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Development of Learning Material toward Basic Understanding of Information Systems for Secondary Schools

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Abstract: Web-based information systems are very popular in our daily life. But there are no learning materials to give understanding of the mechanism of the system for secondary schools. Current authorized textbooks describe individual technologies enough, however, the information systems themselves are treated from the viewpoint of end users. The next course of study in Japan for junior high school issued this year includes the problem solving activity by programming contents using interactive network connected computers, and for senior high school under review requires more higher level. In this paper, the new learning materials focusing on these requirements are proposed. Trial experiments to school teachers and university students are executed. The result of survey to participants was quite positive and it suggests that our developing learning material will have a good educational effects to secondary school learners.

1. Introduction

Information systems, especially, Web-based online services are familiar in our daily life. But currently, there are no learning materials for secondary schools to give understanding of the mechanism of such systems. Current authorized textbooks for secondary schools introduce individual technologies regarding to information systems well, but the mechanism of information systems are not enough described, and only introduced various examples in the society. Our standpoint is understanding the mechanism of the systems in our daily life leads learners have a vision of utilizing them well and abilities to apply the technology for developing our future life. The next course of study in Japan issued this year for subject "Technology" in junior high school (ages 13–15) newly introduced "the problem solving activity by programming contents using interactive network connected computers" as compulsory unit. This will come into effect from fiscal year 2021. For the subject "Information Study" in senior high school (ages 16–18), "fostering the programming ability for utilizing information systems that are composed of multiple information devices which work collaboratively" is under reviewing. This will come into effect from fiscal year 2022. Those suggests new approach for developing learning materials and teaching methods from the basic understanding of computer systems using computer networks are required.

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2. Related Works

2.1 Delivery Planning Game

One of the authors have developed and is conducting continuous practices of a learning material and its teaching method for learning the process of developing algorithms; "Delivery Planning Game"[1], [2], [3]. This learning material is based on traveling salesman problem, but by introducing the realistic constraint in package delivery service business such as the necessity for delivering on time that customers specified, varying traffic conditions by hours, and the need for the rest of drivers to avoid long time continuous work, the problem was gamified. During the lesson, groups of learners discuss the delivery plan for pursuing the optimal goal of the lowest cost. The group who could find the lowest cost in the classroom is a winner of the day. After this, the educator let learners organize their delivery plan into the forms of "sequence, condition and iteration" which can be expressed as the computer algorithm. With this activity, learners found there are certain patterns in their plans, and know they developed their algorithms of solving the problem. This activity is supported by an application of Android tablets. The application is developed by the school teacher who are a practitioner of this lesson. With the real-time feedback of showing record of operations (move to another node or have a rest) and effective sounds, learners can try much plans with limited time of the lesson.

2.2 Haulage Sharing and Freight Matching Service

Along with the progress of internationalization and popularization of electric commerce, the amount of distribution of materials, components and products are increasing rapidly. In this situation, the efficient operation of freight vehicles and containers are re-

Fig. 1 Understanding without computer and computer networks

quired in an economic point of view and with the consideration of environmental impact by carbon emissions. For maritime industry, the movement of empty containers to resolve the unbalance allocation of containers among seaports is a problem**?**. For carriers that transport goods and products, running of empty vehicles is also a problem[5]. Both occurs when there are not anything to carry after delivery have done. In order to eliminate these wastes, "Haulage Sharing" have started by contract among carrying companies. In this manner, a group of carrying companies share their own cargo with each other. Also in Japan, "Haulage Sharing" are permitted by Ministry of Land, Infrastructure, Transport and Tourism (MLIT) in 2012 for enabling efficient logistics.

The "Freight Matching Service"[6], [7] is another approach for sharing cargo. This idea was arose from the requirement of improving the operational efficiency of market place among agents and carriers. In this service, by introducing electronic auction system, the adjustment process of various needs among participants is fully automated. This service is build as Web-based service on top of the cloud computing system and the matching agent is a software. With this nature, a lot of startup companies are entering this business worldwide. In Japan, this service is also rapidly expanding with the expectation to resolve the serious shortage of workers in logistics contrast to continuous growing the needs of transportation.

