Regular Paper

A Web Education System with Personalized Navigation Based on SQ3R☆

Guozhen Zhang,[†1] Zixue Cheng,[†2] Aiguo He,[†2] Akio Koyama[†3] and Tongjun Huang[†4]

The research on Web-based learning is a hot research topic in recent years. But the personalized learning support is limited in most research studies, because the human cognitive process and educational psychology-based study method are not considered. Our previous work proposed a learning support system based on a study method known as SQ3R. The system provided a set of tools following the SQ3R. But the navigation support in the system is not flexible enough to follow the substance of the method. In order to support and promote learners to learn as per the SQ3R schedule, we give three types of navigations using agent technology in this paper. These three navigations are named as heuristic tool-using navigation, traffic-light progress navigation, and suggestive review navigation. In addition, we have implemented and evaluated the Web education system with the SQ3R-based navigations.

1. Introduction

Over the past several years, the development of IT [1] has changed the style of education. Education is no longer restricted to a certain fixed time, and in a designated place due to using Internet technology. Web-based distance learning, as a new medium of learning, suits the user's needs, and becomes more attractive and valued.

Many research studies on the design of Web-based distance learning systems have been done. For example, a typical approach directly transplants traditional school courses onto the WWW [2], providing sequential, systematic, and complete courses. But this approach is not dynamic enough for learners to search for related knowledge, and can not provide different learners with personalized supports. Wu [3] designs WWW course contents directly by using links to connect related areas of knowledge. By using this system, learners obtain related information and knowledge by visiting the linked pages. But a beginner may lose his/her way in the linked pages, and lose study time. It also may be hard for learners to obtain the whole view of the course. Several research projects [4)~6)] not only focus on organizing the course contents well, but also give personalized learning supports in different approaches. For example, according to the pattern of quiz answers, Zhu [4] highlights the parts that have not been learned enough by the learner, and gives advice for learning the weak parts. Kuwabara [5] provides several types of support messages according to results of tests. Hasegawa [6] gives an index of the course contents, and a navigation function for contents that need to be learned systematically. However, while a learner is learning, it is difficult to point out the learner's weak actions, and give a specialized support as an instructor does in traditional school.

To solve these problems, educational psychology-based study methods have been applied in the Web education, to support learners with specialized instructions as in the school education.

A Web tool [7] is provided to make checking sheets to support learners learn based on a study method called SQ3R. Learner can use the checking sheets to check the learning steps, and record the main ideas. These sheets assist learners to finish the learning process based on the SQ3R. But using this tool, learners only can write on the sheets, and the recorded information at each stage is separate. This tool cannot support a learner to finish SQ3R stages smoothly while the learner has some troubles, and there is no environment to integrate the learning stages together. Our previous work [8] gave a group of tools (learning environments)

†1 Graduate School of Computer Science and Engineering, The University of Aizu
†2 School of Computer Science and Engineering, The University of Aizu
†3 Faculty of Engineering, Yamagata University
†4 Information Systems and Technology Center, The University of Aizu

☆ The work was supported by New Energy and Industrial Technology Development Organization Japan, grant ID: 12HT2003.

to help learners learn at each SQ3R stage. A learner can write notes, mark main points, and check his/her understanding situations by answering quizzes. While a learner has some troubles in his/her learning processes, he/she can use query tool to ask other learners questions, or use search tool to find related information among the learning materials. Further more, the previous work integrated tools with SQ3R stages together, and let the learning stages be not separate. For example, the memos recorded at *read* stage can be listed up at *review* stage as review points, and so on. Learners' actions and responses are gathered simultaneously, while learners are using tools. By analyzing these responses, learner's situations can be grasped by teachers. But to a learner who cannot use the SQ3R and tools well, appropriate supports are not considered.

In this paper, we focus our research on providing appropriate supports to help learners learn as per SQ3R schedule in Web education environment. In order to point the learner's weak actions exactly, and support him/her individually, a method, which uses an SQ3R-based agent to support and suggest learners to learn, is proposed. The agent offers navigations to guide learners to learn in accordance with the SQ3R method.

Based on the SQ3R learning mechanism, three types of navigations are offered by the navigation agent according to learners' learning trace (tools using information, and so on.) and learning progress. The offered navigations are as follows:

(1) **Heuristic tool-using navigation**: In the learning process, in order to guide learners to use appropriate tools to improve learners' comprehension, an advice is given to suggest learners which tool should be used.

