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Development of Simulation-based Contents for Exploratory Science Education Connecting Real and Virtual World

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Abstract: This study implemented science learning contents by GoGo Board, an open source hardware, and NetLogo, a free software. We built a customized GoGo Board, incarnated experimental environment for learning using various sensors and then utilized NetLogo to develop exploratory science contents. The selected topics cover heat equilibrium for changing temperature appeared in the textbook of middle school science class. With the proposed devices, students can visualize the change of temperature cold and hot waters in terms of heat equilibrium. The developed simulation contents were validated with computational checking procedures using one of the NetLogo's special features. At the end, we report the evaluation results with two K middle school students for formative evaluation.

Keywords: simulation-based contents, NetLogo, GoGo Board, formative evaluation

Introduction

As the importance of knowledge service emerges nowadays, Microcomputer Based Laboratory(MBL) learning method has been implemented for science experiments from elementary schools to high schools. MBL education brings computer into laboratories and grows science education with advanced education methodology. However, teachers are experiencing difficulties on preparation of MBL education and equipments for MBL are being phased out because of its expensiveness.

This paper aims at implementing experimental devices with which students can explore scientific ideas using GoGo Board and NetLogo that connect real and simulated worlds[1, 2]. Related research literature was reviewed to design a simulation-based learning model using computer simulation and robot-related activities.

In order to construct devices for exploratory experiments, GoGo Board was applied for developing the interface of Micro-Based Laboratory(MBL) devices with several sensors. NetLogo was used for connecting MBL devices (real world) and simulated experiments (virtual world).

The GoGo Board is open-source hardware that can be easily assembled according to movie manual without any limitation. With NetLogo that has been widely used as freeware it is easy to develop simulation-based contents using Logo language grammar.

The main part of this thesis shows how to design and develop a proposed experimental devices in the heat equilibrium for changing temperature appeared in the textbook of middle school science class. With this device, students can visualize the change of temperature cold and hot waters in terms of heat equilibrium.

1. Implementation of science learning contents

The simulation in education represents actual of the situation in the computer therefore students learn in the similar to the actual environment. Students could be enhanced the

interesting and incentive of studying. The simulation can be classified into four types. The physical simulation is not real experiment on physical phenomena. Students do not have to conduct an experiment in a real laboratory with experimental tools. They can do experiment using the computer. Iterative simulation is for the students to select and input parameters, to observe certain phenomena and to interpret the result during each simulation cycle. Procedural simulation is method for students to learn the order of behavior for achieving goal. Situational simulation supports various situations for learners who study with human and organizational behavior and attitude[3].

The learning environment proposed by this paper makes it easy for students to do activities such as finding proper sensors and assemble them, building an experimental tool by connecting sensors to GoGo Board and developing learning contents using NetLogo which can be embedded into GoGo Board. We expect that this activity will encourage student's participation, motivate their interests and eventually make science education be more effective. We also anticipate that this learning environment will help student with learning capability by building and manipulating robot that promotes creativity, problem solving ability, logical thinking[4]. We built science experiment contents using the GoGo Board and NetLogo for science curriculum.

1.1 Initial model: Calculating temperature with flower blossom

Initially, the experimental design for 'calculating temperature in various circumstances' from 'calculating temperature' was conducted with 3rd graders. Students in this experiment connected temperature sensors to the input module of the GoGo Board, choose a good and bad place for sunlight then calculate temperature of these places. Using the GoGo Board, the measured data for temperature change were sent to computer in real-time. NetLogo shows the result of the data, students can observe the science experiment result visually by seeing how fully the flower on the screen is blossomed (left picture of Figure 1). Students can become very active when they interact with the environment and asking their own questions to the nature. They often internalize what they experience[5].

