Full Length Research Paper

Using Fairy Pitta as a case study for multimedia ecological learning materials

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Fairy Pitta is considered one of the most beautiful and mysterious birds, and is listed as an endangered species by the United Nations. During its reproduction period, they nest in Alishan of Chiayi County and Huben Village of Yunlin County in Taiwan. Under the increased awareness of ecological and environmental protection in recent years, many websites have especially introduced the fairy pitta. However, they have attracted very little attention, as the photos and text descriptions cannot vividly present the beauty of Fairy Pitta. Therefore, this study applies multimedia technology to design a digital system that is user-friendly and can serve as teaching materials, featuring sound effects, games, puzzles, and tests, to introduce the habitat of fairy pitta. This study hopes to promote the understanding of Fairy Pitta and the importance of environmental protection, raise public awareness of environmental conservation, and investigate the opinions of university students on the multimedia ecological teaching materials.

Key words: Fairy Pitta, multimedia, digital learning, environmental conservation, game-based learning.

INTRODUCTION

Fairy Pitta, also known as the Indian Pitta, with the scientific name *Pitta nympha*, is a type of small bird in the Family Pittidae of Order Passeriformes (Endemic Species Research Institute, 2008). Fairy Pitta has bright colors, but seldom seen. Under the increased awareness of ecological and environmental protection in recent years, many websites have especially introduced the Fairy Pitta. The contents of e-Learning websites have three main presentation methods: WebPages, streaming presentation, and scenario simulations. This study aims to use multimedia to design digital materials to introduce Fairy Pitta, in order to raise the public recognition and understanding of ecological sustainability.

Game-based learning can increase students' learning motivations, and inspire self-motivation as they become more interested and curious about the contents. Information on environmental conservation can be presented by multimedia digital systems to trigger users' learning motivations, provide an overall understanding of the species, and define the meaning of ecological environments. In addition, the Internet technology can be used to develop digital ecological archives to promote the importance of environmental conservation.

The purpose of this study is to design multimedia digital learning materials on the Fairy Pitta, and incorporate game-based learning approach with visual and sound effects, in order to deepen users' interest in learning and attract public attention. Such game-based learning strategies can provide an interesting and entertaining introduction of the ecological environment through virtual reality, thus enhancing the public awareness of environmental protection, facilitating family outdoor activities, and improving the effect of parent-child education. In order to investigate learners' opinions on multimedia ecological teaching materials, this study conducts a questionnaire survey that examines students' perspectives and the propriety of the multimedia ecological teaching materials. The research objectives of this study are as follows: (1) to determine the reliability and validity of the questionnaire regarding the multimedia ecological teaching materials, (2) to discover the students' overall opinions of the multimedia ecological teaching materials, and (3) to find out the propriety of the multimedia ecological teaching materials.

LITERATURE REVIEW

Characteristics of digital game-based learning

Games have always played an important role in our lives. Prensky (2001), who promotes digital game-based learning, mentioned that the 21st century is the era of digital game-based learning. Prensky (2001) referred to the generation born after 1975 and grew up along with technology as the G-generation (Game generation). The emergence of the G-generation and the popularity of the personal computer after 1985 triggered the prevalence of digital simulation games. Past studies emphasized on the benefits of games to children's learning, and suggested that games should be included in teaching objectives. Game-based learning can also overcome boredom in the classroom. Rosas et al. (2003) indicated that games are important factors to enhance children's development in cognition and social skills, since children are required to think in order to solve the challenges of the games. They can acquire knowledge and skills while watching others play, and learn how to interact with others. Entertaining digital games and gaming experience can easily attract users to game-based learning. Children's increased exposure to digital games and their impacts have been widely discussed and studied. Digital games are no longer for entertainment only, as studies have proved that they are beneficial in many ways. Hong (2003) suggested that increased intelligence of people from countries with advanced technology and information affluence is not reflected by literacy rates, but rather in the non-literary abilities of dimension and judgment, which is the performance focus of the Raven's (1938) test. Flynn (1987) further analyzed young adults in 20 countries, and found that the main differences of the recent generations is "digital games", as related to computer, TV, and other multimedia. Thus, the increase of non-literary intelligence is very likely resulted from digital games.