(2) **Traffic-light progress navigation**: In accordance with the combination of tools' usage, a navigation with notice information is presented to remind learners of the missing stages. This type of navigation guides learners whether the learning is enough to go ahead or not.

(3) **Suggestive review navigation**: Base on the SQ3R learning schedule, to review on time is helpful for memorizing. In order to prompt learners to review on time as per the SQ3R schedule, a prompt review notice is given.

A Web education system embodying the navigation agent is designed and implemented, and the usability and the effectiveness of the system are evaluated by experiments.

This paper is organized as follows: Section 2 outlines the study method SQ3R, and compares previous SQ3R-based Web learning systems. Next, an agent-based course navigation system is described in Section 3. The implementation of the agent, navigation functions, and the system are shown in Section 4. In Section 5, the experiment and the evaluation of the implemented system are described. Finally, Section 6 concludes this paper.

2. Outline of SQ3R and Previous SQ3R-based Web Education Systems

Due to the reading is the main action in Web-based learning process, study method SQ3R is more suitable for using in Web education systems [8] instead of PORPE [9], REAP [10], and KWL [11] study methods. Here, a summary of SQ3R and SQ3R-based systems are introduced.

2.1 Introduction to SQ3R

In traditional school systems, the SQ3R is accepted as an effective study method. SQ3R stands for *Survey*, *Question*, *Read*, *Recite*, and *Review*. They are five stages (skills) used for learning. The study method SQ3R is based on research results of educational psychology, and considers the mechanisms of memorizing, forgetting, and cognitive processes of brain.

The SQ3R (*survey*, *question*, *read*, *recite*, *review*) stages integrated for optimal learning. In order to sustain learning, the motivation and learning strategies are considered as the most important points. The study method SQ3R addresses these two points. In 1800's, psychologist H. Ebbinghaus [12),18)] researched on the memorizing algorithm and found the forgetting curve of memorizing, and concluded that as time elapses, so does the memorized content. In addition to that research, psychologist Robinson found that learners who reviewed regularly compensated for the forgetting. Applying that research, he developed the study method SQ3R.

The relationship between the SQ3R stages and memorization is shown in **Fig. 1**.

In the *survey*, *question*, *read*, and *recite* stages, learners learn and memorize more and more information. Although, after each stage, the learned knowledge is easily forgotten as time passed, but this can be redressed soon

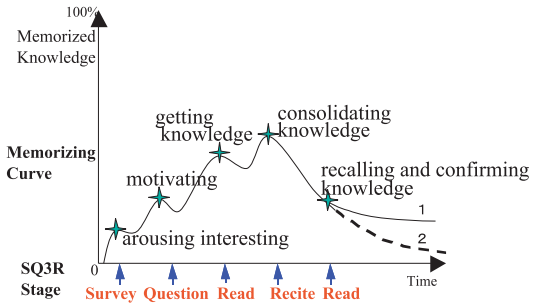

Fig. 1 Relationship between the SQ3R stages and memorization.

since the intervals between every two stages are not so long. After learning, if learners review the material in time reinforcing memory, learners can maintain memorized knowledge as the curve 2 shows. On the other hand, if without reviewing, the memorized knowledge will elapse as shown in curve 1.

A brief description of the five components summarizes SQ3R based on the articles[12)~17)].

***Survey*:** In order to help learners to get a whole view of the learning material (e.g., a book or a chapter), psychologists advise learners to skim over the title, headings, charts, graphs, introductory and concluding paragraphs, and summary, to find the core ideas in the material in a short time.

***Question*:** In order to arouse learners' curiosity, and help them to understand the learning material, psychologists advise learners to ask many questions. One technique mentioned is to change titles or headings into questions using "how", "what" or "why" and so on.

***Read*:** From an educational psychologist's point of view, it is useful to read material carefully, seeking the answers to questions asked in the *question* stage. Making notes or underlining important words or sentences is also useful.

***Recite*:** Psychologists suggest learners recite the material after reading, and answer the questions without referring to the material. When the recitation cannot be continued, psychologists advise re-reading the forgotten parts and immediately recite again, then continue with re-reading and reciting to the end.

***Review*:** After learning the material, psychologists suggest learners look over the headlines and notebooks, and recall the knowledge according to the SQ3R schedule.

