TEACHING AND PROMOTION ON INQUIRY-BASED INSTRUCTIONAL MODULE

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Abstract

The purpose of this study is to design two teaching modules that will enable science teachers to teach laboratory course for students to achieve a meaningful and useful learning. We emphasize students' self-exploration about science. Each module can be modified for students of different grades (7-12 students) and abilities. The modules greatly enhanced the teacher's own understanding of what he/she wishes the laboratory teaching to achieve. The module contained inquiring activities with explicit teaching of the nature of science. At the same time, these activities can promote their learning motivation; let the students have a better understanding of the science concepts by doing the experiments, and to undergo an experience of learning and reflection by themselves. By observing interesting phenomena and practicing the scientific process skills repeatedly, the modules also efficiently inspired students who lack of learning motivation. This study involves the design of two experimental teaching modules dealing with concepts about animal life, plant life, foraging behavior and social behavior. The designed modules are: 1) Ecosphere experimental teaching module: including photosynthesis, respiration and burning; and 2) Animal behavior ecological observation experimental teaching module: including foraging behavior and social behavior.

Keywords: Instructional module, inquiry-based learning, learning motivation

Introduction

General background information

Recent theories on students learning of science emphasize the construction of personal knowledge is not a reaction to external concrete world, but a result of the active construction by individual mind. For instance, Jean Piaget proposed that knowledge is not from innate genetic, nor the acquired environment, but from individual's spontaneous action (Piaget, 1970; Boden, 1985). Hofstein and Lunetta (1982) recommended that in addition to academic achievement, attitudes, cognitive ability, operational skills and understanding of the nature of science, scientific process, scientific interest, work independently, maintain memory, we still have to pay attention to the related variables of laboratory teaching environment, including teachers' attitudes and behavior, the nature and content of laboratory activities, experimental teaching objectives, social context and learning environment and so on. Bredderman (1983) presented a meta-analysis findings on experimental learning lessons. He encouraged the use of inquiry experimental activities rather than Didactic Teaching. Also, he proposed the direction of reform efforts that is how to make classes more interesting by experiment lessons.

The purpose

The teaching modules designed in this study consisted of scientific activities related to ecology and physiology, such as photosynthesis and cell respiration. These activities focused on student's self-inquiry of science,and the activities of the experiment modules may vary for students of different grades and abilities. The two modules wewe: 1) Ecosphere experimental teaching module: including photosynthesis, respiration and burning; and 2) Animal behavior ecological observation experimental teaching module: including foraging behavior and social behavior.

Literature Review

Implementation theory

Teachers are often encouraged not to impart knowledge directly but to apply various instructional principles and teaching strategies, in an attempt to explore ways to guide and assistance student. And then, students are expected to have the experience of using a range of scientific methods and process skills, such as observation, comment, forecast, confirm, assess, and publication. During the implemented process, teachers can induce students' intrinsic motivation (ex. curiosity, knowledge, exploration) to arouse students' learning motivation. Teachers also guide students into abstruse scientific theories through implemented learning experience and reflection. In this way, we can also launch on the promotion of students' motivation effectively. Application of ARCS (Attention, Relevance, Confidence, Satisfaction) (Bredderman, 1983), to train students' "hands-on implementation to learning", we can promote their active learning and build their confidence through DIY. Research studies based on Elaboration Theory (Reigeluth) which emphasized a shift from teacher-centric instruction to learner-centered instruction has demonstrated that students are highly interested in implementing what they have learned. If teachers provide proper assistance, it can build students' motivation and achievement. Anderson and Mohan also suggested that practical changes to classroom instruction may result in more effective pathways to the Upper Anchor, but there is less attention given to carefully sequence of teaching materials (Anderson & Mohan. 2009).

