Symbolic design of ecological objects in ecological simulation experiment

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Abstract. In order to vividly and vividly express the characteristics of ecological objects, according to the appearance attributes of ecological objects in real life, design ecological symbols to replace the objects being studied, image the ecological phenomena and reflect them into the simulation experiment environment. Simulate the actual situation of the ecological objects involved in the experiment, improve the learners' cognition, and enhance their understanding and treatment of complex problems in ecological experiments.

1. Introduction
Due to the complex spatial structure of ecological objects (EO) in the ecosystem and the excessive macroscopic movement behavior, it is difficult to observe the entities in traditional experimental teaching, and students are required to have large-scale spatial imagination ability, which can not achieve the expected experimental teaching effect. According to the principle of similarity, the model symbols of EO are designed to represent the EO being studied, and they can be applied to ecological simulation experiments. The abstract ecological phenomena and features can be intuitive and dynamic without being restricted by spatial size and time. The way to express, rehearse or reproduce the real ecological process in a short period of time [1], so that learners can deepen their understanding of the entire experimental process and experimental phenomena. The following will explain the specific implementation process from the basic attributes of the ecological object symbols (EOS), the composition of EOS and the sample display.

2. Basic properties of EOS
The ecological object models in the simulation experiment environment are composed of abstract symbols representing the actual ecological resource individuals. The EOS have three basic attributes: location, content and style. According to the characteristics of EO, the symbol object are divided into two sub-objects: dot symbol (DS) and linear symbol (LS), which all have three basic attributes of the symbol objects [2]. The overall conceptual model of EO symbol is shown in Figure 1.
2.1. Location attributes
Location refers to the spatial location of ecological symbols, and the positional relationship between symbols can reflect the distribution relationship between adjacent ecological entities. The position information adopts the vector data structure model, and the ecological entities are represented by determining the coordinate value \((a, b)\) of the geometric objects and the simple geometric objects of the point and the line, and controlling the position of the ecological symbols in the experimental scene, accurately expressing and displaying the spatial distribution and symbolic effects of EO.

2.1.1. Point ecological symbols are the smallest units in the model. They are used to represent EO in a single location, such as nests, foraging sites of animals, etc. The dimensions are zero-dimensional. Select a pair of coordinates \((a, b)\) to determine the position information[3]. The location file of DSs is shown in Table 1.

| Point number | Coordinate |
|--------------|------------|
| 1            | a1, b1     |
| 2            | a2, b2     |
| ...          | ...        |
| 20           | a20, b20   |

2.1.2. Linear ecological symbols are linear or strip-shaped. The geometrical features of ecological entities are usually controlled by straight lines or smooth curves to achieve a similar effect [49], such as streams, animal walking paths, etc. Its dimensions are one-dimensional, its position is composed of a series of ordered coordinate strings, the position information is stored in the set \(M(a, b)\), and the position file of the linear symbols is shown in Table 2[3].

| Line number | Starting point | End point | Point number |
|-------------|----------------|-----------|--------------|
| a           | 1              | 5         | 1, 2, 3, 4, 5|
| b           | 5              | 7         | 5, 6, 7      |
| ...         | ...            | ...       | ...          |
| g           | 11             | 15        | 11, 12, 13, 14, 15 |
2.2. The attribute of the primitive

The attribute of the primitive. The primitive is the smallest component of the symbol of EO. The shape of the primitive determines the basic shape of the symbol. Among them, Point ecological symbolic primitives include basic geometric shapes such as square, circle and triangle. Linear ecological symbolic primitives are linear primitives composed of continuous points. The shape of primitives is shown in Table 3.

| Primitive type | Primitive shape |
|----------------|-----------------|
| point primitive| ![Point Primitive Shapes](image1) |
| linear primitive| ![Linear Primitive](image2) |

2.3. Style attribute

2.3.1. Colour. Color plays an important role in ecological symbols. Usually, the point and LSs are applied separately or combined with other elements to better distinguish the characteristics of EO. The color makes the symbols of EO more vivid and distinct. When the same primitive shape is endowed with different colors, the meanings expressed are not the same. As a visual variable, the values of color attributes are R, G and B. The values of color parameters of different symbols are different. As shown in Figures 2 and 3, clouds are generally represented by light blue, and stars are represented by yellow five-pointed stars to enhance the symbolic representation of EO.

![Figure 2. Cloud: light blue.](image3)  
![Figure 3. Star: yellow.](image4)

2.3.2. Size. The size of ecological symbols refers to the different sizes of symbolic shapes. Measuring factors need to consider the length, width, height and radius of geometric figures. The size of point ecological symbols refers to the size of the symbol pattern. For example, the circle symbols can represent different symbols with different diameters or radii. The size of Linear symbols refers not only to the thickness of lines, but also includes the size and spacing of the points in the dotted LSs, the
spacing of the double LSs, and the like, such as the width and thickness of the path. As shown in Table 4.