2.2 Previous SQ3R-based Web Education Systems

Some Web-based tools have been developed to support learners/teachers to use the study method SQ3R[7)]. In the research[7)], WWW pages, which can help learners/teachers to make checking sheets according to the SQ3R, are given. In these sheets, the tasks at each learning step are listed out. While learning, learners can fill in every field of the sheets. The sheets help learners remembering important concepts from their reading. Using these sheets is helpful when learners read a long reading material, since the sheets assist learners to record the main ideas at each learning step. However, the functions provided by these tools are inadequate to make good use of the study methods, more support functions are necessary. Moreover, using this tool, learners only can write on the sheets, and the recorded information at each stage is separate. The tool cannot support learners to finish SQ3R stages smoothly while learners have some troubles, and there is no environment to integrated the learning stages together.

Our previous work[8)] developed a group of tools (learning environments) to support learners to learn on Web environment. The eight kinds of tools include memo tool, marker tool, search tool, query tool, and so on. The query tool presents an environment for learners to make and answer questions; The memo tool is used to record thoughts, comments, and important parts of the learning material; The marker tool highlights the selected lines in the learning material; The search tool helps learners to find associated knowledge among the materials. Learners can write memos, mark main points, and check his/her understanding situations by answering quizzes. These tools effectively support learners to finish each SQ3R learning stage, since tasks of each SQ3R stage can be indicated by these tools.

While a learner has some troubles in his/her learning processes, he/she can use query tool to ask other learners questions, or use search tool to find related information among the learning materials. Further more, the previous work integrates tools with SQ3R stages together, lets the learning stages be not separate. For example, the memos recorded at read stage can be listed up at review stage as review points, and so on. Also, learners' actions and responses are

gathered, while learners using tools. By analyzing these responses, learners' situations can be grasped by teachers.

However, there are still some issues have not been solved in our previous work. For instance, the detected learner's information has not been used sufficiently; For someone who couldn't learn as per the SQ3R schedule well, or who cannot make use of the tools properly, there are no particular navigations to guide the learner. The remained problems in our previous work can be summarized as follows:

(1) to provide learners with a personalized course navigation responding to the detected learners' tools using information;
(2) to provide learners with individual support according to learners' understanding situations;
(3) to conduct learners learn as per SQ3R schedule;
(4) to guide learns the missing points in the learning process;
(5) to provide an intelligent-support Web education environment.

3. Web Education System with Agent-based Personalized Navigations

In order to solve the above mentioned problems, we first develop agent-based navigations, then develop an advanced Web-based education system by combining the agent-based navigations with the tools set developed previously.

3.1 Navigation Agent

In this research, we develop an agent, which autonomously provides learners navigations by adapting learners' situations to the SQ3R-based domain knowledge. The domain knowledge is built up according to the mechanism of the study method SQ3R.

Figure 2 shows the architecture of the navigation agent, which is composed of the following three modules.

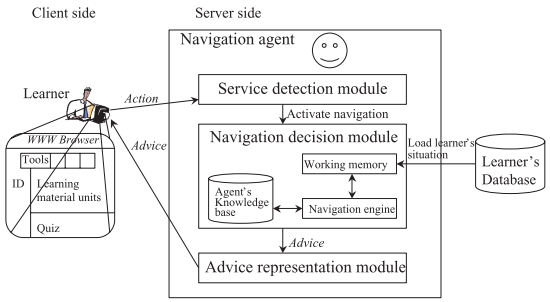

Fig. 2 Architecture of the navigation agent.

(1) Service detection module: This module detects whether the navigation engine should be activated. The activations include timer-driven activation and action-driven activation.
(2) Navigation decision module: Navigation functions are designed in this module. The navigation decision module includes:
  (a) Agent's knowledge base: The agent's knowledge about the usage of SQ3R is stored in the knowledge base. The agent's knowledge is represented as rules.
  (b) Working memory: While the navigation engine is working, learners' situations, such as information of using tools and correct answer rate to quizzes are loaded to the working memory.
  (c) Navigation engine: By matching learners' situations to the agent's knowledge, the agent will find adapted advice for learners to provide personalized learning. Forward-chaining reasoning technology is used to decide navigations for learners.
(3) Advice representation module: This module represents the solutions provided by the navigation decision module as an advice message, then sends the message to learners.

The navigation agent works together with a learner's database, which records the learner's learning historical data.

3.1.1 Service Detection Module

In this module, the agent detects when the navigation functions should be activated. There are two ways to activate the navigation engine:

Timer-driven activation: This type of activation is mainly used for the suggestive review navigation, and activated by a timer.

Action-driven activation: By detecting learners' actions, to decide whether the navigation should be activated or not. For example, the heuristic tool-using navigation is activated by a learner's request, the traffic-light progress navigation is activated by the action that a learner changes learning from one material unit to another one.