Value of research

The design, development and production of quality instructional materials are important and urgent for the implementation of science education at schools. The current design of teaching plans and activities in science textbooks has a polarization problem. Some are too complex to operate, using expensive electronic detection equipments and ignoring the observation and analysis of important concepts in biological experiments, the others too simple and low frequency of use, or to make a serious bias of the focus of study, only concerned with finding out the answers rather than engaging students in the operations and processes of scientific exploration and practices. We have made some efforts trying to solve such a polarization problem in this study. In Eco-Box, a combination of a series of modular biological observation experiment aids was developed. We have developed interactive ecology modules that are in line with the goal of science education emphasizing science enquiry and the learning of science concepts. The teaching aids developed in this study have received a number of patents, and they have reached a reasonable market price and popularity commercialization objectives. Using the teaching modules developed in this study, we expect to engage students in activities that will raise students' intrinsic motivation toward curiosity, lead to the acquisition of knowledge and science inquiry skills, etc. We hope to provide increase students' interest in learning and their understanding of the relevant concepts and principles, by guiding them to explore the scientific theories through practical works, which provide them with adequate experiences and opportunities for reflections.

Teaching plan development

1. **Implementation design**

Eco-Box is a teaching module for natural science, which designed for grade 7-12 students. Teachers or parents can lead students to build up the Eco-Box.While enjoying the DIY process, students can use their imagination to create their own unique miniature ecosystems.

(1) Ecosphere experimental teaching module: including photosynthesis, respiration and burning

Eco-Box is a complex word of ecosystem and box. Respiration (often confused with breathing) is defined as the transport of oxygen from the outside air to the cells, and the transport of carbon dioxide in the opposite direction (uptake O_2, release CO_2)(Fig. 1). It is essential to cells for survival. The transport of oxygen and carbon dioxide in photosynthesis is reversed. But, both of respiration and photosynthesis cannot be directly observed by naked eyes. Does plant absorb carbon dioxide and emit oxygen under sun light? What kind of changes in the gas proportion will happen? How can we observe the variations in concentration of oxygen and carbon dioxide?

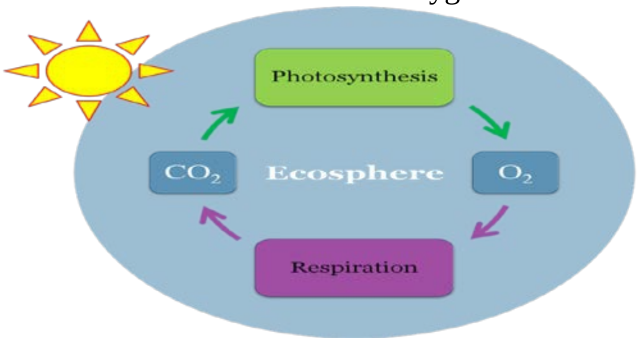

Fig. 1. Carbon is exchanged among the biosphere and atmosphere (incomes and losses) in a specific loop.

The carbon cycle is the biogeochemical cycle. It comprises a sequence of events and describes the movement of carbon as it is recycled and reused throughout the biosphere.

(2) Animal behavior ecological observation experimental teaching module: including foraging behavior and social behavior

This model design with silicone tube connector and has equipment to monitor the concentration of oxygen and carbon dioxide in glasses (Fig. 2). This model is able to examine each experimental group individually. For example, photosynthesis group only use ecosphere (part E). When inserted the plants into this model, the changes between oxygen and carbon dioxide can be measured by gas sensor (part G). In the part A, only using algae to produce oxygen and collect it by gas sensor (part G). Respiration group only use the ecosphere (part E), the same as photosynthesis group. In the B part, using for burning group, the data collected by part G.

When many groups are combined, showed on Fig. 2, to test the effect of oxygen and carbon dioxide on animal and plants, the animal and plant will be put inside the ecosphere (E part). Firstly, the changes between oxygen and carbon dioxide in gas sensor (G) were recorded. Then, switching on the B part to lead the carbon dioxide, created from burning, flowing into the ecosphere (E part) and record the data of changes of glass in gas sensor (G) again. Waiting for a while and switching part B off and part A on. The oxygen produced by algae flows into part E, and collects the data in part G once again.

