

# Development of the Novel e-Learning System, “SPES NOVA” (Scalable Personality-Adapted Education System with Networking of Views and Activities)

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**Abstract:** The Faculty of Industrial Science and Technology at Tokyo University of Science developed a two-campus system to produce well-trained engineers possessing both technical and humanistic traits. In their first year of study, students reside in dormitories in the natural setting of the Oshamambe campus located in Hokkaido, Japan. The education program at Oshamambe instills a rich appreciation/awareness of humanity which especially enables them to empathize with nature. The faculty has been developing a novel e-Learning system called SPES NOVA (Scalable Personality-Adapted Education System with Networking of Views and Activities). SPES NOVA, which is intended to increase competency in communication skills, is based on a remote meeting system that is accessible simultaneously to multiple users via a Flash plug-in on the Internet. To link users in separate locations, each user must have a headset and web cam attached to a personal computer with an Internet connection. At Oshamambe, the SPES NOVA e-Learning system links the students to each other and to the professors. In one of the first applications of SPES NOVA, a student puts on a headset and sits in front of a computer equipped with a camera, and then accesses small-group instruction of a humanity course based mainly on discussion. An electronic whiteboard is displayed at the center of the monitor, and live-action shots of the users are arranged around the computer screen. The voice and picture data of the lecture are stored as educational materials on the server. Consequently, students can review an entire lecture as well as their own speech and behavior. The teacher can easily cut segments from the motion pictures of the lecture and combine them into teaching materials. SPES NOVA includes an e-Learning system that distributes educational materials via a wireless LAN during instruction. The system has also been used effectively in an example of ubiquitous computing in laboratory training courses, which included small group instruction. The students are able to browse the systematic exposition of experimental techniques as well as learn the correct usage of experimental apparatus by using a portable video game player during experiments. The teaching materials contain not only the answers to possible questions, but also the lectures for the day. The e-Learning system can record the laboratory training course lectures and then stream them back in video format. Furthermore, the portable video game player can save images as well as data from the experiments. This e-Learning system is connected to the computer network on campus. Therefore, students can review the learning materials by using a personal computer before and after the laboratory training courses. When used during the small group instruction of the laboratory training course, this unique system effectively helps participants develop lecture note-taking skills, hone communication skills, and learn the correct usage of the experimental apparatus used in liberal arts. Furthermore, with SPES NOVA, we can classify individual students not only according to their academic achievements, but also in relation to their behaviour, temperaments, and lifestyles. Subsequently, we can establish a recursive evaluation system for each student.

**Keywords:** blended learning, knowledge management, communication skill, small group instruction, laboratory training course

## 1. Introduction

### 1.1 Liberal arts in the dormitory

The Faculty of Industrial Science and Technology was established in 1987 at the Tokyo University of Science and it consists of three departments: Applied Electronics, Materials Science and Technology,

and Biological Science and Technology. The faculty developed a two-campus system to produce well-trained engineers who possess both technical skills and humanistic traits. This new educational system is based on interpersonal communication and rich interaction between people and nature. In their first year of study, students reside in dormitories in the natural setting of the Oshamambe campus located in Hokkaido, the northernmost part of Japan, before transferring to the Noda campus near Tokyo for the remainder of their studies. The Oshamambe campus offers a unique curriculum to foster well-rounded individuals. The education program is comprised of a tutoring system run by faculty members to aid students in their campus life. This program consists of small group instruction sessions for the humanities courses taken by the students, all of whom are enrolled in science and engineering, small group instruction sessions for the science courses through laboratory training and exercises, and also on-site training courses that provide farming experiences, nature-based experiences, and social studies field trips. These various elements provide students with a rich appreciation of humanity which especially enable them to empathize with nature (Murakami 2005, Murakami 2007).