3.1.2 Navigation Decision Module

The agent's navigation decision module consists of agent's knowledge base, working mem-

ory, and navigation engine parts.

(1) Navigation agent's knowledge base

The knowledge used by agent is stored based on the study method SQ3R. In order to describe the fundamental of using SQ3R, knowledge is represented using the following data.

(a) the rate of correct answers to quizzes.

(b) the learner's information on using tools, e.g., the frequency of using query tool at *question* stage, the frequency of using memo and marker tools at *read* stage, the frequency of using search and glossary tools at *recite* stage are mainly checked.

These SQ3R-based domain knowledge used for navigations is specified by rules. For example, a subset of rules used by the navigation agent can be described as follows:

rule 1	if	it is check-reading
	and	search-tool is not used
	then	advice: use search tool
rule 2	if	it is tool-navigation
	and	Score to quiz $\leqslant 50$
	then	check-learning and check-review
rule 3	if	it is check-review
	and	marker-tool-used-count $\geqslant 3$
	then	advice: recheck the marked lines
rule 4	if	it is check-reading
	and	glossary-tool-used-count $= 0$
	then	advice: use glossary tool

Here, "tool-navigation" is a boolean variable representing whether the navigation is a heuristic tool-using navigation, which is activated by an on-demand request. Similarly, the "check-reading" and "check-review" are variables representing whether the agent needs to check the learner's *read* stage or *review* stage again.

(2) Navigation engine and working memory

The navigation agent uses forward-chaining reasoning to find an appropriate navigation for a learner, the learner's initial situations and the temporary results are saved in a working memory.

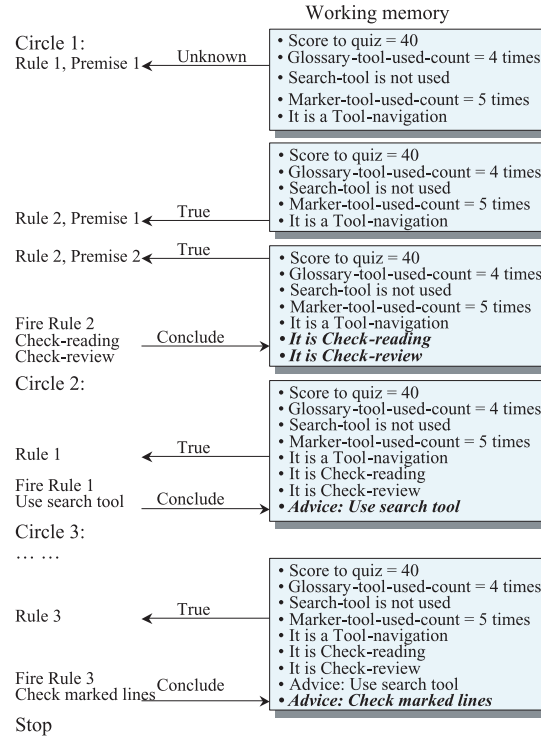

Fig. 3 Changing of the working memory in the navigating process.

Below, we show an example of the reasoning process. While learning, a learner's learning trace is saved in the learner's database. Suppose that a learner's learning situation saved in the learner's database is as follows:

- Score to quiz = 40
- Glossary-tool-used-count = 4 times
- Search tool is not used
- Marker-tool-used-count = 5 times
- It is a tool-navigation

Then using the above-mentioned rules, in the reasoning process, the data in the working memory is changing as shown in **Fig. 3**.

After the solutions are created, the advice representation module checks the messages saved in the working memory, and makes an advice for the learner. The advice will be shown to the learner through a pop up window. In this case,

the advice: "Please use search tool to get related knowledge, and recheck the marked lines." is given. This is one step of navigation that the agent gives to a learner.

As long as the navigations are activated, the navigation agent will reason advice for a learner continuously. If we track the advice that have been given to a learner, it should be a route, which guides the learner to learn following the educational psychology-based study method SQ3R.

3.1.3 Advice Representation Module

The solutions made by the navigation agent are stored in the working memory. The advice should be provided to a learner are the information that starts with a keyword "Advice: ", the advice representation module collects these information, and synthesize them to one advice message, then the agent sends the advice message to the learner.

3.2 Navigations Provided by the Navigation Agent

According to the SQ3R, the learning process is divided into five stages. These five stages cover the whole learning process. In order to support a learner to learn effectively, the agent provides the learner with three types of navigations.