Digital learning can also be achieved through Virtual Reality (VR), which uses a microcomputer system and simulator to simulate movements similar to a real environment. Sensory scenarios are created using visual and sound effects for real-time interaction between human and machine. Virtual reality may be defined as, "a science to integrate human with information technology." Burdea (1993) proposed that virtual reality is a high-tech user interface that includes real-time, immersion, and interactive dynamic simulation techniques. It manipulates the multiple senses of humans, allowing smooth immersion into a computer constructed environment with realistic feelings (Tung et al., 2003). Virtual reality covers three dimensions: imagination, interactive relationship, and immersion (Burdea, 1993). The progress of virtual reality techniques allows increased creativity and convenience through different applications. Achieving the result of immersion depends on the computer graphics

and human-machine interaction relationship created by the system.

Digital learning allows users to study anytime and anywhere, and utilize the resources to acquire professional and technical skills. It can strengthen the connection of work, life, research, and society, and improve the ability to adapt to alterations or transitions. In addition, the cost for developing teaching materials can be reduced as material design and course management become ever more convenient. Material contents can be easily updated for a wider range of users, and a national promotion plan could help Taiwan evolving into a digital society. In terms of academic and industrial development, the overall competitiveness of the country can thus be raised in this knowledge economy era.

Immersive learning and game-based learning

Csikszentmihalyi (1975) defined immersion as follows: "Users enter into a mode of common experience. They seem to be absorbed and concentrate their mind on a very narrow scope. Some irrelevant senses and thoughts are filtered out and they lose their ego-self. They only react to certain concrete goals and explicit feedback. They have a sense of control by controlling the environment." In other words, it is "an overall experience that people feel when they are fully immersed in what they are doing" (Moon and Kim, 2001). Ghani and Deshpande (1994) suggested that there are two features of immersion, which are "complete concentration in the activity" and "enjoyment brought from the activity." They also proposed that "cognitive challenge" and "sense of control" are the two main factors affecting the immersion experience, as the effect of the immersion experience allows users to pay attention to the process, not the result, and lose their sense of time. Moon and Kim (2001) argued that the entertaining effects can explain hidden motives, and proposed measurement through "concentration", "curiosity", and "enjoyment" based on Csikszentmihalyi's theory.

Visually oriented people like to use visual tools, such as graphs, charts, and pictures to process information, while verbally oriented people prefer to acquire information through reading or listening to verbal media (Jonassen and Grabowski, 1993). Richardson (1977) found that there are many characteristic differences between visual and verbal orientation. The thought processes of visually orientated people are more concrete, and they prefer to use real objects or imageries to assist their thinking; whereas, the thought processes of verbally orientated people tends to involve the manipulation of abstract symbols. In addition, the thought patterns of visually orientated people are subjective self-orientation, while verbally orientated people are inclined to objective task-orientation. Paivio (1971, 1986) proposed a

dual-coding theory to explain how people collect and process information. He considered that the human cognition system contains verbal related information, such as languages and written words, which are processed, coded, and stored in the verbal system of a vocabulary memory area. The system is also responsible for processing visual imagery information, which is then coded and stored in the imagery system of an imagery memory area. According to Paivio, the human cognition system consists of two presentation systems, verbal and visual, which are connected to assist each other. Theoretically proven, graphs can assist text learning. Mayer (1997) indicated that a good multimedia assisted learning system could help learners to establish effective learning practices. Guo and Chou (2006) suggested that multimedia systems could help learners utilizing working memory to select, organize, and integrate information. In terms of learning effects, visually oriented people perform better with combined graph and text materials, rather than mere texts. The most important principle of multimedia design is the inclusion of visuals, words, and sounds.

