the natural environment”. (PI02-Q3-20200112)

Based on the above interview and questionnaire survey results, there are five primary aspects in the course development model of integrating environmental sustainability issues into “Game Design Theory and Practice” (Figure 2).

(1) Introduction of local environmental sustainability issues: By examining and reflecting on the current issues faced by the living environment in Taiwan, students shifted from the discussion of real-life problems in the local environment into practical problem solving and concern, and then turned the concern and appeal into practical design. This not only gave students a sense of accomplishment, but also made players realize that Taiwan’s environment and diverse ecological issues are important.

(2) Introduction of appropriate design methods by teachers: In this study, we found from course implementation that the role of the teacher has changed from a top-down transmitter of linear game design knowledge to a facilitator of discussion. The PBL model and game design method (ADDIE) were applied to promote the possibility of co-learning and co-creation among students, group members, and players. Teachers should inspire students to actively participate in discussions, manage time to provoke different opinions, and act as problem listeners to integrate more creative views, and try to lead them to “use design to solve and care for environmental sustainability issues.”
Promotion of students’ participation in design thinking and discussion by teachers: Students contributed their professional design knowledge to demonstrate and care for the living environment issues through action, and produced a sense of application of what they have learned. Teachers should encourage students to ask questions and solve problems in real-life scenarios and proactively seek interaction and cooperation with group members to address problems, thus developing students’ concern for environmental sustainability. This allows students to change from passive listeners to questioners, practical creators, and communicators.

Design corrections based on the feedback from players: In the past, students often considered their initial designs perfect. However, by listening to players’ feedback and making many revisions to their designs, they produced quality designs to convince and inspire the players to care about environmental protection and ecological sustainability.

Interaction and communication between different characters: Through the brainstorming process of “Game Design,” teachers, students, and players were united, and design students and players were invited to care about environmental issues. With solving environmental problems at the core, they started from understanding local environmental problems and aimed to promote sustainable development through the learning of awareness, knowledge, attitude, design skills, and action.

Figure 2. A model of “design courses on environmental sustainability.”

6. Course Review and Teacher’s Reflection

Several observations were made about the course and are shown below. First, students felt that the course length was too short and there is not enough time to understand the issue and the time frame can be lengthened to deepen the design. Second, students needed more professional knowledge, case analysis, and communication and discussion, and there is a need to share and explore practical cases and for more talks on environmental protection issues. Also, students needed more specialized information and professional knowledge courses, and more in-depth discussions and increased interaction between different groups. Third, students have difficulties in constructing and improving the rules of the game, how to accurately integrate the issues into the game mechanics, objects, characters, and maps, and making models. Fourth, students also had difficulties in making the rapid prototype. The integration issues in game design can be evidenced by the following interviews:

“It is difficult to improve the rules of the game and integrate the issues accurately” (SI21-Q4-20200110).

“It is a big challenge to think about issues and integrate the feelings about issues into the player’s experience and making rapid prototype is a bit difficult and challenging” . (SI23-Q4-20200111)
In response to the above-mentioned course review and the difficulties students encountered in their learning process, teachers reflect on the following. The time frame should be lengthened to let students have enough time to understand the issue and improve the design and build the design rapid prototype. Also, it is necessary to invite environmental experts to analyze and explain more professional courses on environmental sustainability and it is essential to improve the course explanation on the design of game mechanics and explain how to accurately integrate the issues into the game mechanics, objects, characters, and maps. More in-depth discussions and increased interaction between different groups are needed. Students have insufficient ability to make rapid prototype, so teachers who make rapid prototype need to participate in teaching.

7. Conclusions and Suggestion

From the analysis of the collected data, the following conclusions can be reached.

(1) The integration of local environmental sustainability issues into the “Game Design Theory and Practice” design course can inspire university students to understand environmental issues and express concern for human sustainability.

From the questionnaire results and student interviews, students believed that, after taking this course, they could understand global SDGs and the dilemmas over local sustainable development. In addition, they argued that using environmental sustainability for design could better display their concern for environmental issues in Taiwan and worldwide. This echoes Filho’s view [3] that the design of ESD should center on local contexts and cultural particularities, consider the uniqueness of the society in which a higher education institution is located, and lay emphasis on solving local problems. Such course design prioritizing local cultural context is close to the daily lives of students and will easily resonate with them.

(2) The implementation of the integration of environmental sustainability issues into the “Game Design Theory and Practice” design course has positive effects.

Students understood how to use professional skills to transform environmental sustainability issues into design and found that understanding environmental issues facilitates game design. They also felt that integrating environmental sustainability into game design could provide them with more transdisciplinary knowledge and help improve the integration of design practice. Moreover, they deemed the interactive process of this design course interesting, fulfilling, and creative.

(3) The integration of environmental sustainability issues into game design can be used as a method and tool to promote students and players to assume sustainable citizenship.