As shown in Fig. 1, the main goal in the *survey*, *question*, *read*, and *recite* stages is to master and memorize information. In order to help learners to understand the information well, we have provided tools to help learners to finish each learning stage. But for someone who cannot make good use of the tools, advice is requested to promote the learning process smoothly. Consequently, a **heuristic tool-using navigation** is offered to support the learner to accomplish the learning.

In addition, we have given a group of tools [8], every tool helps the leaner to learn at different SQ3R stages, according to the combination of the using information of these tools, the stages that have been disregarded or jumped over by a learner can be detected successfully. To remind the learner of the missing, a **traffic-light progress navigation** is offered to avoid unnecessary misstep in the learning.

As the above mentioned, the learned knowledge is easily forgotten as time passed, but if the learner reviews the material in time reinforcing memory, the memorized knowledge can be maintained for a longer time. To help the learner review in time, a **suggestive review navigation** is offered to support the learner to accomplish the *review* stage.

Let's summarize the main points that have been discussed in this section. The agent provides three types of navigations, and these navigations can be briefly shown hereinafter:

(1) Heuristic tool-using navigation:
- **Activation condition:** on-demand, e.g., after finishing quizzes, learners can request an advice on-demand.
- **Scope:** in one unit of the learning material
- **Service:** to help a learner to learn one unit smoothly and integrally.

(2) Traffic-light progress navigation:
- **Activation condition:** action-driven: while changing unit of learning material.
- **Scope:** among material units
- **Service:** to give a reminder if a learner didn't finish learning as scheduled based on the SQ3R.

(3) Suggestive review navigation:
- **Activation condition:** timer-driven: after learning, the learned units are listed up for reviewing as the time goes.
- **Scope:** points to special material units among the learning materials
- **Service:** as the time goes, to notice the learner to review as the SQ3R scheduled, the learned units will be listed up times, e.g., after one day of learning, after two days of learning, after one week of learning, after one month of learning, and so on.

3.3 Outline of the Advanced Web Education Supported with Agent-based Navigations

The Web education system is composed of

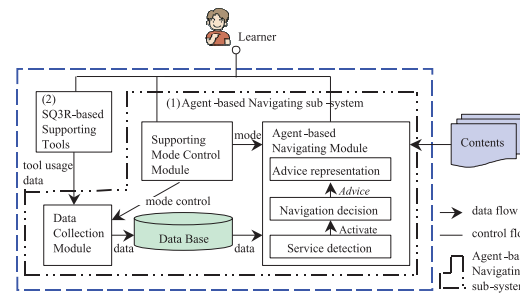

Fig. 4 SQ3R-based learning support system.

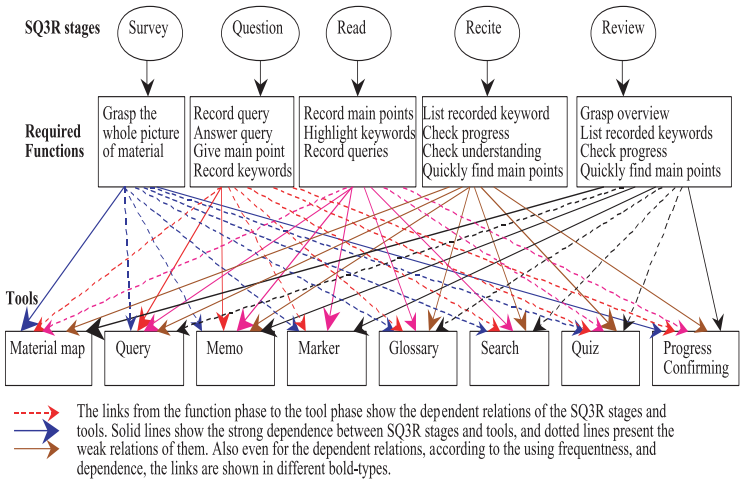

Fig. 5 Investigation of tools.

the following sub-systems as shown in **Fig. 4**.

(1) The agent-based navigating sub-system

In this system, learners' learning trace is detected and recorded. According to learners' actions, course navigations are offered by the agent. This sub-system consists of the following modules:

(a) Supporting mode control module

In the Web education system, two supporting modes are given. These two modes are on-line mode and on-demand mode.

(i) On-line mode: The system provides learning material to learners and manages learners' progress using the navigating agent automatically.