The entertaining element of games allow learners to maintain their focus for a longer period of time, which helps to develop higher-level cognitive skills in a more casual and natural manner. Learning effects are further enhanced through participation motivation to accept gaming challenges. Stepping away from traditional educational methods, simulation and gaming activities are designed to raise students' interests, improve their skills, give them a break from tight classroom learning schedules, and provide educational information that users are willing to repeat (Kim and Keiiough, 1991). In game-oriented teaching, digital games feature challenges, spark curiosity, and encourage fantasy and imagination, which are all natural stimulus for arousing students' motivation to learn (Malone, 1980) and stimulating immersive learning. Therefore, game-based learning can voluntarily raise students' learning motivations through interest and curiosity. Game-based teaching methods are also known as game-based computer-assisted learning, and the inherent nature of games makes them attractive to children, young adults, educators, and parents (Hsiao et al., 2005). Ellington et al. (1982) proposed that learning processes of games are more entertaining, learners can remain focused for longer intervals of time; they cultivate higher-level cognitive skills easily and naturally, and appeal to all. Games are the most commonly applied method for training skills of creativity.

Special features of digital games for learning

Kiili (2005) proposed the Experiential Gaming Model, stating that when designing digital learning games, there are three key points to be considered: psychology, education, and game design. In terms of psychology, the purpose of educational games is to provide learners with challenges related to a key mission (that is, learning purpose), and expect that learners would have an opportunity to experience the flow, which refers to a state of mind. Under this state, people would be completely involved and fully immersed in a certain activity (Csikszentmihalyi, 1991), and obtain the best participation experience during the process. When they are in the state of such an experience, they would forget whatever surrounds them, concentrating only on the activity at hand. In a computer-mediated environment, there are certain factors contributing to a user's experience of the flow, which is concentration, clear goals, instant and proper feedback, and desire to control the game, challenges matching one's skill level, and playability and applicability of the game (Chen et al., 1999; Hoffman and Novak, 1996). In terms of education, Kolb (1984) proposed the Experiential Learning Model, which served as a complete theoretical foundation for the integration between game design and education. The model suggests that the nature of learning is a chain of target oriented activities, and it emphasizes on the importance of direct experience and reflective observation. The theory divides learning into four stages: concrete personal experience, observation, and reflection, forming abstract concepts, and testing new concepts. These four stages are cyclic, and stages follow each other in close sequence. In terms of game design, three sets of digital game measurement principles are concluded from literature review, which are: the GameFlow Model (Sweetser and Wyeth, 2005) for general measurements of commercial and entertainment games; the Experiential Gaming Model (Kiili, 2005) for the measurement of educational games; and a specifically designed framework for evaluating game- and simulation-based education games (Freitas and Oliver, 2006).

The GameFlow Model contains eight core elements: concentration, challenge, skills, control, clear goals, feedback, immersion, and social interaction. These are the factors contributing to player enjoyment during the gaming process. The Experiential Gaming Model suggests that factors, such as clear goals, feedback, concentration, applicability, skill development, and game control, affect players' experience of the flow. The framework for evaluating game and simulation-based education games sets its target to help teach designers to design a methodology that can immerse games into teaching scenarios. The framework suggests that four dimensions, which are student, teacher, tools/resources available, and game presentation, should be taken into account in order to design a teaching methodology that can immerse games into teaching scenarios.