3. Research Issues

Web-based information systems are familiar in our daily life. The characteristics of Web-based information systems is that they are built with server-client architecture using computer networks and the client is Web browsers. Users normally does not aware of the existing the server and computer networks unless the service stops or a trouble of the network occurs. Thus, people sometimes misunderstand the architecture as peer to peer communications between users, or the local PCs that users operate. Though there is a data processing on the server, for the people recognize the service with this model not aware that the service is built with the computer program that is designed and implemented by human. That is why education for the technology of computer and computer networks, especially the experience of programming and thinking of algorithms through problem solving activity is required.

In the case of "Freight Matching Service," people miss the existence of servers as computer imagine this service as shown in **Fig. 1**. People understanding the system with computer and computer networks will image the structure as shown in **Fig. 2**.

In order to fill the gap between above understandings, especially in secondary education level, development of cognition for the mechanism of computer systems that processing with communication via computer networks, and data transferred among the system have a form that is necessary for processing on other computers in the system is necessary in junior high school level,

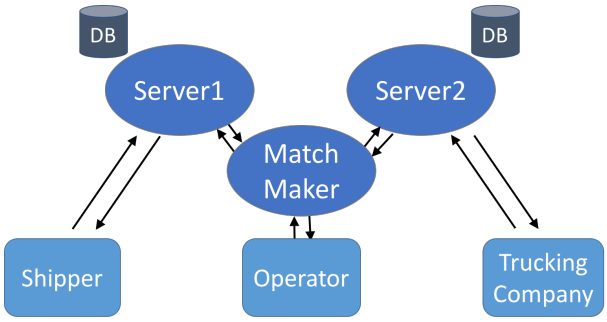

Fig. 2 Understanding of the system with computer and computer networks

and designing and implementing knowledge and skill for their own prototype system are required in senior high school level.

More concretely, the following requirement is set for this study.

(1) The model of Web-based information systems have a clear goal that can easy to understand how useful to what kind of people or society
(2) The structure of the system is simple but have enough persuasion
(3) Data is visualized and the format of the content is simple
(4) The learning materials is attract interest to student
(5) The lessons using learning materials enhance students view to the systems
(6) The code of the learning materials can be a reference model for high school students

4. Developed Learning Materials

4.1 Design Policy

In this study, the "Freight Matching Service" is embraced as an example of Web-based information systems. The primal advantage for using this system as a model is closely connected to, and steadily supports our daily life. In addition, this service have developed by focusing on the common problem consciousness with the "Delivery Planning Game"; decreasing wastes of consuming energy, optimizing the operation of cargoes, and optimizing the worker's labor time that can have enough rest.

In order to let learners understand this technology, carefully designed hands-on learning materials and well-coordinated lesson plan is indispensable. For educational reason to novice learners, the simplified structure of the system is needed. The nature of distributed system, communication between components are essential. In this study, showing data with carefully designed format explicitly to learners is considered to help understanding of it. The lesson plan using above system is also necessary. The detail of above will described in the following subsections.

4.1.1 Simplified Structure of the System

The real system of "Freight Matching Service" have identical matchmaking program which calculate semi-optimal logistics solution varying time to time automatically. But for novice learner, this "hidden" mechanism is too hard to understand. With this reason, the matchmaking software is moved to a role of the human in this study. The condition for matchmaking is also drastically simplified to only a match of time between shipper and carrier. This simplification is considered from the experience of "Delivery Planning Game" for satisfying good understanding

