A system for Learning Ecology with 3D graphics and Local Materials Database

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Learning about preserving the natural environment has become more important than ever before. While there is a variety of material available on the Internet that gives informatin about environmental issues, there is little material for learning ecology. Therefore we have developed an ecology learning system using locally relevant materials; in our case, the ecology of Lake Shinji. Our system is constructed with a simulation of water clarity of the lake and a database for creatures living in the lake. With this system, users can simulate water clarity in the lake. The relationship between environmental parameters and water quality in the lake can be shown with 3D graphics. In addition, we used XML to construct an ecology database that has data and movies of creatures living in the lake. Twenty students learning ecology tried this system and evaluated it. The result showed that they found the simulation of water clarity and database useful and helpful for understanding ecology of the lake and environmental pollution. Additionally, they evaluated that the variety of access methods made the ecology database easy to use.

Keywords Ecology; e-Learning; 3D graphics; Multimedia database; Simulation

1. Introduction

As issues on environmental preservation become more important, the number of classes at elementary and junior high schools that focus on environmental preservation is increasing. Various kinds of activities have been utilized in study program. For example, the learning ecology network that was developed as one of the environmental model projects. In this network, issues such as acid rain and the heat-island phenomenon are raised and students can access information about them on the Internet [1]. There are also some web-based modules to help learn about air pollution and living creatures such as fireflies [2]. Though learning resources for environmental preservation can be found on the Internet, it is difficult to find equivalent ecology sources. The few sites that exist are information based only, and are usually not attractive or interactive enough to appeal to learnners [3].

To help resolve these limitations in available learning resources, we planned to develop an interactive educational resource for ecology that could be accessed on the Internet. We wanted content that would be relevant to our local users. We think it important to do so, since local contents are more interesting for users and could be expected to help motivate their study on environmental issues. For these reasons, we selected the biotic system of Lake Shinji, large brackish lake in our immediate area. The content of our system focuses on two key components of the ecological system of Lake Shinji, water clarity and living creatures [4]. We also adopted 3D graphics as part of our system since some research reports on effectiveness of a virtual school using 3D have shown these graphics to be useful, helpful, and strong motivation factor [5][6]. We also developed a 'Picture Book Mode' utilizing multimedia in combination with 3D graphics. The 'Picture Book Mode' and 3D graphics are designed to work together to improve educational effectiveness. We tried to design the system to be both attractive and interactive so as to maximize appeal for learners.

2. System Construction

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The 'Eco-system of Lake Shinji' we have developed can be used anywhere on the Internet because it is constructed using Java and XML language.

The system has two modes; 'Water Mode' and 'Picture Book Mode'. Fig.1 shows the construction of the system. The 'Water Mode' is displayed in the 3D space by Java3D. We thought that it was important to give visual cues to understand the changes in environmental conditions. Therefore we show the condition of the lake by displaying fish swimming in the water and 'shijimi' clams living on the bottom of the lake. The influence of environmental parameters on conditions in the lake is shown by changes in water clarity. The clarity of water changes according to changes in chemical oxygen demand (COD) or practical salinity unit (PSU) and the amount of garbage dumped or removed.

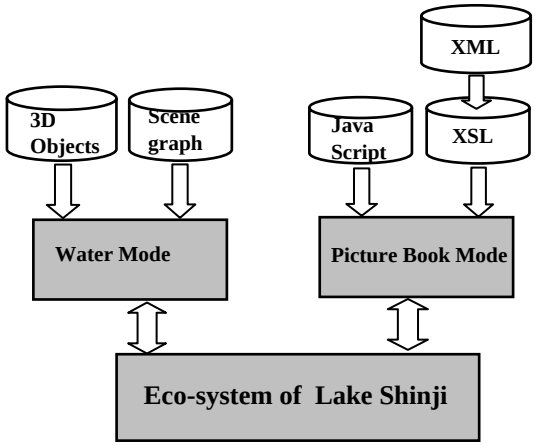

Fig. 1 Construction of 'Eco-system of Lake Shinji'

The databases for living creatures and environmental terms are built by XML language, and folded into 'XML'. To make this database, we collected many pictures, movies and environmental terminology at the Shimane Prefectural Aquarium [7]. A method written with XSLT is used to access XML and it shows data on the screen using JavaScript. XML makes it easier to access the databases, and XSLT helps to show data freely on the screen.

3. Methods of display and Access

Java3D is a graphics API based on Scene Graph written by tree structure. Primarily there is a main Branch Group under the Locale. Another Branch Group manages the display changes of environmental parameters. The processing is improved to be lighter by minimizing redisplay. The number of creatures living in the lake is increased by appending new objects in the Trans Group. The avatar is shown on the screen by adding avatar's object in Platform Geometry Group when the avatar is operated by a keyboard.

