Towards Scientific Conception Acquisition under Ubiquitous Environment

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Abstract. We introduce ICT-based applications, offering students to shape their scientific concepts. Students' misconceptions are coming from their daily life and robust even after studying physics. These tendencies are significant on invisible phenomena. Visualization of these phenomena may be one of the solutions to overcome their naïve concepts. We have developed ICT-based various modules to visualize phenomena. These modules are useful and effective enough to change students' concept dramatically. We also propose some experiments through the active utilization of ICT tools.

Keywords: Ubiquitous, Active Learning, ICT-based teaching method
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INTRODUCTION

We have developed ICT-based applications to encourage teachers to use them in the classroom, science laboratory and anyplace, under ubiquitous environment. Combination of experiments and ICT tools are powerful procedure to approach students' interest and construct their science concepts [1,2].

In Japan, the government encourages usage of ICT tools at elementary schools (7-12 years old), junior-high schools (13-15 years old) and high schools (16-18 years old). In fact, nowadays computers with internet environment have been spread around the country. On the other hand, there are still some problems in addition to the fact that these ICT equipments are still expensive. First, we mention problems in ICT-based physics education which is clarified by surveys, and discuss how to overcome these problems.

PROBLEMS IN ICT-BASED PHYSICS EDUCATION

Survey for Teachers' Satisfaction

ICT tools are everywhere in our daily life, there are still some problems to utilize them in science (physics)

Our first concern is science teachers' awareness. The Japanese Science and Technology Agency (JST) carried out a questionnaire survey for elementary school, junior high school and high school teachers in

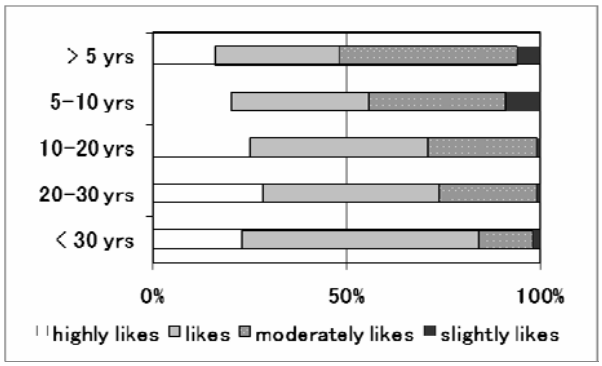

FIGURE 1. Junior high school teachers' likes and dislikes of teaching physics according to their experience is shown.

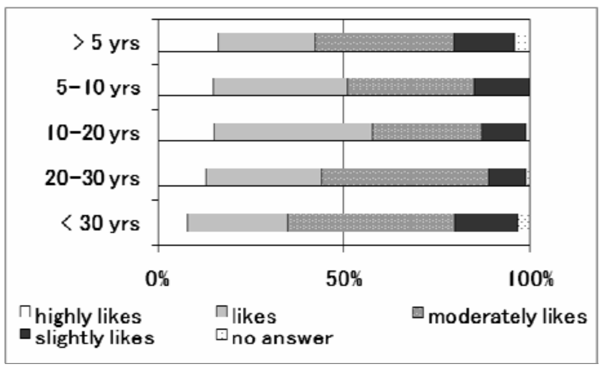

FIGURE 2. Junior high school teachers' likes and dislikes of usage of ICT tools according to their experience is shown.

2008 about their environment and feelings in science classes [3]. The number of teachers who answered the questionnaire survey was about 935, 572, 3250

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respectively. The survey was done randomly in terms of area.

Figure 1 and 2 show the junior high school science teachers' likes and dislikes of teaching physics and usage of ICT tools according to their experience. Although more than 90% of teachers have scientific background, they do not have much confidence with teaching physics or usage of ICT tools. Teaching experience helps to gain their confidence as shown in Figure 1, but they still give a wide uncertainty to usage of ICT tools in all ages as shown in Fig. 2.