In addition to considering the three key points, as mentioned earlier, when designing digital learning games that offer learner enjoyment, some scholars suggested that compared to the design of general commercial
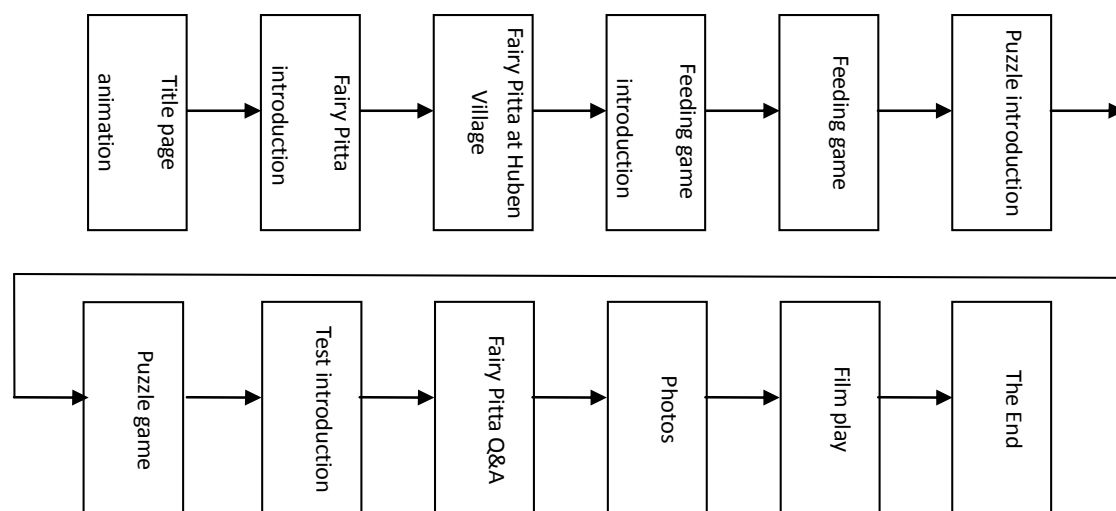
Figure 1. Presentation flow of teaching content of digital Fairy Pitta.

(leisure) games, factors such as situated context in learning, learning theory and application, and learners' (individual and group) quality, should be considered when designing learning games (Freitas and Oliver, 2006). In addition, acquired knowledge varies as learners achieve their goals because their expected learning goals are different (Bloom, 1984; Jonassen, Mayes and McAleese, 1993; Biggs, 1999). Therefore, when designing and applying digital learning games, different styles of games should be designed based on different knowledge levels, knowledge types, and contexts to be applicable to teaching (Prensky, 2001).

RESEARCH METHODS

Construction of teaching content

This study conducted field investigation to collect data on the habitats of Fairy Pitta, and employed multimedia technology to integrate the data and create animated teaching materials. The contents are divided into different units, and presented in various multimedia forms to show the birdcalls, photos, animations, and films of Fairy Pitta. The flow chart of the framework is shown in Figure 1.

Teaching goals

Considering the overall goal of the design of a digital interactive navigational system, this study introduces two user-centered key factors, Usability and Avatar, as the design elements for the Fairy Pitta project. The goal is to integrate the technology of virtual reality within three scenarios, which are immersion, imagination, and interaction, through scenario design in order to create a user-centered digital learning game. This study selects the habitat of the Fairy Pitta, its unique colors, and a storyline as the themes of this design. The learning units include animated entry page, introduction to Fairy Pitta, feeding game, puzzle, and Q&A test. As users are guided to appreciate the digital Fairy Pitta, they are expected to obtain an overall understanding of the bird's features,

habitat, and the significance of digital culture. This study hopes to promote more opportunities for users to access digital archives through the Internet technology and supporting functions of a digital museum. The design concepts of the teaching contents are explained as follows:

1. The design is simple and easy to understand, suitable for use by any age group.
2. The films and photos used in the navigation background of the games are real images recorded at the Fairy Pitta's habitat in the Alishan area of Chiayi County, and the reserved area for Hushan Dam in Huben Village of Linnei Township, Yunlin County. It makes the background more vivid and authentic, while providing a glimpse of scenic areas around the Yunlin and Chiayi regions to users.
3. The design contains educational information, starting with the navigation image of the earth rotating 360°, which magnifies until it is enlarged and focused on the Yunlin and Chiayi regions. As the earth rotates, images of the Fairy Pitta will follow the yearly route of migratory birds to the Yunlin and Chiayi regions. Users can learn about the geographic location, including where the Fairy Pitta migrates to and from their migratory habits, habitats, natural enemies, the effect of the Hushan Dam on their habitat, etc. Menu selection options and entertaining screen shots allow players to understand the Fairy Pitta, and gradually realize the importance of environmental protection as they play the game. The Internet-based lessons, lively music, real photos, films taken at the scene, etc, can leave users with the feeling of a personal connection with environmental protection.