Through the integration of sustainable issues into the design of board games, we have found that games can be used as a method and tool to promote sustainable citizenship. Students (designers) presented various environmental issues through game production and gathered players by playing games. Players were pleasingly engaged in the game and discussed the causes and consequences of environmental damage. This allows players to reflect on the destruction of the natural environment and the need for civic responsibility, which is much more effective than a teacher’s autonomous appeal to protect the natural environment.

(4) This study has constructed a development model of “design courses on environmental sustainability.”

The primary aspects in this development model include:

- The introduction of sustainable development issues;
- The introduction of design methods by teachers;
• The promotion of students’ participation in design thinking and discussion;
• Design corrections based on users’ feedback;
• Interaction and communication between different characters, including teachers, students, players, and experts.

(5) This course helps students to develop multi-faceted thinking and enhance their ability to integrate meaningful game design.

It is necessary to build a meaningful game design oriented to players (users), so that players find the task engaging and gain internalized experience. First, it is important to make players feel that goals are meaningful, so that they are more likely to produce spontaneous behavior; moreover, users need to feel that the game content is meaningful. Then, the game context should be relevant to the player’s life, thereby guiding the player to evolve. Only when the user’s background and viewpoint match the game context can the user be influenced by the game context to satisfy their motivations. This echoes the theories of situational relevance and situated motivational affordance proposed by Deterding [30] and Nicholson [31], respectively.

(6) The “design courses on environmental sustainability” framework planned and implemented in this study has filled a gap in previous studies.

The “design courses on environmental sustainability” framework planned in this study has filled a gap in previous studies. We established interdisciplinary research and teaching in the field of humanistic design to guide design students to connect with their living environment. In this way, in addition to design principles and professional planning skills, design education courses can extend thinking from the connection between the self and the living environment to caring about real-world issues. By handling practical issues in the living environment, we proposed solutions to practical problems in the living environment, transformed them into designs, and carried out transdisciplinary thinking and integration of “practice.” This echoes Sterling’s [9] call that learning is a process of creation, reflection, and participation that trains students to develop the ability to deal with ambiguity and uncertainty. In a dynamic process, learning is about embarking on sustainable living and developing the ability to adapt to the environment.

The following are relevant suggestions on the integration of “environmental sustainability issues” into the planning of “Game Design Theory and Practice” course. In terms of teaching content, the content of the “Game Design Theory and Practice” course should continue to adopt “user-centered” design thinking that considers environmental dilemmas. Students should extend their learning from the technical knowledge of design to study the social context and practical efficiency of problem solving. It is essential to unceasingly participate in and care for our environment with a more open, diversified, and in-depth perspective to shape the students’ long-term concern and empathy for environmental sustainability. The planning of the “Game Design Theory and Practice” course should underline the possibility of co-creation and co-prosperity as well as interdisciplinary integration. The future planning of the course needs to enhance students’ creative thinking and integration of varied fields, including the relevance of topic selection or the hiring of other professionals (environmental scholars, ecologists, and product designers) to participate in teaching and evaluation, thus developing the benefits of co-learning and co-creation. With respect to long-term teaching goals, we aim to impel teachers and students to develop more concern for and action participation in sustainable development issues, as well as more care for, dialogue about, discussion on, and protection of the living environment.

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Appendix A

Interview questions with students at the end of the course learning

1. What are the improvements and suggestions for the game design course with United Nations’ sustainable development as the issue?
2. What other assistance is required for helping you understand more about United Nations’ sustainable development?
3. What is the most interesting part of this course?
4. Do you encounter any difficulties in the game design course?
5. Do you think the game design result presenting the current issues of United Nations’ sustainable development?
6. Does the integration of United Nations’ sustainable development issues into game design help you better comprehend the content of sustainable development?
7. Do you expect to have such innovative game design courses in the future? Why?

Appendix B

| Question | Extremely Disagree | Disagree | Fare | Agree | Extremely Agree |
| --- | --- | --- | --- | --- | --- |
| 1. Present aesthetics? | □ | □ | □ | □ | □ |
| 2. Need to increase new functions? | □ | □ | □ | □ | □ |
| 3. Show easy-understanding game rules? | □ | □ | □ | □ | □ |
| 4. Present innovative game rules? | □ | □ | □ | □ | □ |
| 5. Conform to your behavioral model? | □ | □ | □ | □ | □ |
| 6. Meet your expectation? | □ | □ | □ | □ | □ |
| 7. Easy to access the game? | □ | □ | □ | □ | □ |
| 8. Feel the learnability of the game after playing? | □ | □ | □ | □ | □ |
| 9. Meet your requirement? | □ | □ | □ | □ | □ |
| 10. Feel fun of the game? | □ | □ | □ | □ | □ |

Note: It is a 1–5 scale; the higher score stands for the higher agreement.

Appendix C

Player (user) interview questions

1. How to reinforce the aesthetics (shape, color, material)?
2. What do you understand or learn after playing the game?
3. What is the most impressive part of the game? Which part should be reinforced?

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