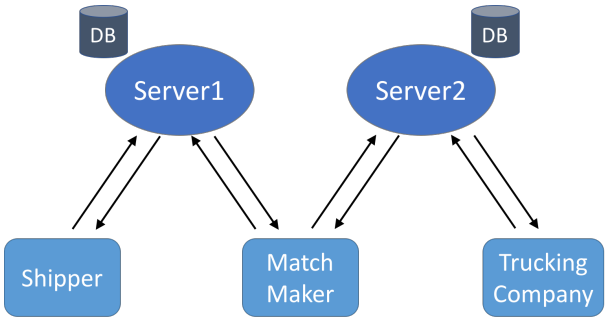

Fig. 3 Simplified Structure of the system for this study

within a limited time of school schedule. In the "Delivery Planning Game," the minimal time unit is 10 minutes, but in this study, time slot is set to only three; "Morning," "Noon," and "Evening." This simplification of three time slots is for the sake of help understanding of the format of data. The detail is described in the next section. But this setting will be changed with the improvement process by reviewing comments from school teachers and results of future experimental lessons to students. The simplified structure of the system in this study is shown in **Fig. 3**.

4.1.2 Message Format

In this study, the impact of explicitly showing data to learners is considered. Then, because exchanging data among components sometimes behave as a command in the system, the word "message" is used hereinafter. For the help to novice learners, the message format should be simple and easy to read. During the design process of a total learning system, finally, the message is set to be composed of nine-digits number. The format of this number is shown in **Fig. 4**.

The format is similar to the data frame of the packet in computer networks. The fields of sender and receiver is necessary. The second receiver field is necessary only for "Match Maker." As shown in Fig. 3, "Match Maker" send a message both to shipper to trucking company when the requested pickup time slot and the vacant time slot of trucking company were matched. By receiving this message from "Match Maker", shipper is able to know which trucking company will come in which time slot, and trucking company is able to know which shipper is a customer to go for picking up and which time slot is the required time.

Rest of three flag digits are designed for easy understanding of how matchmaker check. As shown in Fig. 4, if a message from a trucking companies of these fields include 1, they means they are the candidate for matching. A message from a shipper of these field includes 1, they means they are also the candidates for matching. Then, aligning messages of trucking companies and shippers vertically, if there is a place both are 1, they are matched. If multiple matches are found, matchmaker choose one of them and send messages to both that result.

4.2 Lesson Plan

In this study, the following learning plan is set. In the following description, the "player" is a generic name of "Shipper", "Trucking Company", and "Match Maker (matchmaking service provider)."

There are four steps in this lesson plan as following:

Sender	Receiver	Reciever2	Morning	Noon	Evening
21	31	00	1	1	0

Player ID: (x=1..9)
1x:Trucking Company
2x: Shipper
3x: Match Maker
00 is permitted only in Rec2

Flags:
in Tracking company:
0 = busy, 1 = vacant
in Shipper and Match Maker:
0 = busy, 1 = time of pickup

Fig. 4 Format of the message

(1) Know what is a "Freight Sharing Service"
(2) Understand how each component in the system communicates
(3) Know the data in the communication
(4) Understand the role of the data in the system

In step 1, learners are described what is "Freight Sharing Service" in a short. Then, the educator introduces players in the system with the role of each player.shows what players exist, what role does each player have, and how the service work with what kind of information is communicated by way of servers using the Fig. 3.

The interactive computer programs for learners to experience this system are used. at step 1, single screen program that help explain the process of this system is used. At step 2, a set of three kind of programs correspondent to each player is used. A group of learners choose who charges what player, and operate their screen with collaboratively. At step 3 and 4, another set of three programs that show the data apparently to the screen is used.

Those programs are named in order, "Rule Briefing Program", "Virtual Experience Program", and "Message Focused Program." Detail of them are described in the next section.

4.3 Implementation of Programs

Programs of learning materials in this study are implemented with Dolittle programming language. The reason for choosing Dolittle are three; (1) it have a networking functionality as "server" object (2) it can program in compact with plain text (3) The syntax is simple and it can use Japanese, then students can read the program with less effort.