The user can use the operation board to change COD and PSU parameters and levels of garbage deposition/collection. Water clarity and the number of creatures living in the lake change according to these parameters. This action is implemented by leaf nodes; recognition of mouse click by SimplePicking, keyboard operation by SimpleKeyBehavior and animation by InterPolator.

We developed four kinds of access mode; a 50-character- kana Syllabary Access Mode, a Keyword Access Mode, a Fuzzy Access Mode and a Term Access Mode. All of them are implemented by use of XML, XSLT and JavaScript language. A user can select an operation from among these four kinds of access modes. The XML database is constructed with tags such as item, ID, reading, image or movies. Replacement of a screen image is executed using a replacement function constructed with JavaScript, which is defined in the SELECT tag of XSLT.

4. Functions of the system

The 'Eco-system of Lake Shinji' we have developed has 'Water Mode' and 'Picture Book Mode'. They have different functions and are designed to work together.

4.1 Water Mode

Fig.2 shows a sample screen of 'Water Mode'. The user operates the avatar shown as ① in Fig.2. The user can view the lake three-dimensionally and swim by operating the keyboard. Many kinds of creatures living in the lake are shown ② in the 3D virtual space with corresponding sound effect.

COD is the amount of oxygen consumed when materials in the water are oxidized. If dirty water drains into the lake, the COD value increases. This can result in an oxygen deficiency in the water, and some fish die [8]. PSU is the saline content of 1kg of water. If a user increases the COD value (shown as ③) by clicking the mouse, the water in the lake will become muddy, and the number of fish will decrease.

Turbidity is the concentration of particulate in suspension in the water. When the turbidity is high, the water contains many impurities. In our system, turbidity (④) will change in responce to the garbage deposition/collection button (⑤) and the COD/PSU slider. COD and turbidity will worsen when the garbage deposition button is selected, and will improve when garbage collectioni is selected.

If a user selects a creature in the lake by clicking on its image, the screen changes and detailed data about the organism is displayed.

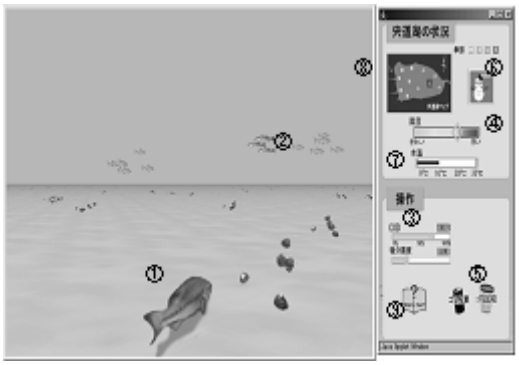

Fig. 2 Sample screen of Water Mode

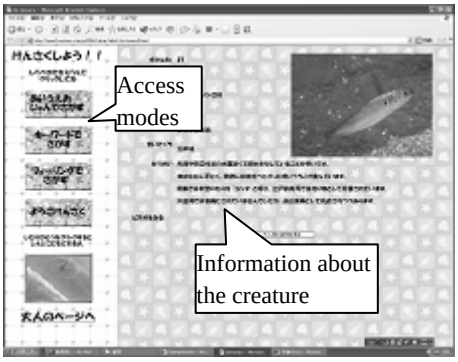

Fig. 3 Sample screen of Picture Book Mode for children

4.2 Picture Book Mode

Fig.3 shows a sample screen from the 'Picture Book Mode' for young learners. A user can learn about creatures living in Lake Shinji. When the name of the fish is selected from the access menu in the left window, the database is searched and a picture of the fish appears. When the button under the picture is selected, information about the fish will be shown on the left side of the picture. When the video play-back button is pushed, a movie about the fish will be played. These functions enable young learners to access detailed information about any creature that captures their interest.

The database of the Picture Book Mode is constructed by XML and XSLT. Users can readily select Picture Book Mode for eather adults or children. The contents for children are written in Japanese Kana characters so they can easily read the text.

The 'Picture Book Mode' has four subsidiary modes; (1)50-character-kana Syllabary Access Mode, (2)Keyword Access Mode, (3)Fuzzy Access Mode and (4)Term Access Mode. Users can select a mode by clicking one of the four buttons and access the database. 'Fuzzy Access Mode' has four setting boxes

such as type, size and habitat. Users can try to find the creature he/she wants to study even if they only have fragmental knowledge about it. For instance, users can set the size of creature he/she wants to find, such as 'between 10 cm and 20 cm'. In addition to this, user can assign the habitat of the creature by combining conditions 'AND' and 'OR'.

5. Evaluation of the system

Twenty students at our college trialed 'Eco-system of Lake Shinji' and evaluated it. They read an operation manual and tried the system out for about 30 minutes. Then they answered a questionnaire. The evaluation options for each question were five levels randing from; 'Excellent' to 'Bad'

(1) Evaluation of the Water Mode

Q1: Keyboard and a mouse operation. Q2: Design of this screen. Q3: Screen layout.
Q4: Animation of creatures. Q5: Usefulness of 3D graphics. Q6: Usefulness of COD/PSU operation.
Q7: Usefulness of garbage deposition/collection button. Q8: Effectiveness of sounds in the lake.
Q9: Usefulness of pictures of the creature selected by clicking mouse.