Survey for Experimental Situations in High School

In addition to this survey, there is another survey for physics education environment. M. Yamazaki *et al.* investigated more than 2,500 1st grade university students how many physics experiments did they make in high school in 2006 [4]. They are 42 experiments in the high school textbooks. They concluded that about forty percents of students made experiments less than 5 times. Moreover, twenty percent of all students made no experiments. On other hand, twelve percent of students made experiments more than 15 times. Note that these results are based on only their memories, so some of them are not accurate. Even though, it means that students' experience for high school experiments split up into two groups, a group with a lot of experiments and no experiments. The reasons are assumed as follows. (1) There is no time for experiments because teachers should teach a lot of topics. (2) Teachers are so busy during office time so they have no time to prepare experiments. (3) They do not have much budget to prepare equipments.

In this paper, usage of ICT is also referred. Simulations such as waves, a parabolic motion were used. However, ICT-tools were not common, because teachers do not feel the need to use them.

Improvement of Networking Infrastructure

Since computers or well-developed ICT environments are set up at a certain room, such as a computer room. If they want to use ICT tools at the laboratory, it takes more time to set up them. Thus teachers can not deal with ICT tools effectively.

PROMOTION OF ICT-TOOLS USAGE IN UBIQUITOUS ENVIRONMENT

We first provide various ICT-based teaching modules with a digital camera and IT sensors.

Low cost and Convenient Teaching Materials for Kinematics in two dimension

Many demonstration equipments for Mechanics have been developed. These days, Khumaeni *et al.* constructed a frictionless two dimensional plain with fine spherical plastic beads with a custom-ordered wide glass plate [5]. We applied this idea and set up different type of the equipment as follows in Figure 3.

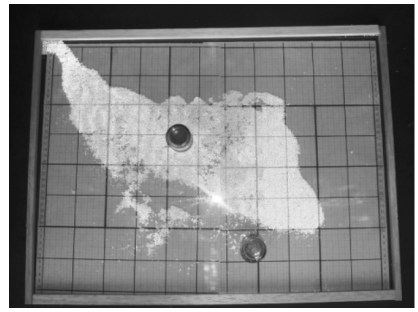

FIGURE 3. Frictionless plain with glass beads and an acrylic board is shown.

While performing kinematics experiments, one can record data as moving pictures with a digital camera, and analyze objects' motions on the plain with computer software. Our main purpose to develop this material is to encourage school teachers to use in physics class easily. Therefore, this should be (1) low cost, (2) safe to treat, and (3) convenient to bring around to demonstrate at a laboratory or a classroom. As shown in Fig.3, we use a transparent acrylic board for a plate and thin timber for a frame. Glass beads are on the board and a grid sheet is under the board. They cost only about 10 dollars and are on sale at DIY shops.

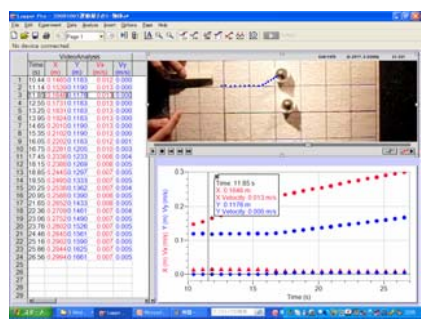

FIGURE 4. The video analysis of collision with a software (Logger Pro). Analysis data (locations and velocities for two directions) are on the left as a table. The horizontal axis denotes time and the vertical axis denotes locations and velocities for x and y. The table and graph are synchronized with the video.

Since glass is easy to be charged positively and acrylic is negatively, one can create a frictionless plain easily. Glass beads should be uniformly-sized and also not too small and too large. Typical glass beads we used are 1 mm in diameter. So they are large enough to prevent from scattering and there is no danger for students to drink or get them in their eyes by mistake. Moreover, an acrylic plate is very light, and can be rolled; one can bring around and demonstrate in anyplace. Figure 4 is an example of experiment of momentum which is analyzed by Vernier Logger Pro [6].