## **1.2 Develop the novel e-learning system**

The faculty began development of the novel e-Learning system, "SPES NOVA" (Scalable Personality-Adapted Education System with Networking of Views and Activities), based on the experience gained from 22 years of teaching at Oshamambe. In Latin, "spes nova" means "new hope," and it is the name of the Oshamambe campus. The goal is to produce well-trained engineers possessing both technical skills and humanistic traits.

One part of the project required development of an e-Learning system that distributed educational materials via a wireless LAN during instruction. The system evolved to help users acquire laboratory skills and to upgrade their communication skills. Both of these skills were used in the classroom and in the dormitory. The e-Learning system is explained briefly here.

Approximately three-hundred students were divided into groups of ten in the laboratory training course and each group worked together on the same experimental subjects. Students of the three departments (Department of Applied Electronics, Department of Materials Science, and Department of Biological Science and Technology) were included in each small group throughout the year. Students participated in a total of twenty-two experiments from all the scientific fields, including physics, chemistry and biology. Students conducted the various experiments so that they could acquire the broad knowledge required of a scientist. With this arrangement, students belonging to the Department of Applied Electronics assumed a leadership role during physics experiments. Likewise, students from the Department of Materials Science led the chemistry experiments. Finally, students belonging to the Department of Biological Science and Technology led the biology experiments. Students learned how to decide who should be responsible for which task according to their specialization, and they assigned part of each experiment to each student.

## **1.3 Problems of small groups in the laboratory training course**

When we started the small group instruction in the laboratory training course, we discovered some problems. First, students who passed the entrance examination with only a physics or biology background had almost never performed a chemistry experiment in high school. They could not smoothly conduct the chemistry experiments because they could not adequately visualize how to use the experimental apparatus from the figures and explanations in the textbook. As a result, some of the students could not finish an experiment within the allotted time. Such students concluded that chemistry experiments were difficult.

Second, students could not understand the outline and hints that the professor explained at the beginning of an experiment. Since they did not even know the names of the experimental apparatuses, it was unreasonable to expect them to be able to mentally visualize how to use them. Third, students in the dormitory did not share information about the experiments. Many discussions and debates were expected to be initiated between the students who had already finished the experiment during the previous week and the students who would do it at the next week. However, once we started small group instruction, it became clear that students did not discuss and debate as well as we had expected. Though there were additional issues, we tried to solve these problems first by developing a novel e-Learning system and employing it in the small group instruction.

## 2. Development

Figure 1 shows a diagram of the e-Learning system configuration. A video camcorder (FV-10, Fuji Film Corp.) was connected to the Intel-Mac (Mac mini 1.33 GHz, Mac OS X 10.4.7, Apple Computer Inc.) using IEEE 1394 via a hardware encoder (GV-1394TV, I-O Data Device, Inc.). The recorded images were converted to a portable music player (PMP) format using the Intel-Mac. The PMP format is playable on a portable video game player (PSP; Play Station Portable, Sony Corp.). Movie files were shared using a server (Amphis MT729C2D; Core2Duo 6600@2.40 GHz, Windows XP Professional edition, Aro-system Co. Ltd.) connected to the Intel-Mac. The server had a dual video streaming system. One video streaming system distributed the educational materials using the PiMP Streamer streaming software by DickyDick1969 for the portable video game player via wireless LAN (IEEE 802.11b/g), and the other system used VLC software for general web systems via the campus computer network. On this system, six PiMP Streamer instances ran on the giga-bit Ethernet and were delivered to several PSPs and web systems simultaneously. The PSP users could then play lecture videos on-demand if they wanted to view any missed lectures. The firmware of the PSP had to be downgraded to version 1.5 for the PiMP streamer (2.01 sub) on the PSP to operate correctly. We downgraded from PSP version 2.8 to version 1.5 using the system control software (Device Hook 0.4 launcher for 2.71).