(2) Evaluation about Picture Book Mode

Q11: Operation of the mode. Q12: interest in this mode. Q13: Usefulness of access result.
Q14: The amount of contents/data. Q15: Which access mode is easiest to operate?
Q15-1: 50-character-kana Syllabary Access Mode Q15-2: Keyword Access Mode
Q15-3: Fuzzy Access Mode Q15-4: Term Access Mode
Q16:Usefulness of Children's / Adults' functions.

(3) Evaluation on the whole system

Q17: Which mode are you interested in? Q18: Do you think this system useful for learning ecology?

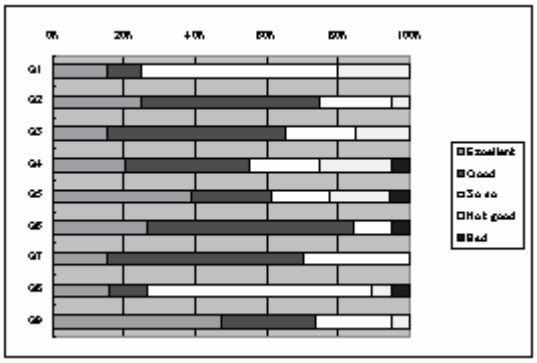

Fig. 4 Evaluation of Water Mode

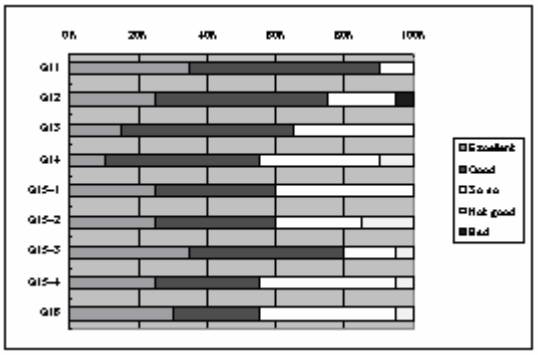

Fig. 5 Evaluation of Picture Mode

Fig.4 shows the evaluation results for the Water Mode. More than 60% users regarded this system as useful on the whole. In particular, design, screen layout and 3D graphics (Q2,Q3 and Q5) were rated highly because of the effects of 3D graphics. The interactive activities for COD/PSU and garbage deposition/collection (Q6 and Q7) also scored well. This seems to be due to the effectiveness of water clarity simulation using COD/PSU and garbage deposition/collection.However, ease of operatiion (Q1) seems to be a problem and needs improvement. The results for Q8 show that the sound effects are not good enough either. Q9 result shows that the function to show the data picture book about any creature selected by clicking the mouse seems to be useful.

Fig.5 shows the evaluation results for the Picture Book Mode. According to Q11, Q12 and Q13 results, users considered that this system was easy to operate, interesting and useful. On the other hand, according to Q14, this system is not yet good enough because it needs more content. The highest

evaluation result for Q15, and Fuzzy Access Mode was found to be the most useful. This is because users can find the creature by this mode even if they have only a little knowledge about it.

80% users evaluated this system was useful to learn ecology (Q18). Sample comments about the system were as follows:

(a) "This system is useful to learn ecology, because user can use the picture book and 3D graphics at the same time. "
(b) "Both Water Mode and 3D graphics mode are useful, since I can learn about ecology from different viewpoints. "
(c) "This system can be better if users can operate the value of parameters; COD/PSU and garbage disposition/collection. "

6. Conclusion

We developed 'Eco-system of Lake Shinji' to learn ecology using materials relevant to users. This system allows users to see creatures living in the lake drawn with 3D graphics. The users can get access to an environmental educational database developed by XML. Users can also simulate water clarity and the number of living creatures displayed in the 3D space by modifying environmental parameters. Furthermore, users can search for creatures they want to know more about using four mode options that provide easy access to the XML database. Detailed information on living creatures and pictures and movies help users to learn about them and they also help users to understand special termnimology assosiated with ecology.

Twenty students at our college tried using the system and evaluated it by answering questionnaires. They considered that simulation of water in the lake using 3D graphics was useful for understanding the parameter's effects on the environment. Also their evaluation showed that the four access modes, especially the 'Fuzzy Access Mode', were useful for developing an understanding of environmental preservation. On the other hand, they commented that it was desirable that these two functions work more effectively.

The material from our 'Eco-system of Lake Shinji' can be applied to other settings such as seas, lakes and rivers by changing the data. We believe that this system, which can be used in many parts of the world, has potential to become a leading e-Learning system for learning ecology.

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