(ii) On-demand mode: The agent-based navigations will work for a learner, but it will not force the learner. The navigations only works while requested by the learner.

By checking a learner's understanding and progress through the material, the system can dynamically change the support mode for the learner. Also, a learner can select various support modes by themselves at each stage of the learning process.

(b) Data collection module: In this module, the learner's learning actions and progress at each SQ3R stage are detected. Then, the detected data will be stored in the learner's database. These data will be used in the agent-based navigating module.

(c) Learner's database module: This is a storehouse for the detected learner's data. It is the basis of agent-based navigating module.

(d) Agent-based navigating module: In this module, based on the detected learner's actions and the learner's learning progress, navigation agent will provide navigations to the learner. The details of the navigations will be described at the next subsection.

(2) SQ3R-based supporting tools sub-system

According to the mechanism of the SQ3R, and in order to fulfill the requirements of each stage, a group of tools are provided in this sub-system. These are the query tool, memo tool, marker tool, glossary tool, search tool, quiz tool, material map and progress confirming tool.

The process for designing tools is first to identify the goals and needs of each stage, then the tools to accomplish these needs and functions are designed. The tools for each SQ3R stage are shown in **Fig. 5**. The details has been discussed in a previous article [8].

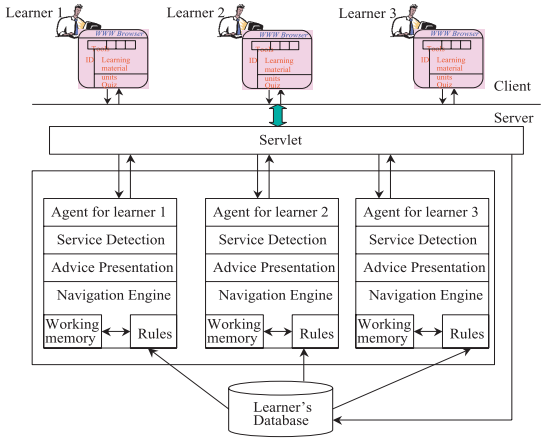

Fig. 6 Implementation of the system.

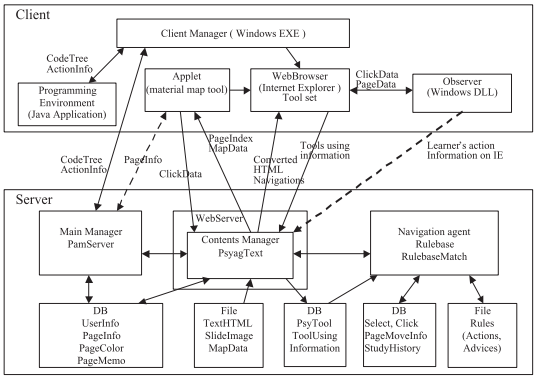

Fig. 7 Architecture of the system.

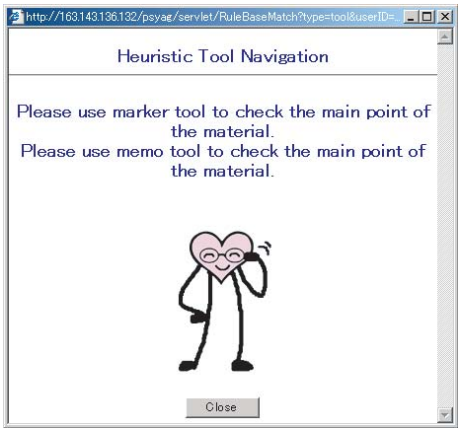

Fig. 8 A sample of a heuristic tool-using navigation.

4. Implementation

The above-mentioned Web education system, navigation agent and navigations have been implemented using Java, Database, RuleBase, and forward-chaining reasoning technologies.

4.1 Implementation of the System

The architecture of the implementation can be represented diagrammatically in **Fig. 6**.

At the client side, learners can learn units of learning materials using the provided tools (support environments), and get navigations, which are offered by the navigation agent. While system is running, learners' learning actions (learning trace) are timely recorded into learner's database at the server side. For each learner, a navigation agent instance is created. The navigation agent adapts learners' situations in the database to provide learners with suitable navigations.

The details of the implemented system is shown in **Fig. 7**.

On server side, a main manager is built, it manages the user's information. When a socket connection is requested by a Client Manager from the client side, PamServer checks user's login information. After the connection is built, the Contents Manager, which is on server side, reorganizes and transmits contents to client side. The Contents Manager is built as a Web server using Servlet. Learners' actions (requests), such as using a tool or clicking to the scrollbar, are sent to the Contents Manager. The requests are distinguished and sent to different modules.