For preparation of future expansion of lesson plan such as an activity of modifying or adding a feature to these programs by a student, the implementation is intentionally keep simple and easy to read.

4.3.1 Rule Briefing Program

This program is operated by an educator. **Fig. 5** is the last scene of this step. Attached numbers are the operation order of this program.

At first, by assuming Ken wants to pick his package up at morning, click corresponding button (1). By clicking every three buttons in "Picking Time" area, the background color of them are alternately change between red and white. Red means this time slot is not selected. After clicking, "Order" button and arrow in the box of (2) appears. Then click "Order" (3). "Check" and arrow in the box of (4) appears. The educator ask "What is matched between Ken's request and trucking companys' vacant time?" to learners. In this case, the color of both "Picking Time" and "Delivery Time" areas are white is only Trucking1, then click the

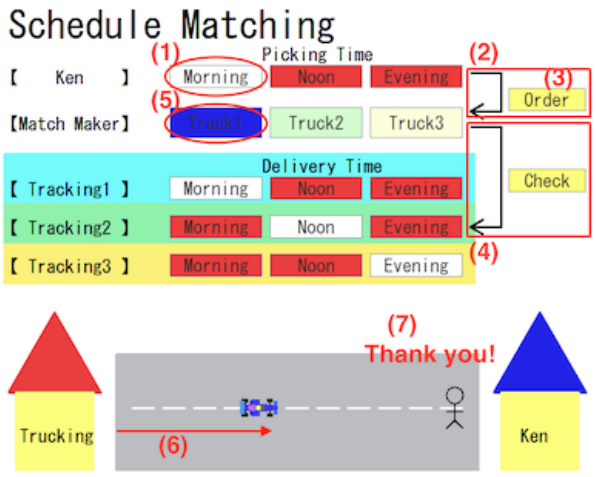

Fig. 5 Rule Briefing Program

"Morning" button at "Match Maker" area (5). The car appears on the road and go forward to Ken (6). After the car arrives at Ken's icon, the message "Thank you" appears.

In "Delivery Time" area, every three time slots which color is white is identical to three trucking companies, the educator can show learners choosing arbitrarily time slot. Above sequence can repeatedly show until learners understand the process.

4.3.2 Virtual Experience Program

These three programs are operated by learners (**Fig. 6**). At fist, the educator let learners choose one "Match Maker." The educator also let rest of learners separate to "Trucking Company" and "Shipper." In this program, the number of both "Trucking Company" and "Shipper" are up to nine. But the limitation of displaying area on "Match Maker", the number of "Trucking Company" should not be over three.

The color of buttons on the shipper's screen, gray means the available time slot for picking up, and sky blue is not. The meaning of the color on trucking's screen, gray means the vacant time slot and blue is busy. The color changes alternatively by clicking the button.

The session can start from either the shipper learners or trucking learners. The matchmaker learner should wait for their messages.

A shipper learner choose one or more available picking-up time slot by clicking corresponding button as gray colored, then click "Send" button. The message is sent to the matchmaker. The texts of what's happened are displayed on both the shipper and the matchmaker screens at the left bottom text areas. At the same time, on the matchmaker's screen, the line including the name of shipper as "SH1" (SH + number) and three buttons indicating the shippers available time with the same color of the shipper appear under the line of "Trucking3." This displays available time from a shipper are registered to the matchmaker. All buttons displaying time slots on matchmaker screen is placed as displaying only. They can click, but nothing happen.