With this frictionless plate, various experiments are available. For example, Newton's third law, conservation of energy, collisions, rotational motion and so on. Figure 5 shows the rotational objects around the pole. Students can learn angular moment and dynamics of rotational motion. Instead of straws, one can use a rubber band, to study the spin. The band will wind around the pole at the end. This is a model for a figure skater. The skater outstretches hands and arms before spinning, and wrapped around his body while executing the spin. Analyzing these videos with software gives an estimation of angular speed.

FIGURE 5. A small fan is on the small plate. Two fans are fixed by two pair of straws, so they rotate around the pole in the center.

Visualizations of Inducted Electromotive Force

Electromagnetism is one of the difficult parts to construct scientific concept since they are not visible. Students deal with this topic starting from an elementary school, they study the electrodynamics in detail with formula in high school. However, as we mentioned, they do not have much time to do experiments.

We introduce some ICT-based experiments which do not take time to prepare and also strong tool for students' understanding of electromagnetism.

Figure 6 shows visualization of inducted electromotive force with a voltage sensor. In Figure 6(a), a cylinder in front of a monitor is a simple experimental arrangement for an inducted electromotive force. A magnet and a coil are inside of the cylinder. Since this magnet can pass through the coil, changing the magnetic field generates a voltage. To connect a coil to a voltage sensor with a computer, one can measure a voltage in the coil. Students can recognize that the sign of the voltage depends on how the magnet is removed.

In order to attract students, to use a LED is also useful, since a LED specifies a current direction. Two LED bulbs are on the transparency board as shown in Figure 6 (b). The arrows indicate the direction of current through LEDs. For the upper LED bulb, the current flows left to right, for the lower one, the current flows right to left. To connect each end of a coil to the LED bulbs, the bulbs light up the upper one (red) first and the lower one (green) second.

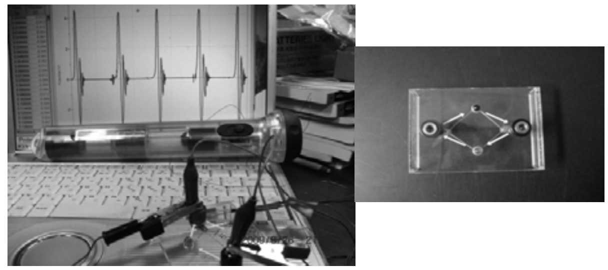

FIGURE 6. An analysis of induced electromotive force with a voltage sensor. (a) Left picture shows an arrangement of equipments. (b) Right picture shows a two LED bulbs and signs for current direction.

When we showed this experiment to our students, they expected that the LED lights up the upper one, and continuously the lower one for the first movement of the magnet (In Fig. 6 (a), for example, the magnet moves in to the coil and out of the coil, from left to right). For the second movement (the magnet also moves in to the coil and out from the coil, but right to the left this time), it lights up the lower one first and continuously the upper one. Their expectations were not correct. It lights up the upper one first and the lower one second in every movements.

To explain this observation, usage of IT sensors is useful since the voltage and the current are visible and students can understand the theory through their experiment

Visualization of Storage and Discharge of a Condenser

Figure 7 shows visualization of storage and discharge of a condenser. A hand operated dynamo-electric generator (An object with a handle) is connected to a condenser, which is measured by a voltage sensor and a current sensor as shown in Fig. 7 (a). According to time, one can measure and confirm how a condenser storage or discharge as shown in Fig. 7 (b). In each graphs, the data curves are not flat. Indentation corresponds to the number of rotation of the generator handle, where the generator is operated by hand. One can see the condenser discharges exponentially.