When a navigation request is received, the navigation agent is activated. The agent reads users' information from database, loads learners' situations to working memory, loads rules from rule files, then infers a solution for the user. After one navigation request is responded, the working memory is cleared, and the agent waits for the next activation.

The knowledge base used by agent is represented by rules in this system, and the knowledge is built based on the study method SQ3R.

4.2 Interface of Navigations

4.2.1 Interface of Heuristic Tool-using Navigation

Heuristic tool-using navigation is activated by learners' on-demand request. While learning, the learner can request the navigation by click to a "tool navigation" button in the toolbox, then an advice adapted to the learner is given through a pop up window. A sample of the heuristic tool-using navigation can be shown in **Fig. 8**.

This kind of navigating advice can be given at anytime during learning processes. If the advice is gathered together, it is a route that

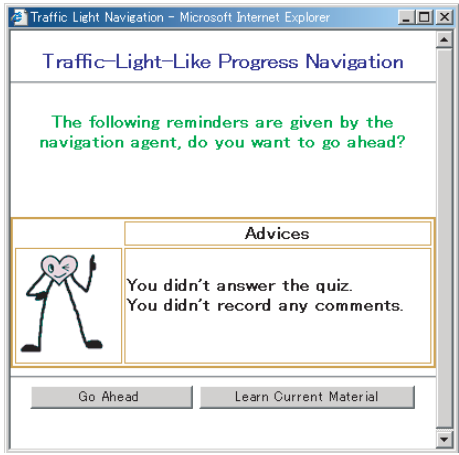

Fig. 9 A sample of a traffic-light progress navigation.

guides the learner to learn following the study method SQ3R.

4.2.2 Interface of Traffic-light Progress Navigation

Traffic-light progress navigation is using some prompt messages to inform learners of the ignored SQ3R stages in learning process. While a learner wants to render a new learning unit, before the new unit shown, the traffic-light progress navigation will be activated, to check if he/she has learned the current unit as per the SQ3R schedule well. If he/she has, the new learning unit is presented. Otherwise, the ignored stages or actions will be listed up in a window (**Fig. 9**). Two selections, which are "Go Ahead" and "Learn Current Material", are given at the same time. The learner can decide his/her selection.

By this way, the traffic-light progress navigation reminds learners of the disregarded or jumped over stages or actions to avoid unnecessary misstep in the learning.

4.2.3 Interface of Suggestive Review Navigation

Suggestive review navigation divides the "days after learned" into six segments to help learners to systematically review learned materials as per the SQ3R schedule. The six segments are: one day after learning, two days after learning, four days after learning, one week after learning, fifteen days after learning, and thirty days after learning. Also, they are six situations that the suggestive review navigation is activated. **Figure 10** shows the image of this type of navigation. The date of a learning unit learned is shown in the first column. The second column shows the "days after learned". In

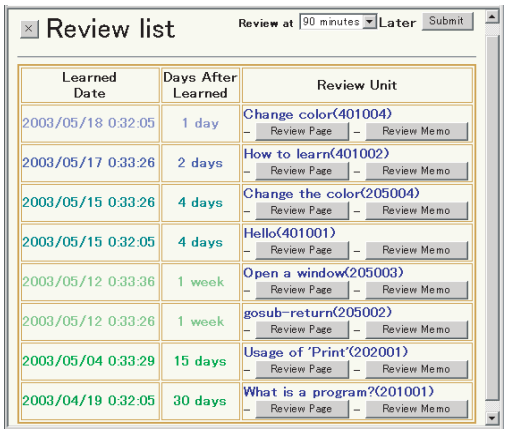

Fig. 10 A sample of a suggestive review navigation.

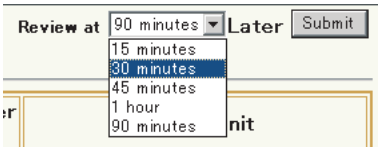

Fig. 11 A sample of timer setting for a suggestive review navigation.

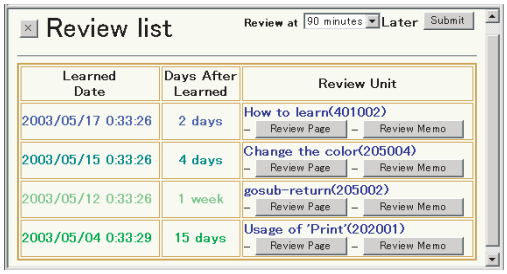

Fig. 12 A sample of a suggestive review navigation after some units have been reviewed.

the third column, the title and ID of the learned unit is shown. Learners can click to "Review Page" to read the unit, or review the recorded memos for that unit by clicking to the "Review memo" button.