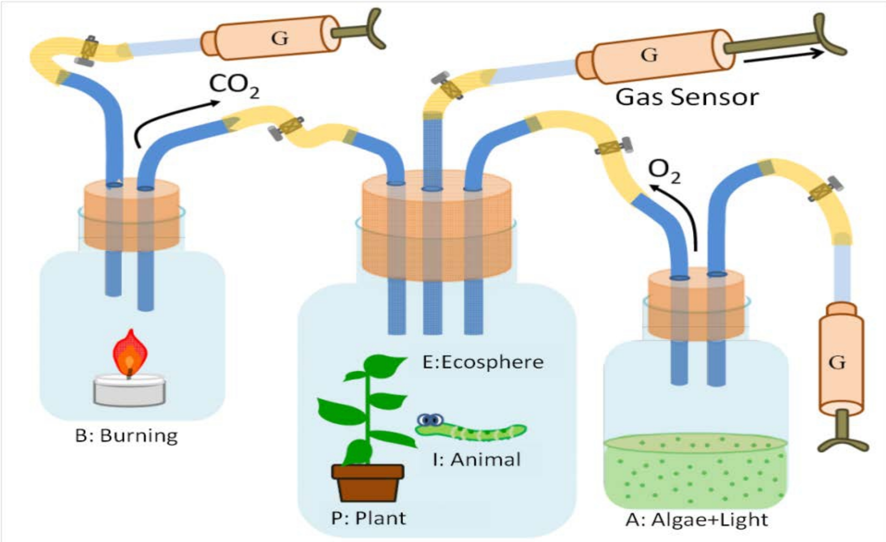

Fig. 2. The teaching aid module

2. The Eco-Box characteristics

(1) Reusable: All materials of Eco-Box are reusable. It made by acrylic and is easy to clean and reuse (Fig. 3).

(2) Flexible : Experimental components can be added as you need, e.g. control module of different light waves, gas concentration (oxygen, carbon dioxide and nitrogen), temperature, moisture, etc (Fig. 3).

(3) Simple: Eco-Box is easy to assemble and carry, consisting of several acrylic plates and columns (Fig. 3). Just a few steps, the user with imaginations and some decorations, a miniature ecosystem is ready to use.

(4) Adaptability: Box can be used individually or with multiple combinations.

Fig. 3. Eco-Box consists of several acrylic plates and columns, and easy to assemble and carry.

3. The assemblage of Eco-Box

According to the protocol, the Eco-Box is easy to assemble. The border corner area of acrylic components embeded magnet. When put each basic component to suitable place, it will fasten by magnetic force. A rectangular box constructs only few steps (Fig. 4). Then put small animals or plant into it, a miniature ecosystem is ready to use (Fig. 5). It can combine two Eco-boxes to large one. Eco-Box is suitable for rearing small invertebrates like ladebugs, snail, crickets, etc.