This study applies digital technology to produce colorful Fairy Pitta images, and uses Flash to create a multimedia animated educational game, which allows the users to have a clearly defined understanding of the Fairy Pitta's habitat in Asia. Multimedia animation presents the users with an introduction to the Fairy Pitta's habitats through relevant photos and images. The combination of video/audio/text naturally raises learning interests as well as enhancing memory.

Game-based learning

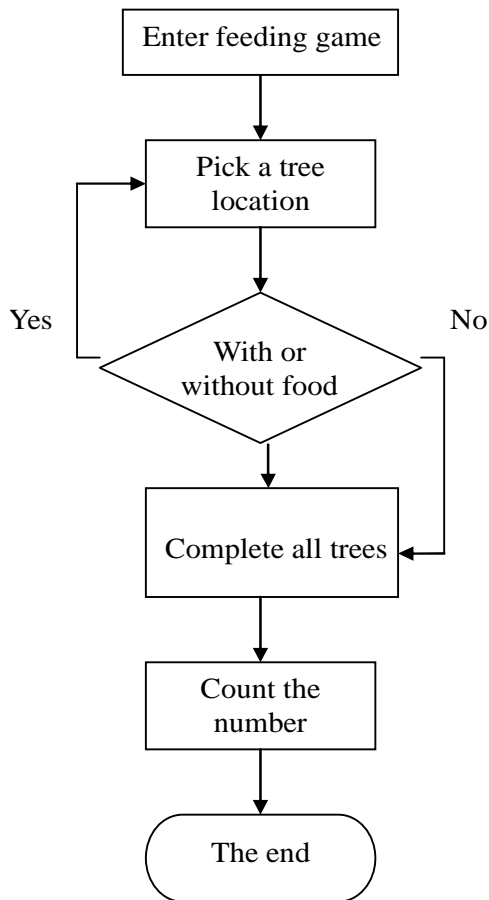This study adopts game-based learning approach in order to

Figure 2. Feeding game structure.

Figure 3. Puzzle game structure.

deepen users' perception and learning interests on digital ecological learning. The units include the Feeding Game, as shown in Figure 2, the Food of Fairy Pitta, and Feeding the Fairy Pitta Game, which allow learners to learn about Fairy Pitta in a pleasant gaming environment. Moreover, this study designs a puzzle with the body parts of the Fairy Pitta to deepen the learners' understanding. Figure 3 shows the puzzle game structure.

Online test

A multimedia test system can quickly and accurately examine students' attained competence, reduce their fear of taking tests, and provide them with proper assistance. Tests can help learners to understand how well they have learned, and help teachers to know how well the learners have learned. In order to allow learners to think and reply in an effective time frame, a 100-s countdown is designed. Those who take the test are able to control their time and know how much time is left to answer. Figure 4 shows the online test structure.

Survey on multimedia ecological teaching materials

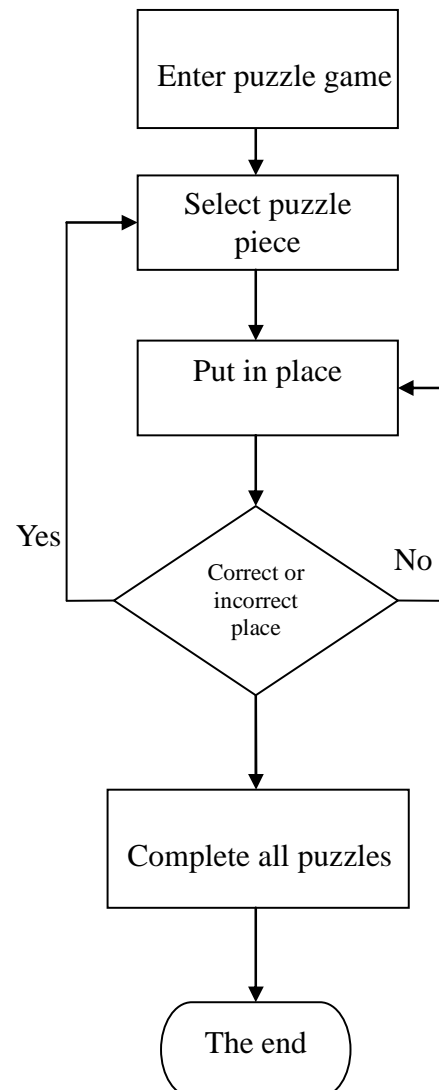The "Survey on Ecological Teaching material for Multimedia   Digital