A trucking learner choose one or more vacant time slot by clicking corresponding button as gray colored, then click "Send" button. The message is sent to the matchmaker. The texts of

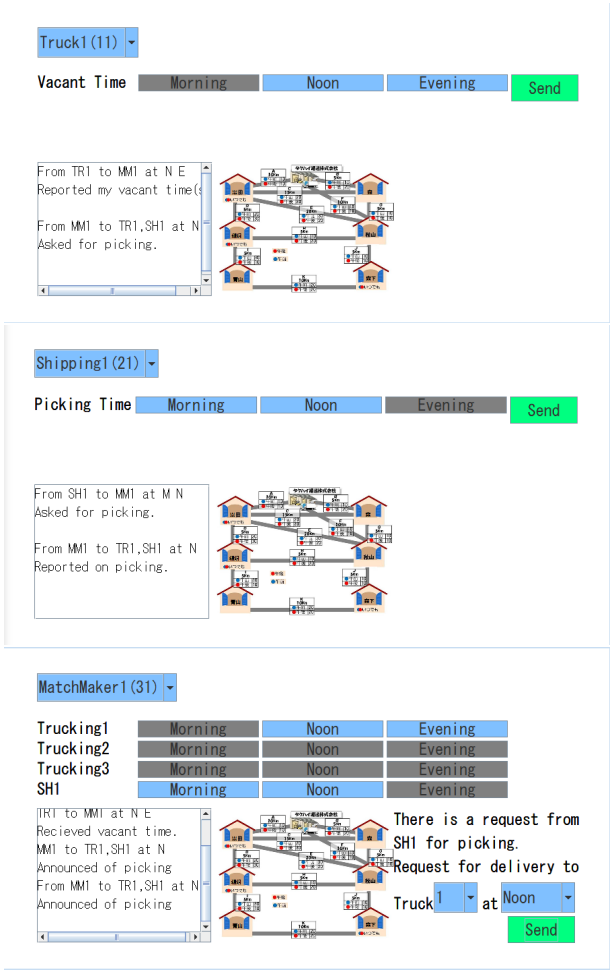

Fig. 6 Virtual Experience Program

what's happen are displayed on both tracking and matchmaker screens as the same manner of the shipper did. As the same with shipper's case, all registered vacant time from each trucking are displayed on matchmaker's screen.

Then, the turn of matchmaker learner come. The matchmaker learner look at the display, and check if requested available time from the shipper and registered vacant time from trucking match or not. If there is a match, operate two select menus at the bottom right of the screen as corresponding trucking number and time slot are selected. By clicking "Send" button, messages are sent both chosen trucking learner and shipping learner, and displays texts that describe they are matched.

The session is over at this time, but any shipper learner can send another request, and any trucking learner can change the vacant time at any time. The matchmaker learner should check the match and send return message repeatedly.

As described above, only the matchmaker learner is busy, but only the matchmaker can see all information on the screen and understand what message is transferred from where by looking at the change of the screen. Thus, it is recommended that the educator advises as much learner in the group as possible to experience the matchmaker within the defined time.

4.3.3 Message Focused Program

After experienced virtual experience of the "Freight Matching Service", students moves to the next activity. **Fig. 7** is screens of