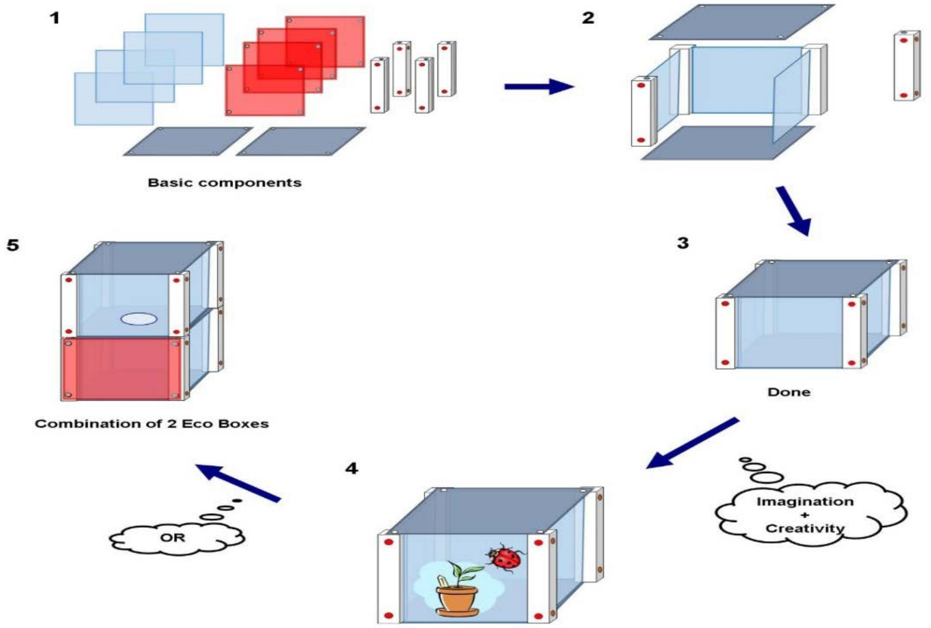

Fig. 4. The procedure of Eco-Box assemblage shows subsequently and it can combine two boxes together.

Fig. 5. A miniature ecosystem is ready to use.

Results and Discussion

Eco-Box is a miniature ecosystem, it makes obscure concept of the ecosystem from theoretical into practical.

1. Ecosphere experimental teaching module: including photosynthesis, respiration and burning

Is there any more convenient, more intuitive approach to investigate the gas equilibrium? We started to design an Ecosphere Experiment Module (Eco-Box), and we hoped that it can integrate the various experiments in one, and can also allow students to do the experiments one by one. And more important, is to make the measurements easily by using gas sensors.

2. **Animal behavior ecological observation experimental teaching module: including foraging behavior and social behavior**

This model design to examine the balance between the concentration of oxygen and carbon dioxide of the following groups: photosynthesis group including plants and algae, respiration group for animals, burning group. This model is able to test the changes in each group or to combine two to four group together to test the changes for oxygen and carbon dioxide (Fig. 6).

The Eco-Box is very meaningful for nature live in different zone, they can communicate with each other among different species including humanity. Insects and plants can be cultivated in a special space of our design, through individual cultivated or interconnected in series. Each region has its own functionality, such as living, eating and fighting. Consumers can buy modular equipment and instrument, we design to upgrade the function of each zone. They can learn life sciences and ecology from our products and observed and recorded flora and fauna issues. The main idea of our design is establishing the interaction between species and the interaction between the owners. Learning natural science is no more boring but with fun! And through further teaching, students have a better understanding of the ecosystem. During the DIY process, students can learn how to overcome problems by themselves, in order to build up a perfect ecosystem. Eco-Box not only stimulates students' creativity, but also the learning motivation in natural science.

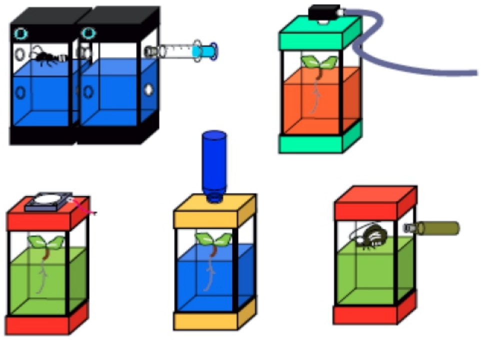

Fig. 6. This system is able to meaure the changes of oxygen and carbon dioxide in each group or the combination of two to four groups.

Conclusion

The module we developed in this program is suitable for the promotion of environmental and science education and lifelong learning. Meanwhile, students' feedback indicated that they were satisfied with the module. But, considering the following points, we suggest further research is needed to solve the problems faced.

1. It spent a lot of time waiting for the gas to accumulate. Many students responded that there was not enough time to complete the activity. Students also indicated that more equipments were needed.
2. We could increase the number of hours for the activity next time. We could also let students rest during the waiting periods and devise some mini experiments.
3. Many students have not enough experience and patience in doing the experiments. There is a gap between students' needs and performances, even for students with the same grade.
4. Even though student's background knowledge and understandings were improved, we found that there were still some misconceptions that need to be clarified.

Acknowledgement

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