Learning" is developed by this study. It is based on a five-point Likert scale, and includes four dimensions and 43 items, of which, 10 items are in reference to multimedia ecological knowledge, 6 items are in reference to multimedia learning skills, 8 items are in reference to multimedia learning motives, and 19 items are in reference to the propriety of the teaching materials. In addition, there is one open-ended question. Statistical methods include descriptive statistics, Pearson correlations, and factor analysis.

RESULTS

Sample description

The subjects of this study were freshmen and sophomores of the National Chiayi University. After   they
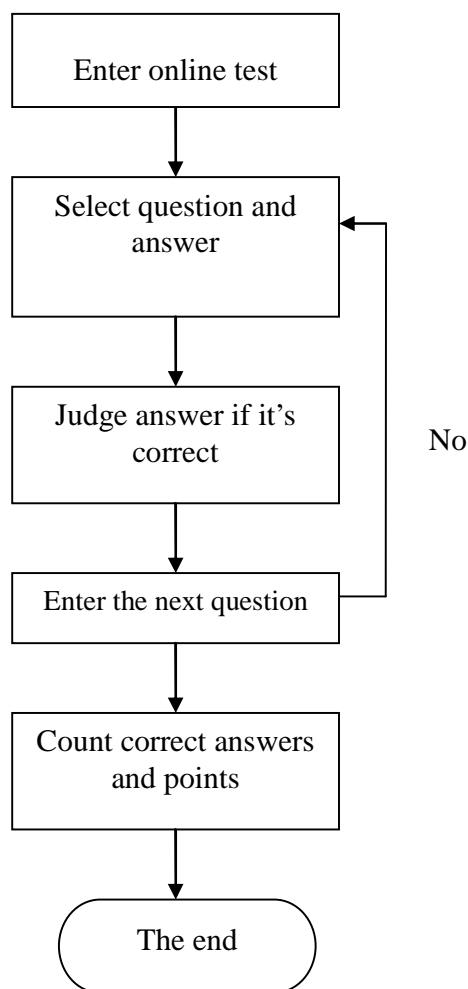
Figure 4. Online test structure.

which are multimedia ecological knowledge, multimedia learning skills, and multimedia learning motives. The propriety of teaching materials is presented in the frequency table. Factor analysis is conducted to test the construct validity. First, the co-factors of the variables were extracted by principal axis factoring, and then the factors with an eigenvalue greater than 1 and screen plot were selected. The factors were rotated by direct oblimin of oblique rotations in order to determine construct validity of the questionnaire.

According to factor analysis, the KMO of the questionnaire is 0.878 > 0.5, the Bartlett Sphericity Test χ^2 is 3044.90, freedom is 276, and significance =0.000 <0.05. Thus, the factors of the questionnaire meet the criteria of stability and consistency.

Reliability analysis

The internal consistency of the questionnaire was tested by Cronbach's α and Pearson product-moment correlation. As Nunnally (1967) suggested, α should be greater than 0.6. The α of questionnaire items is 0.848 in the dimension of multimedia ecological knowledge, 0.916 in multimedia learning skill, and 0.858 in multimedia learning motives. The α of the overall survey items is 0.886. In terms of the dimension and overall score, Pearson correlation coefficient is 0.661 to 0.769 (p < 0.01), reaching statistical significance (0.01). The Pearson coefficient between each dimension is 0.285 to 0.295, indicating good internal consistency reliability.