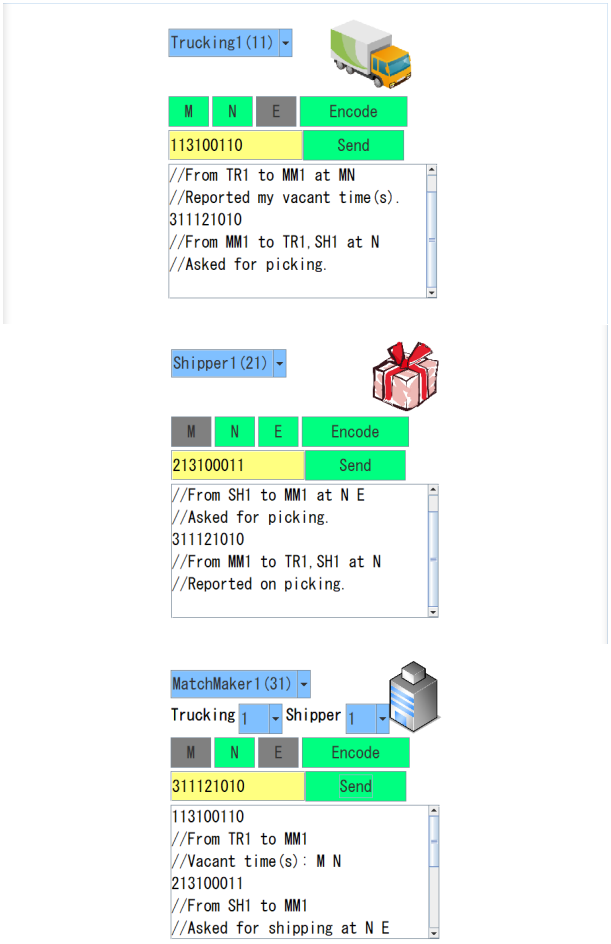

Fig. 7 Message Focused Program

programs on this activity.

Before starting this activity, the educator tells learners that the last system were functioned by exchanging the messages with nine-digits numbers, and this system can see them. The educator also let learners select their role the same as the last activity.

Then, the educator tell learners to click any button within "M," "N," "E" which means the time slot of morning, noon, and evening and click "Encode" button. The nine-digits number appears in the yellow colored area. The educator describe this number is a content of the message, and let learners think the mean of it with the talk.

The script of the talk is as follows:

"Look at the leftmost two digits of the message. and look at the top of the screen."
"There is a two-digits number in the braces beside of your name."
"Think, what is the mean of leftmost two digits?"—Myself.
"Right. So, look at the next two digits of the message. What does it mean?"
"The number is different with each player. Shippers and truckings, what is the number?"—31.
"31. Who's number?"—Matchmaker.
"Yes. But think. Why you are the same?"
"It might be difficult. Remind the last activity. At the start, what did you send?"—Time.
"Who received your time?"—Matchmaker.
"Right. This means you are just sending this message to matchmaker."
"Now, you know the leftmost two digits are the number of yourself. You are the sender, and next two digits are the number of receiver of this message."
"Alright. So, what is the next two digits, Shipper?"—00.
"How about matchmaker? Read six digits from the left."—311121.
"Your number is 31. So, who have a number 11, and who have 21?"—Trucking1 and Shipper1.
"Good. The matchmaker is just sending the message to Shipper1 and Trucking1. Read the second line from the top."
"Matchmakers, you can select the number. Try select another number and click Encode."
"So, what does it mean the rest of three digits? Look at the button of M, N, E."—Gray is 0, and Green is 1.
"Then, truckings, click Send button."
"Messages from truckings are sent to the matchmaker. That's the mean of the mesage."
"Let's start the activity. The procedure is the same as the last one."
"Keep watching the text area. You can see the message sent to you."

Table 1 Summary of Trial Experiments

Date	Attribute	Participants
Jul. 26	Teacher (5-year career)	5
Aug. 4	Teacher (10-year career)	2
Aug. 29	University Student (junior)	11
	Teacher (6-year career)	1

5. Trial Experiments

In order to evaluate if this learning materials have a possibility to work in the lessons of actual schools, trial experiments to school teachers and university students who take teacher training courses were executed. The summary of each experiment is shown in **Table 1**.

Early two experiments for teachers were executed with each in-service training program under the permission of the board of education. In Japan, the induction training and the training for ten-year career teachers are legally obligated. The training for five-year career teachers is set by prefecture for expanding the professional skills on daily practices in the school. The purpose of the legal training for ten-year carrier teachers is developing their special expertise that can act as a middle leader of the school.

The last experiment was executed to junior-grade university students who take teacher training course. One teacher joined in this experiment.

All teachers are currently teaching subject "Technology," and university students also take a course to have a license of this

Q1: What kind of applications in our daily life are reminded from the description?
Q2: What kind of learning materials are required for the lessons?
Q3: What is your current idea for the lesson plan on this unit?