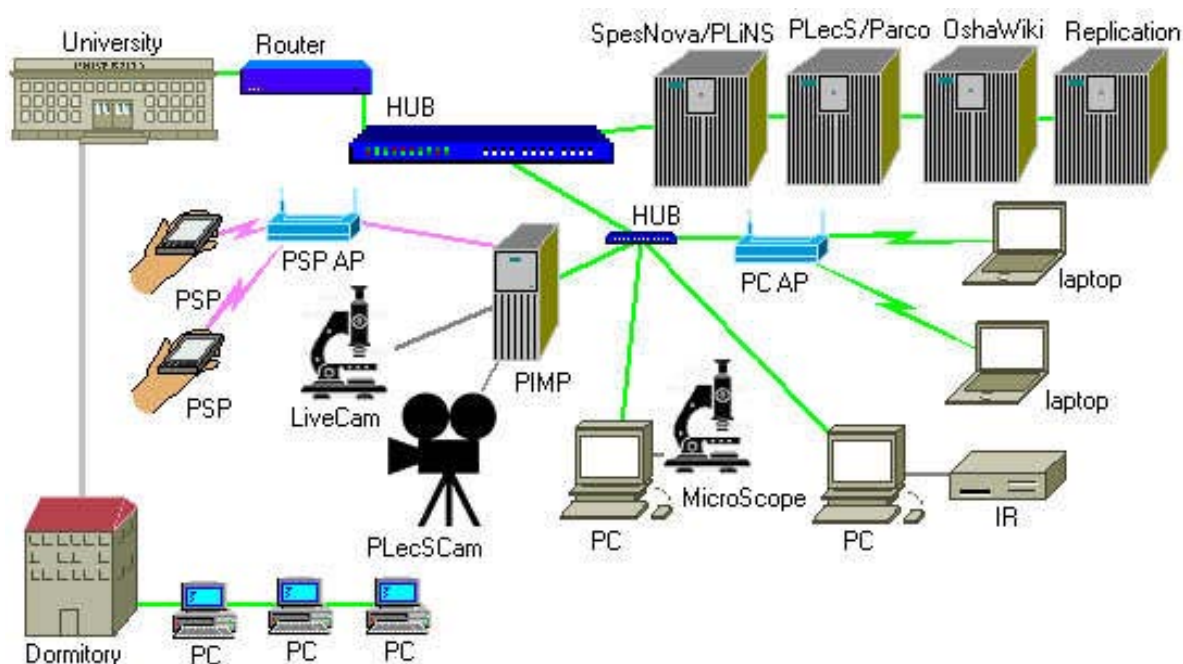


Figure 1: Diagram of the e-learning system configuration

## 3. Achievement

### 3.1 Design of the e-learning system for small groups in the laboratory training course

The e-Learning system was applied to the course, "The Quantitative Analysis of Iron (Fe) in Solution Using a Visible Spectrometer." For this course, twelve students were divided into six pairs. Each pair prepared five kinds of solutions with different concentrations of Fe as the standard to provide a calibration curve. The pairs were then instructed to help each other measure the concentration of Fe in an unknown solution. Through hands-on practice, students learned the correct experimental techniques for instruments such as a pipette, measuring flask, pH meter, and spectrometer.

At the beginning of the experiment, the professor explained the outline of the experiment and gave hints as to how to carry it out smoothly. The explanations and hints were recorded and immediately delivered to the portable video game player. A video showing how to handle the experimental apparatus was prepared and saved on the server in advance. All of the video contents, including the explanation, hints, and method of using the apparatus, were saved. The students could watch the

videos at any time and any place, even after they had returned to the dormitory. While having access to the video as a reference, they then wrote their research papers in the dormitory.

Currently, it is prevalent for a desktop and/or laptop computer to be used in e-Learning. However, it is difficult for a course involving experiments to make use of a desktop and/or laptop computer, because there are usually many materials on the lab table, such as the apparatus and chemical reagents. The presence of even a single laptop computer on the lab table can disrupt the experiment, and if all students bring their laptop computers and place them on the lab tables, it would be quite difficult to carry out the experiments. In addition, from the viewpoint of safety, it is preferable to avoid putting a computer on a lab desk. Therefore, on the Oshamambe campus, the videos are distributed to the portable video game players using the wireless LAN. With this method, computers no longer competed for valuable lab desk space.