Table 4. Size pattern of ecological symbols.

| Symbol type | Size style |
|-------------|------------|
| DS          | ![DS symbol](image) |
|linear symbol | ![linear symbol](image) |

3. Composition and sample display of EOS

The previous section describes three basic attributes of ecological symbols. According to the overall concept of ecological symbols, ecological symbols consist of two sub-objects: DSs and linear symbols. This section describes the composition process of different sub-objects, and combines various ecological symbol structures to design three sets of ecological object symbol samples.

3.1. DS. Its position is usually fixed and its shape is relatively simple, including single DSs and multi-DSSs.

3.1.1. Single DS. It is an ecological symbol composed of a basic dot primitive, such as roof, raindrops, stars and so on. It gives the basic dot primitive a certain size and color, and can form symbols that express specific EO. Table 5 shows the composition of single-symbols, that is, single-DSs are composed of attributes such as basic primitives, size, and color.

Table 5. The Composition of Single DSs.

| Name of ecological symbols | Basic primitive | Attribute parameter | symbol |
|----------------------------|-----------------|---------------------|--------|
| roof                       | ![roof symbol](image) | size, color         | ![roof symbol](image) |
| raindrop                   | ![raindrop symbol](image) | color               | ![raindrop symbol](image) |
| star                       | ![star symbol](image) | size, color         | ![star symbol](image) |

3.1.2. Multi-primitive DSs. It consists of a combination of multiple primitives, not only considering the attributes assigned to the single DSs, but also considers the combinations among primitives [49]. Table.6 shows that symbols such as the sun, the nest, and the cake are formed by this method.
Table 6. The Composition of Single DSs

| Name of ecological symbols | Combined primitive | Attribute parameter | symbol |
|----------------------------|--------------------|---------------------|--------|
| sun                        | +                  | size, color         | ![Sun](sun.png) |
| bird's nest                | +                  | size, color         | ![Bird Nest](birdnest.png) |
| cake                       | -                  | size, color         | ![Cake](cake.png) |

3.2. Linear symbol

3.2.1. Simple linear symbol. It is a LS consisting of a basic line type primitive, which expresses an ecological phenomenon by giving properties such as the color and width of the basic element. Table 7 shows a linear example of the walking route of the animal.

Table 7. Simple linear symbol example

| Name of ecological symbols | Basic primitive | Attribute parameter | symbol |
|----------------------------|-----------------|---------------------|--------|
| animal walking route       |                 | line width           | ------- |

3.2.2. Compound LSs. It is a LS consisting of several basic line style primitives. The multiple line types are arranged and combined, and the attributes are configured to obtain the desired composite linear ecological symbols. Table 8 shows the fence examples of the captive livestock.

Table 8. Simple LS example

| Name of ecological symbols | Combined primitive | Attribute parameter | symbol |
|----------------------------|--------------------|---------------------|--------|
| fence                      | +                  | Line width, color    | ![Fence](fence.png) |

3.3 Sample of EOS. Combining the dot and linear ecological symbol structures, three sets of ecological symbols, such as environmental resources, animal objects and animal feeding resources, which are common in ecology, can be designed, as shown in Table 9.
Table 9. Sample of EOS.

| Category                      | Object symbols |
|-------------------------------|----------------|
| environmental resources       | ![Environmental Resources](image1) |
| animal objects                | ![Animal Objects](image2) |
| animal feeding resources      | ![Animal Feeding Resources](image3) |

- the first group is environmental resources that provide material and energy: stars, sun, raindrops, nests, fences and hives;
- the second group is animal objects: bees, voles, cows, fish, sheep and turtles.
- the third group is the food resources that provide nutrition to the animals: cakes, flowers, leaves, cherries, bananas and four-leaf clover.

The EOS are stored in the simulation experiment symbol library. According to the experimental content of the ecological experiment[4], the teachers and students can select the corresponding symbols and add them to the main view area of the simulation experiment system to simulate the evolution process of EO in the experimental process. Figure 4 is an example of the “marginal value of bee foraging” experiment, adding honeycomb, bee and flower symbols to the grass of the simulation experiment.

Figure 4. Add symbol diagram.

4. Conclusion
This paper explores the basic properties of EOS and constructs a corresponding symbol library to abstractly express the ecological entities commonly found in ecological experiments. Finally, taking the ecological simulation experiment “marginal value of bee foraging” as an example, honeycomb, bees and flowers were added to the grass of the experimental scene. The method realizes the simulated evolution of EOS in the simulation experiment and enhances the evolution effect of the simulation experiment.

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