Students' opinions on multimedia ecological teaching materials

Overall opinions of students

This study analyzed students' overall opinions on multimedia ecological teaching material, and the propriety of the material based on descriptive statistics. Results are presented in Tables 1 and 2. As shown in Table 1, the average score for multimedia ecological knowledge is 4.09, indicating that students have positive response to the knowledge covered in the material; the average score for multimedia learning motives is 3.69, suggesting that students' learning motives are relatively weak; while the average score for multimedia ecological learning material is 3.89, revealing that students gave positive feedback on the teaching materials.

As for the percentage of the propriety of multimedia ecological teaching materials, elementary school (71.1%) is the most appropriate for using the multimedia digital ecological teaching material. If the multimedia ecological teaching material is directed at elementary school students, middle division (51.8%) is the most suitable

received instructions based on the multimedia ecological teaching materials, a questionnaire survey was conducted to discover their opinions on the teaching materials. A total of 272 valid samples were collected, including 94 males and 174 females. Their average age is 21; 251 own a computer, and 6 do not; 213 respondents reported that they use computer on a daily basis, 32 reported that they use it on a weekly basis, 8 reported that they seldom use it, while the remaining 19 gave no answers. The average hours for the completion of the computer lessons were between 2 and 3 h.

Questionnaire reliability and validity

Validity analysis

There are three dimensions in the factor analysis model,

Table 1. Students' overall opinions on multimedia ecological teaching material.

Dimension	Number of questions	Number of respondents	Average	Standard deviation	Number average
Multimedia ecological knowledge	9	262	36.87	5.11	4.09
Multimedia learning skill	8	272	31.31	4.72	3.91
Multimedia learning motives	6	267	22.18	3.80	3.69
All	23	257	90.40	9.87	3.89

Table 2. Percentage table of the propriety of multimedia ecological teaching materials.

1.   What level of education is the most appropriate for using the multimedia digital ecological teaching material? Elementary school (71.1%); Junior high school (16.2%); Senior high school (6.3%); College (1.8%).

2.   If the multimedia ecological teaching material is directed at elementary school students, which grade is the most suitable for the material? Low division (19.5%); Middle division (51.8%); High division (23.5).

3.   How would you rate the coherence of the knowledge descriptions? Very coherent (2.9%); Coherent (37.9%); Moderate (52.9%); Incoherent (4.8%); Very incoherent (0%).

4.   How would you rate the clarity regarding the sequence of the teaching materials? Very clear (5.9%); Clear (55.5%); Moderate (34.6%); Unclear (2.6%); Very unclear (0%).

5.   How would you rate the fitness between the colors of the captions and the pictures? Very appropriate (9.9%); Appropriate (48.5%); Moderate (34.6%); Inappropriate (5.1%); Very inappropriate (0%).

6.   How would you rate the propriety of the background pictures? Very appropriate (9.6%); Appropriate (51.5%); Moderate (37.1%); Inappropriate (0.4%); Very inappropriate (0%).

7.   How would you rate the visual feelings? Very good (9.9%); Good (44.9%); Moderate (40.1%); Bad (3.7%); Very bad (0%).

8.   How would you rate the audio effects? Very good (17.6%); Good (50.4%); Moderate (25.7%); Bad (4.0%); Very bad (0%).

9.   How would you rate the clarity of the layout? Very clear (12.1%); Clear (51.5%); Moderate (32.7%); Unclear (2.2%); Very unclear (0%).

10. How would you rate the clarity of the main content? Very clear (16.9%); Clear (51.5%); Moderate (28.3%); Unclear (1.1%); Very unclear (0.4%).

11. How would you rate the attractiveness of the materials? Very attractive (8.5%); Attractive (36.8%); Moderate (44.9%); Unattractive (8.5%); Very unattractive (0%).

12. How would you rate the difficulty of the knowledge covered by the materials? Very difficult (1.8%); Somewhat difficult (5.5%); Moderate (59.9%); Simple (26.1%); Very simple (5.1%).

13. How would you rate the difficulty of using the materials? Very difficult (0.7%); Somewhat difficult (5.9%); Moderate (49.6%); Simple (33.5%); Very simple (8.5%).