**Figure 2:** The portable video game player

### **3.2 Use of the e-learning system during experiments**

When students conduct several experiments throughout a course, important new information can emerge almost weekly. However, anticipating student mistakes is difficult. For example, students may ingest an acid solution through a pipette, break a glass apparatus in an unexpected way, or throw away the compounds they have synthesized. Therefore, the materials recorded on video at the beginning of the fiscal year are not always useful; instead, the video materials for experiments should be recorded weekly.

On the Oshamambe campus, preliminary explanations by the professors in the laboratory training courses were recorded every week. The e-Learning system automatically recorded these explanations and then converted them into a video format for immediate streaming to the portable video game players. The students were thus able to watch the preliminary lecture on a portable video game player repeatedly, or whenever they had questions — even in the middle of an experiment, as shown in Figure 3. They could also watch the same videos with their laptop computers at any time and any place via the wireless LAN, even after they had returned to their dormitory.

There were several advantages to recoding and streaming the explanations weekly. First, an instructor was able to give a different lecture customized for each small group. Second, instructors



could point out the problems from the previous week and explain how the students could avoid repeating them in their experiments.



**Figure 3:** Small groups for laboratory training course with using the portable video game player

### 3.3 After the experiments

Students who finished an experiment could return to their dormitory and begin writing their research papers while watching the videos on the web. Other students, who would carry out the same experiment the following week, could see the students writing their papers with the aid of the information on the web. The students could then ask questions, such as "What is this instrument?", "How do you use this apparatus?", and "What are the key points of this experiment?". The Oshamambe campus took full advantage of its family-like residential status to implement this blended learning approach.

Students who carried out the experiment the following week could have face-to-face discussions about the outline and receive hints and guidance from students who had already performed that experiment. In other words, students who had finished the experiment became the teachers of the students who would conduct the experiment the following week. This blended learning functions as a chain reaction.

Within this series of blended learning chain reactions, the students could experience both the teaching side and the learning side of the experiments every other week. They could naturally learn how to give and receive correct information about the experiments. If the student's communication skills improved, they could be informed about the key points of the experiments without using the videos. It is expected that the students would gain the ability to correctly inform others about how to do procedures that they were unable to do themselves before.

### 3.4 Material production

As stated above, the preliminary explanations by professors were recorded and distributed immediately to the portable video game players on a weekly basis. However, the handling procedure for the basic experimental apparatus did not change every week. Thus, videos that covered how to handle apparatus such as a pipette and measuring flask were prepared in advance. We let volunteer students produce the videos in FY 2006 and FY 2007. The students were entrusted with all of the operations, from the video shoot to the editing of the contents.

To create accurate video materials, the students had to study how to use every apparatus correctly by using books or web sites. The students worked diligently in this respect every day until the dormitory's curfew at 10:00 P.M. Otherwise, younger students were likely to adopt incorrect ways of using each apparatus. The students produced excellent videos by learning the operation of the apparatuses by themselves, as shown in Table 1. From one to four students focused on one subject, and they spent several months to produce one content. These students learned many facts in the process of preparing the content. The students of FY2008 did experiments in laboratory training by watching the content that elder students had produced in FY2006 and FY2007. Some of the students of FY2008 said, "The contents that the seniors produced is incomprehensible," and "I want to polish the senior's contents." Therefore, we let the students of FY2008 produce new content, as shown in Table 1. Although all the Oshamambe campus students are freshmen, it is expected that such chain reactions

between younger and elder students will be established through watching and producing video contents.