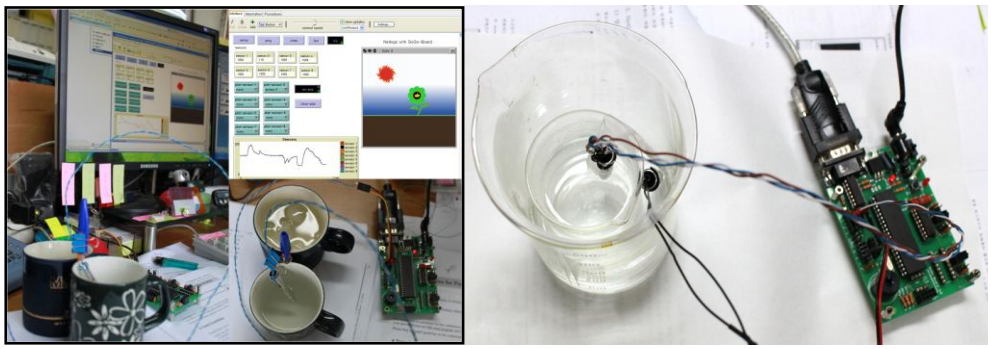

Figure 1. Calculating temperature of hot and cold water

1.2 Connecting real and virtual world: Second version of calculating temperature

The contents for calculating temperature in various circumstances were reviewed by our research team and found that Agent-Based Modeling program can be applied to model heat equilibrium phenomenon. The interaction among hot water and cold water can be observed by the student by importing sensor data from GoGo Board (right picture of Figure 1). In order to understand the underlying scientific phenomenon, simulation for the virtual world can be programmed using NetLogo. By watching the temperature graphs of hot and cold water and observing molecule interactions in terms of energy diffusion, students can explore how the heat equilibrium is attained finally. Red and blue dots indicate hot and cold

water molecules respectively. There are two graph windows; top window displays the sensor data from GoGo Board and bottom window shows the simulated ideal equilibrium model.

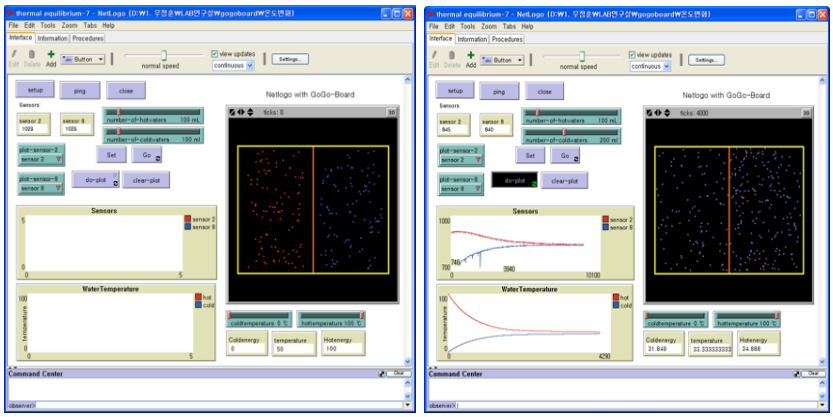

Figure 2. Molecule interactions of hot and cold water

By comparing two different data display, students might pose exploratory questions by themselves on the gap between two windows. By manipulating different parameters on the simulation window, they can explore major aspects of heat equilibrium. Connecting the real experiment and virtual simulation, students can understand scientific phenomena in terms of nature's reaction tolerating error data.

2. Formative Evaluation

The developed simulation contents were validated with computational checking procedures using one of the NetLogo's special features. Several simulated runs using Behavior Space functionality validated outputs for the developed contents by comparing three graphical outputs from real world device (MBL-based sensor model), virtual world (NetLogo model) and the ideal model (heat equilibrium model).
In order to evaluate the developed devices and models, two K middle school students were recruited during the December 2010. While they joined the exploratory activities with the developed devices and models, several questions were posed. According to the video analysis, the overall reactions of the two students showed that they would take advantages of using such simulated environments for better engaging with science inquiry.

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