Fig. 8 Questions of pre-survey

Q1: How do you feel to these learning materials? Please add your thoughts on expected learning effects.
Q2: How do you feel to the nine-digits number data? Please add your thoughts on expected learning effects.
Q3: Did you feel this experience helps you thinking of your future lessons on this unit? (answer with Yes or No) Please add the reason of choosing this.

Fig. 9 Questions of post-survey

subject.

5.1 Procedure

Trial experiments are executed with the following procedure:

(1) Description of the unit regarding to this study in the next course of study and its practical guide for subject "Technology"
(2) pre-survey
(3) practice as following to the lesson plan
(4) post-survey

In the pre-survey, participants wrote answers for three questions as shown in **Fig. 8**. In the post-survey, participants wrote answers for three questions as shown in **Fig. 9**. For the practice, three notebook computers were prepared corresponding to three players; "Shipper," "Trucking Company," and "Match Maker." and programs were installed. They are connected with local Wi-Fi router that brings with computers.

5.2 Result

The total time of experiments except for pre- and post-survey were about 20-25 minutes.

In these three experiments, the participants of the second experiments experienced actual hands-on activity. The reason of the number of participants of this experiments were only two, and we could support their operation on time. In other two experiments, instead of the hands-on, we reproduced hands-on experience with the projection of our computers that run each programs on the screen.

The summary of answers from the pre- and post-surveys is shown in **Table 2**.

Most of all participants could answer Q1 after the description, but no one could answer Q2 and Q3 at the step of pre-survey. But at the step of the post-survey, almost participants could answer all questions well. Although the carrier of participants different, the content of answers were very similar. The difference was only the writing style came from their carriers.

6. Discussion

In the pre-survey, answers to Q1 shown above are part of them

Table 2 Summary of answers from pre- and post-surveys

Pre-survey		
A1	SNS, Car Navigation Systems, Communication Robots, Online Games	
A2	(No Answer, or "I have no idea")	
A3	(No Answer, or "I have no idea")	
Post-survey		
A1	(*Comments*)	
	Very easy to understand.	(1)
	I could understand the mechanism behind the service.	(2)
	I understand how information are exchanged with each other.	(3)
	Built with Dolittle language is good for schools.	(4)
	(*Learning Effects*)	
	Practice can lead students to deep understanding.	(5)
	The theme close to our life can attract student interests.	(6)
	Active discussions in the classroom will be expected.	(7)
A2	(*Comments*)	
	I understand information is expressed as data in computers.	(1)
	It's fun to read numbers because it is like a puzzle.	(2)
	I wonder how the real system deal with hundreds of data.	(3)
	(*Learning Effects*)	
	Learning of data will lead students to deep understanding.	(4)
	Students will look for other examples after learning this.	(5)
	Showing data visually is good help for teaching.	(6)
A3	(*Comments*)	
	I feel I can teach with these easy and simple programs.	(1)
	I could start thinking of how do I teach this unit.	(2)
	Learning mechanisms of the system expands students' view.	(3)
	I think students can think improvements of this program.	(4)

which enough to follow examples written in the practical guide; "*As examples of problem solving activity by programming of contents, it is considerable that adding interactive contents such as Q&A style quiz to an introduction page of the school's official Website, or reproducing simple chat program in the classroom which can send and receive comments each other.*" They are paying attention to human communication via computer networks or communication between human and computer.

The practical guide contains a learning activity to foster the ability of the problem solving. It start from finding the necessity of improvement in the program that a student composed such as an enhancement of the user interface of the program on the Web page or the information security in a chat program, then, thinking how to improve a design and an implementation of the program, and finally, realizing it. This is a bottom-up approach that teachers can think of their lessons smoothly. But when asking teachers and teacher candidates about learning materials (in Q2) and lesson plans (in Q3) immediately after enumerating existing systems (in Q1), even experienced teachers could not answer anything. This suggests the need for providing learning materials for understanding the mechanism of computer systems that include network communications and human-computer interaction. Our proposal focusing on Web-based information systems is a part of such systems.