**Table 1:** Videos that the students produced for these three years

Fiscal Year	2006	2007	2008
Students	13	17	23
Subjects	4	8	14
	Pipette	Separatory funnel	Glasswork
	Measuring flask	FT-IR	Pipette
	pH meter	HPLC	Burette
	Spectrophotometer	SEM	Dimroth condenser
		Tube furnace	Liebig condenser
		Box furnace	Centrifugal separator
		TLC	Rectifier circuit
		Glasswork	Oscilloscope
			Stopwatch
			Prepared specimen
			DNA (sampling)
			DNA (PCR)
			Electrophoresis
			PSP

#### 4. Evaluation

One of the key issues regarding the use of SPES NOVA is the extent to which it can provide a higher level of experimental skill. We carried out a survey about e-Learning in the small group instruction. A range of questions was asked to determine the students' opinions of their learning experience and the use and value of the SPES NOVA for preparation, experiments and writing research papers. The questionnaire was administered near the end of the semester, when students had completed the series of laboratory training. It included both general and specific questions on the students' experiences during the course, and questions requiring reflection on the experience. The questionnaire was distributed to 401 students who attended the small group instruction in the laboratory training course within the Faculty of Industrial Science and Technology, and 370 completed questionnaires were returned (92.3%).

The students were asked to rate SPES NOVA at the stage of preparation for the weekly laboratory training. The total percentage of "very useful" and "relatively useful" responses was 55.4%. These responses suggested that, while slightly more than half the number of students felt that preparation was useful, students did not take full advantage of the web site of SPES NOVA before they came to the chemistry laboratory and attended the laboratory training.

A professor explained the outline of the experiment and gave hints at the beginning of each experiment. The explanations and hints were recorded and immediately delivered to the portable video game player by SPES NOVA. When we asked students to rate the explanations recorded in the portable video game player at the stage of laboratory training in the chemistry laboratory, 68.1% of the students stated it was useful. In contrast, we asked students to rate the video showing how to handle the experimental apparatus in the portable video game player at the stage of laboratory training in the chemistry laboratory: 78.7% students ranked it as having usefulness. Many students set a high value on using the portable video game player.

The students were asked to rate SPES NOVA at the stage of writing the research paper after laboratory training. The total percentage of "very useful" and "relatively useful" responses was 35.1%.

(a) Very useful, (b) Relatively useful, (c) Relatively useless, (d) Very useless

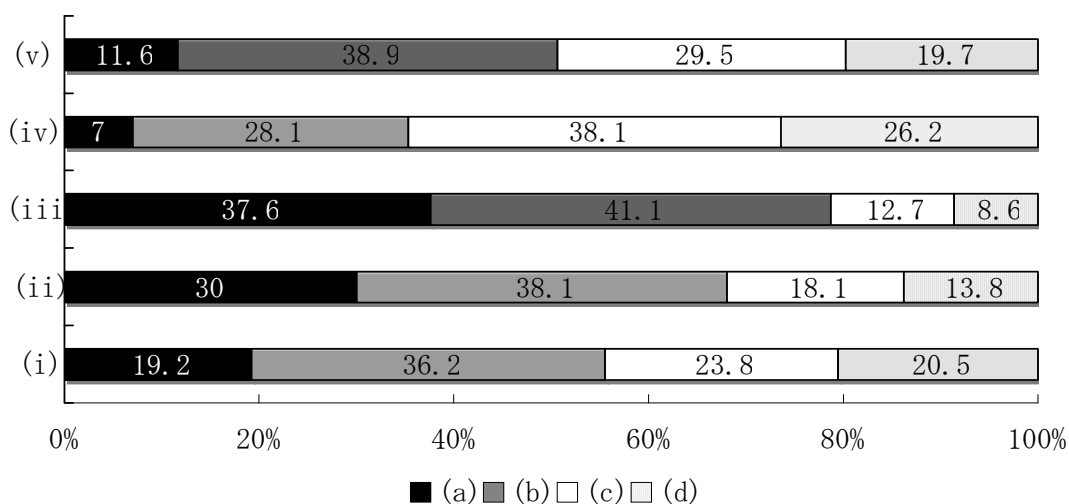
How did you feel about SPES NOVA at the stage of preparation for every week's laboratory training?

