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Making Electronic Textbook for College Chemistry-experiment

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Abstract: We are developing electronic textbook of basic chemistry-experiment for university students in which chemical reactions are shown by computer graphics (CG). The CGs of chemical reactions was made based on quantum chemical calculations and the Quick Time movie of the reaction path was produced which was combined with electric textbook of chemistry-experiment. The CGs include following reactions; 1) formation of di-atomic molecule by collision of two atoms such as hydrogen iodide, 2) hydroxylation of methyl chloride as a model of Walden's inversion where drastic change in structure takes place, 3) esterification of acetic acid and ethanol as an example of more complex reaction. The CG could simultaneously demonstrates the nature of the reaction such as structural change by the ball-and-stick model or the space filling model with electrostatic potential, and potential energy change by the reaction profile. The textbook displays picture of apparatus and flow-chart of small-scale experiment in addition to the CG. Therefore students were able to conduct experiment smoothly and safely while studying dynamical reaction mechanism by CG in the electronic textbook inserted in the Ziploc type plastic bag. The developed electronic textbook could be used to integrate the observable level experiment and the molecular world.

Keywords: Computer graphics, Visualization, Electronic textbook, Chemical experiment

1. Introduction

Understanding the observed phenomena, chemists use to imagine and explain observations in terms of molecules. Observed phenomena and molecular level models are then represented in terms of mathematics and chemical equation (Gilbert, 2009 and Tasker, 2010). Student's difficulties and misconceptions in chemistry are from inadequate or inaccurate models at the molecular level (Kleinman, 1987). A molecular structure visualized by the computer graphics (CG) provides a deeper understanding of molecular structure (Tuvi-Arad, 2006). It is our aim to produce a CG teaching material based on quantum chemical calculations, which provides realizable images of the nature of chemical reaction (Ikuo, 2006 and 2009). If the CG were combined with chemical experiments of student's laboratory, students would observe the reaction from three thinking levels, namely, phenomena in the actual observable level and the CG in the molecular level, and chemical equation in the symbolic level. The CG on the tablet computer was effective to provide image of "Energy" change and also effective to provide image of "Structure" change and "Migration of Electron" during chemical reaction (Ikuo, 2012). Our ultimate goal is to produce an electronic textbook linking chemical experiment, which integrates these three levels. This paper introduces our works of development of the electronic textbook for chemical experiment of student's laboratory at the university, which integrates the observable level experiment and the molecular world.