14. How would you rate your understanding regarding the review questions? Well-understood (4.4%); Understood (36.4%); Moderate (52.2%); Poorly understood (5.1%); Barely understood (0.4%).

15. How would you rate your motivation to further understand the Fairy Pitta after reviewing the materials? Very strong (3.7%); Strong (31.3%); Neutral (57.0%); Weak (4.8%); Very weak (1.5%).

Table 2. Contd.

16. How would you rate your motivation to use the materials? Very strong (4.4%); Strong (32.0%); Neutral (48.9%); Weak (11.0%); Very weak (2.2%).

17. How would you rate your motivation to let students use this material? Very strong (11.0%); Strong (43.8%); Neutral (39.0%); Weak (3.7%); Very weak (0.4%).

18. How would you rate the helpfulness of this material on improving parent-child interaction? Very helpful (14.7%); Helpful (56.3%); Moderate (24.6%); Unhelpful (2.9%); Extremely unhelpful (0%).

19. How would you rate the helpfulness of this material on improving peer interaction? Very helpful (6.6%); Helpful (41.9%); Moderate (39.7%); Unhelpful (8.8%); Extremely unhelpful (1.5%).

grade for the material. Most respondents (52.9%) rate moderate the coherence of the knowledge descriptions. Most respondents (55.5%) rate clear the clarity regarding the sequence of the teaching materials? Most respondents (48.5%) rate appropriate for the fitness between the colors of the captions and the pictures? Detailed information is reported in Table 2.

CONCLUSION AND SUGGESTION

Virtual reality technology provides an opportunity for the creation of digital animation of birds. By visualizing their flying and hopping movements, the digital learning platform becomes livelier, which results in raised public interest to participate in learning. Bitgood (1989) mentioned that the standard used to assess a navigation design should be in accordance with the assessment standards of being attractive, sustainable, comprehensive, and user-friendly. The game-based learning design theme of the Fairy Pitta is a real life habitat simulation, presented through virtual reality technology. It also provides theme subjects, such as feeding and puzzle games, which can strengthen thinking abilities and increase user attraction. In addition, other cultural artworks of past years are provided through multimedia presentation for users to better understand the living environment of the Fairy Pitta.

This study applies digital multimedia technology to design interactive games, online tests, and information content of the Fairy Pitta's habitat, which are simple and easy to understand, and can be used for teaching. This digital material is designed to combine the concept of environmental protection with geographical information, and demonstrates the feasibility of blending science education into teaching; moreover. Such material can teach the public about the Fairy Pitta, and the importance of its environmental protection. At the same time, families may enjoy the pleasure of taking a challenge and learning together through an entertaining process. In a

computer-mediated environment, various factors including concentration, clear goals, instant and proper feedback, desire to control the game, proper challenges, playability, and applicability of the game can allow users to experience the flow of the game, while increasing their knowledge of environmental conservation and the ability to recognize the local geography of Yunlin and Chiayi Counties. This study also hopes to inspire more digital educational materials on the conservation of animals, as well as a multimedia encyclopedia on ecology. Moreover, by teaching students the value of the environment and nurturing positive attitudes toward it, they could appreciate nature and embrace environmental protection. Moreover, they could gain the ability to think independently on the environmental issue, develop good judgments, learn how to appreciate and accept different cultures, and how to care for different ecological groups. Connecting environment related experiences with learning activity renders lesson content relative to life.

Base on literature reviews and empirical investigation, this study probes into students' opinions on multimedia ecological teaching materials. Conclusions and suggestions for educators and researchers are as follows.

1. In general, students gave positive feedback on the multimedia ecological teaching materials;
2. Multimedia ecological teaching materials are appropriate for students;
3. The reliability and validity of the survey on ecological teaching materials for multimedia learning is good.

The suggestions for future studies are as follows: (1) As information technology develops, there is more software for the production of diverse digital teaching materials. The study suggests that researchers could try to use other software to conduct future analysis. (2) This study could employ only limited types of educational resources, and the subjects were limited to students of the National Chiayi University. Future studies can expand the sample

scope to cover wider age groups and different regions.

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