(ii) How did you feel about the explanations recorded in the portable video game player at the stage of laboratory training?

(iii) How did you feel about the video showing how to handle the experimental apparatus in the portable video game player at the stage of laboratory training?

(iv) How did you feel about SPES NOVA at the stage of writing the research paper after laboratory training?

(v) How did you feel about the total e-Learning system in the small group instruction?



**Figure 4:** The answers for the questionnaire

In other words, only one-third of the students felt that it was useful; therefore, students did not seem to use the web site of SPES NOVA when they wrote their research papers after they returned to their dormitory from the chemistry laboratory.

Finally, 50.5% students felt that the total e-Learning system in the small group instruction was useful. In response to being asked what they considered to be the main benefits of the portable video game player, students most frequently stated that they particularly liked being able to access the learning materials anytime from anywhere. The professor who had responsibility for the small group instruction thought that one of the main benefits was the ability to use the SPES NOVA as a depository of information, providing lecture notes and exercises, and making announcements. In all, SPES NOVA provided video content of the initial lecture in the laboratory training course and facilitated distribution of all learning and support materials to the portable video game player through the wireless LAN.

It is hard to understand the proper handling of the experimental apparatus even if students watch a video about its usage on the web site for laboratory training. However, if students watch the video contents on the portable video game player before actually touching the actual experimental apparatus, they more effectively acquire the skill to handle it. This could be the reason why they felt the portable video game player was useful.

When we read and corrected the research papers, we could see evidence of discussions in the dormitory by the sentences written. The reason why only one-third of students felt the usefulness of the web site of SPES NOVA at the time of writing their research papers is that their reports were written with reference only to the students' discussion and not the SPES NOVA web site. We assume that at the beginning of the semester, the student might write a paper while referring to the contents on the web site, but they gradually began to exchange information with each other more actively in the dormitory, then finally stopped using web site during the last period of the semester. It will be necessary to analyze the access log of the SPES NOVA web site in detail to confirm whether our assumption is correct.

## 5. Conclusion

We developed an e-Learning system using a portable video game player and applied it in small group instruction. Approximately one-half of the students thought the web site of SPES NOVA was useful at the stage of preparation for laboratory training. Approximately one-third thought the web site was useful at the stage of writing the research papers. According to both the survey answers and the actual content of the research papers submitted after laboratory training, some of the students

referred to the SPES NOVA web site at the stage of preparation of laboratory training, but they then tended to write their research papers by exchanging information among the students in the dormitory. However, almost 80% of the students recognized the usefulness of the portable video game player in the chemistry laboratory. The professor in charge of the laboratory training course acknowledged that the number of students who asked questions about using the experimental apparatus was much less than the number before e-Learning was established.

In the six years before using SPES NOVA, only one group finished experiments of "The Quantitative Analysis of Iron (Fe) in Solution Using a Visible Spectrometer" within the time limit of 3 hours 30 minutes. However, more than ten groups finished that experiment within the time allotted by using e-Learning. This result could be the reason why the professor realized that the experiments proceeded more smoothly.

We achieved one of our intended purposes: students who had no experience of chemistry experiments more effectively performed the laboratory training. However, it is hard to say that we achieved the other purpose: students who finished chemical experiments wrote their research papers using the SPES NOVA web site. In the future, more improvement of the contents of SPES NOVA is necessary to increase the number of students who prepare for the experiments and write their research papers by using the web site. We also need to continue to improve SPES NOVA to enhance the information exchange among students, and to consider how to create a strategy to encourage student discussions about the experimental data in the dormitory. We would like to set up a peer review system where the students mark each other's contributions, particularly in providing a suitable framework and structure that gives students the opportunity to engage in meaningful discussions.

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