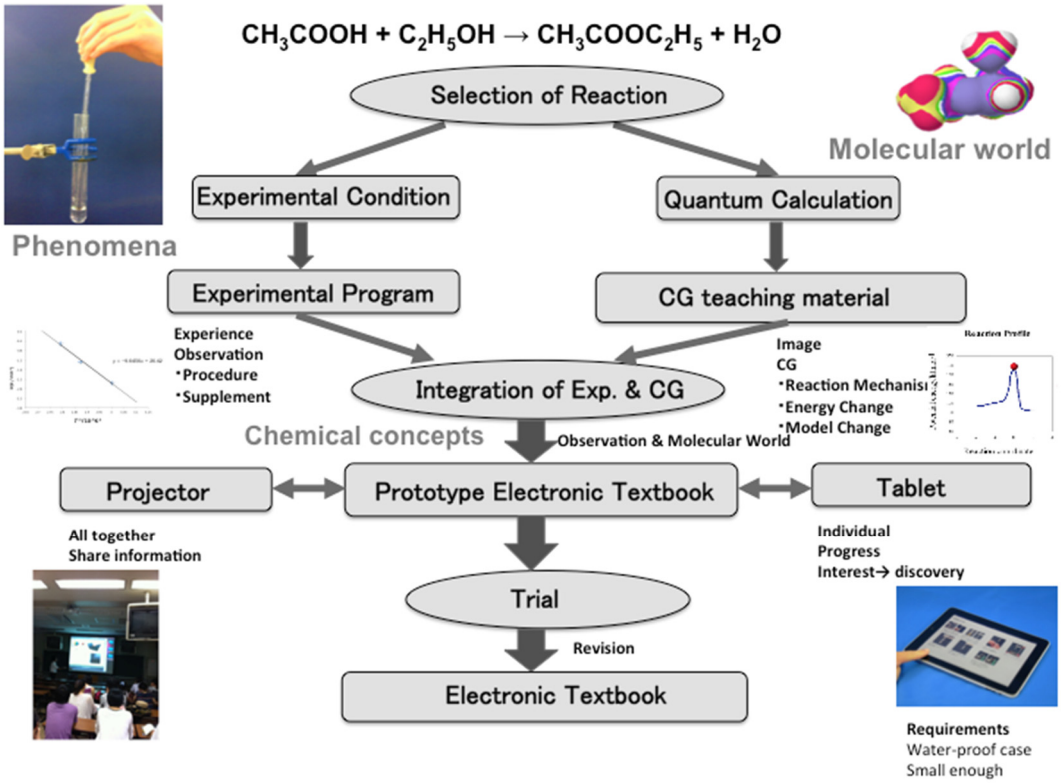
2. Developing Method

Strategy

Electronic textbook has several advantages over paper textbook. For example, realistic image can be shown by photograph or 3-dimensional CG, and movie. These images could be, apparatus, molecular structure, and reaction mechanism. In addition, programmable capability (for example. Singhose, 2013), hyper-link, and networking feature provide inter-active operation. Many electronic textbooks of chemistry are found but most of them are very similar to the paper book, and very few

are related to the chemical experiment (Morvant, 2013). Moreover, combination of CG movie of reaction and experiment are not seen.

Flow chart of development of the electronic textbook for chemical experiment is shown in the Scheme 1. Reaction was selected based on importance in fundamental chemistry. To exhibit phenomena, experimental condition was optimized for the student laboratory and experimental program was made. For easier understanding of experimental procedure, enlargeable-photos and flow charts were used in addition to regular text-base description. The electronic textbook could acts as an individual electronic tutor. To provide image of molecular world, CG images such as realistic shape of molecules, the CG teaching material (movie) were made based on quantum chemistry calculation (Ikuo, 2006 and 2009). Students would be able to see structure and energy change during reaction while they are watching actual reaction progress. In this manner, observable level experiment and the molecular world could be integrated (Scheme 1). In order to use the electronic textbook on the lab bench, it need to be covered with a waterproof, Zip-lock type, case.



Scheme 1. Flow chart of developing method.

CG Teaching Material and Electronic Textbook

A movie of the reaction path was produced by the software DIRECTOR (ver. 8.5.1J, Macromedia, Inc.) following the display of the bond order of the structure of the reactants in each reaction stage, which was drawn by the CAChe (Ikuo, 2006 and 2009). The obtained CG was combined with reaction profile in the same reaction stage. It was confirmed that the drawn CGs of the molecular models of reactants moves smoothly. A ball, which indicates progress of the reaction, was arranged on the reaction profile and simultaneous movements of the ball and the reactants were confirmed. Created movie file was converted to the Quick Time movie for iPad by the Quick Time PRO (ver. 7.66, Apple, Inc.). Electric textbook was produced with iBooks Author (ver. 2.1.1, Apple, Inc.) and was saved to iPad (Apple, Inc.) by using the iTunes (ver. 11.2.1, Apple, Inc.).

3. Feature of Electronic Textbook

The CG teaching material was combined with chemical experiments of student's laboratory for the purpose of making electronic textbook of basic chemistry to provide experiment at the observable-level, CG visualization at the molecular-level, and chemical equation at the symbolic-level. The electronic textbook was inserted with images of experimental procedure in the flow charts and photographs, which can be enlarged by students touch. Student can write memo for the observation. CG teaching materials of reaction profiles were also inserted. When student touches the CG teaching material in the tablet computer, the teaching material appears to show image of the structural change during the reaction. Student can compare different reaction mechanisms. If student touches the material again, the Quick Time control bar appears and the green ball on the profile can move by student's choice. Student can manipulate the reaction back and forth until they obtain the image of the reaction. Although more study need to be done on the effectiveness of the electronic textbook, students were able to conduct experiment smoothly and safely with the textbook inserted in the Ziploc type plastic bag.

4. Conclusions

Developing method of electronic textbook for chemical experiment of student's laboratory at the university was decided which aimed at integration of observable level experiment and the molecular world. The electronic textbook was developed according to the policy. The developed textbook could display picture of apparatus and flow-chart of small-scale experiment in addition to CG teaching material. The CG in the textbook effectively demonstrates images of dynamical reaction mechanism. From the preliminary study, students were able to conduct experiment smoothly and safely with the electronic textbook inserted in the Ziploc type plastic bag. The developed electronic textbook could be used to integrate the observable level experiment and the molecular world.

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