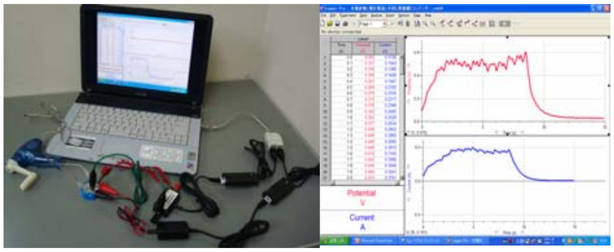

FIGURE 7. Visualization of storage and discharge of a condenser is shown. (a) Left picture shows an arrangement of equipments. (b) Right picture shows an analysis of a voltage (above) and a current (below) according to the passage of time.

Teacher Training

While we are developing ICT-based modules, a training of physics teachers has been carried out. Our training programs are based on hands-on workshop and main contents are

1. Usage of digital contents,
2. Usage of IT sensors and analysis software,
3. Usage of digital camera and analysis software,
4. ICT-based active learning method.

We figure out that lack of concrete IT-based teaching method makes teachers uncomfortable. IT-based physics means to use a computer to make graphs, write a report or research on the Internet. Teachers considered to use IT sensors took more time to prepare rather than typical experiments. In a sense, what they thought was true because they need to use sensors, digital cameras, and analysis software.

The typical training is held in 3 hours for about 10 teachers. They start from installing the analysis software to the computer and do experiments with sensors, cameras for focused issue for example, as written in this paper above. Computers or devices for sensors in our training are stand-alone, so various experiments are available in the classrooms and the field. As a result, we have more than 10 times training in a year and more than 80 percent of participants were satisfied with usage of them and feel to try them in classes.

ICT-Tools Lending System

We have launched ICT-tools lending system to support local schools in the prefecture. Teacher training and lending system prove useful in bringing popularity to ICT-based physics education.

We have organized this system and it works very well at present. The physics classes are running with our IT sensors at some junior high schools. Now, we are undergoing its' efficiency and improve our ICT-based teaching method to fit reality of students' understanding.

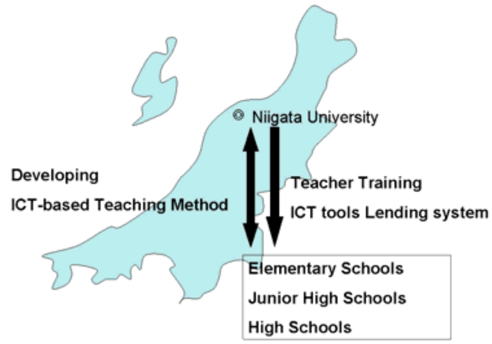

FIGURE 8. The university forms the core of the lending system and teacher support from elementary school level to high school level in the prefecture.

CONCLUDING REMARKS

1. We have developed ICT-based modules with low cost teaching material, and suggested their teaching method, which can be performed not only in the laboratory, but in the classroom.
2. We have held teacher training with ICT-based teaching.
3. We construct IT sensors lending system and it is still under consideration its efficiency.

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REFERENCES

1. A. Kobayashi,``Modularized Materials to Develop Conceptual Understanding in Physics Education", Proceedings of the ICPE2006 (TOKYO), Journal of the Physics Education Society of Japan Supplement (2008) p.154; A. Kobayashi and F. Okiharu, ``Active Learning Approaches by Visualizing ICT Devices with Milliseconds Resolution for Deeper Understanding in Physics", ICPE2009.
2. E. F. Redish, ``Teaching Physics with the Physics Suite", WILLY (2003).
3. The survey was done by Japanese Science and Technology Agency (JST). For example, (in Japanese) http://www.jst.go.jp/pr/announce/20090330-2/index.html
4. M. Yamazaki *et al*., Journal of the Physics Education Society of Japan (in Japanese), 55, 33-38 (2007).
5. A. Khumaeni *et al., Phys. Educ.* 43, 637-643(2008).
6. Vernier Software & Technology http://www.vernier.com