The result of the post-survey suggests our approach is positively accepted. The answers to Q1 will show participants could understand the mechanism of the system that works by transferring messages each other between computers via servers. Some participants commented the hands-on activity of learners could understand deeply as shown in A1-(5). The answer A1-(7) writes a image of classroom of the hands-on session. This participant would start thinking of how he support or make interventions to learners during the session.

The answers to Q2 also supports showing data as nine-digits number helps thinking of data as positive. A participant answers A1-(2) writes reading numbers feels like a puzzle, and there are some other answers using expressions of "data is coded" and "data is encrypted." But the answer A2-(3) shows a doubt if this learning materials describe the large scale Web-based services in the real world enough. This concern is right because there is no data store corresponds to the database in our implementation. Because messages sent to the server is not queued, race conditions are easily occur. Because matchmaking is not automated, "Match Maker" is the busiest player and this model does not work in the real services. These are compensation for our decision of pursuing simple implementation that student could read our source programs as much as possible.

The answer to Q3 shows our learning materials motivate participants start thinking about how this unit deal with in their lessons. A participant in the second experiments told he could find a model of teaching this unit by experiencing this learning materials with the hands-on activity.

Even the answer A3-(5) writes students could improve our programs, and our effort of keeping simplicity, there must need a guide to help understanding the code even for high school students. Current status of our learning materials is still for school teachers and at least junior grade of teacher candidates. It needs more improvement and additional development of materials that can support leaning activities illustrated in the practical guide from the government more effectively both for junior and senior high schools.

7. Conclusion

In this study, a set of learning materials and a lesson plan for understanding the mechanism of Web-based information systems is developed. From the answer of surveys from trial experiments to school teachers and university students who are taking teacher training courses, current settings have positively accepted and impact for giving conceptual understanding of the technology. But this is still under development project. By getting more feedback from school teachers, more refinement of design, more improvement of programs and development of additional materials that support secondary school learners are needed.

8. Acknowledgments

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References

[1] Akiyama, M., Honda, M., Kanke, H., Sasaki, J., and Hanada, M.: *Application Development for Tablets to Support Cooperative Learning of Algorithm Construction*, Bulletin of the Educational Research and Development, Vol. 24, Faculty of Education, Kagoshima University, pp. 81–90 (2015). (In Japanese).

[2] Akiyama, M., Hanada, M., Honda, M., Sasaki, J., and Kanke, H.: *A Study of the Trend of Thought Processes of Students in Solving Vehicle Routing Problem with Time Windows*, Bulletin of the Center for Educational Research and Practice, Vol. 37, Faculty of Education and Human Studies, Akita University, pp. 255–263 (2015). (In Japanese).

[3] Akiyama, M., Honda, and M., Hanada, M.: *Development of Learning Environment for Ability Development of Search Algorithm Construction with a Case Method at Multiple Schools*, Research of Technology Education in Aichi Univeristy of Education, Vol. 1, pp. 3–8 (2015). (In Japanese).

[4] Sterzik, S.: *Concepts, Mechanisms, and Algorithms to Measure the Potential of Container Sharing in Seaport Hinterland Transportation*, Ph.D Dissertation of University of Bremen, pp. 1–143 (2013).

[5] Andriolo, A., Battini, D., Persona, A., and Sgarbossa, F.: *Haulage Sharing Approach to Achieve Sustainability in Material Purchasing: New Method and Numerical Applications*, International Journal of Production Economics, Vol. 164, pp. 308–318 (2015).

[6] Giannopoulos, G. A.: *Towards a European ITS for Freight Transport and Logistics: Results of Current EU Funded Research and Prospects for the Future*, European Transport Research Review, Vol. 1, Issue 4, pp. 147–161 (2009).

[7] Nault, B. R., Dexter, A. S.: *Agent-Intermediated Electronic Markets in International Freight Transportation*, Decision Support Systems, Vol. 41, Issue 4, pp. 787–802 (2006).