For someone who cannot review the learned units right away, a timer is provided. A learner can select one timer from the combo box (**Fig. 11**), to set a timer. When time out, the suggestive review navigation will be activated automatically again. At this time, a new timer can be set once more.

When the suggestive review navigation is activated again, the units that have been reviewed will not be listed up in the new review list. For example, after the above mentioned navigation activating, if the learner reviewed some units in the review list, the reviewed units will not be

listed up in a new review list (**Fig. 12**), which is made by a later time navigation activating.

5. Experiment and Evaluation

5.1 Preparation of the Experiment

Before the experiment, learning materials and support policies used by navigation agent need to be prepared by teachers. The learning materials are saved in HTML format. After the experiment, the teachers can analyze learners' situations and information of using tools by checking the database, then modify the advice messages.

5.2 Method of the Experiment

An experiment of the SQ3R based Web education system was carried out. The contents are about Basic programming language. The learning materials contain explanations, samples, and tasks. Learners learn texts through a Web browser, test samples using VLB☆ environment, then try to do tasks. The screen shot of the interface on the learner's side is shown in **Fig. 13**. Learners were 12 students at the University of Aizu. The learners were requested to learn text contents by two ways. One way is that learners read contents, answer quizzes, and do tasks by himself/herself without any help of tools and navigations. The other one is that learners can utilize the tools by clicking tools' buttons from the "tool set" area (Fig. 13) at any time in the learning process, navigations will work for learners.

The experiment was arranged for two hours, after learning using the Web-based learning system, a questionnaire sheet was given, and answers were collected.

5.3 Results of the Experiment

In the experiment, we checked the performance of the learning supported with navigations and tools.

At first, the availability, validity of the navigations, and easiness for using were collected by questionnaires. The results are shown in **Fig. 14**. About 70% of learners thought that navigations were available and valid, and about over 80% of learners answered that navigation functions were easy to use.

Also, we collected answers of differences among the following cases:

case 1: learning without any support;
case 2: learning with the support of both tools and navigations;
case 3: learning with the support of tools;
case 4: learning with the support of navigations.

These differences were asked from the viewpoints of usability and effectiveness. The usability was collected using the following questions:

U1: whether the support can help learners to understand learning materials.
U2: whether the support can help learners to keep their confidence.
U3: whether the support can give learners a relax learning environment.
U4: whether the support can help learners to get the whole picture of the materials.

The effectiveness issue was collected using the following questions:

E1: whether the support can help learners to increase their correct answer rates.
E2: whether the support can help learners to save learning time.
E3: whether the support can help learners to keep a long-term memory.

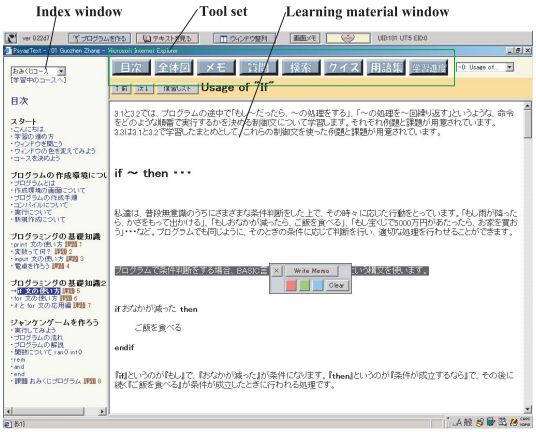

Fig. 13 Screen shot of the interface on the learner's side.

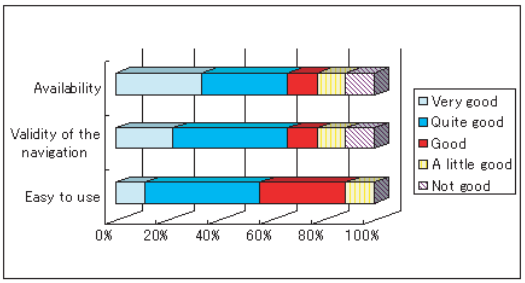

Fig. 14 Diagram of the experiment results about the navigations.

☆ VLB means Visual Legacy Basic, it is an visual basic language editing and compiling environment.

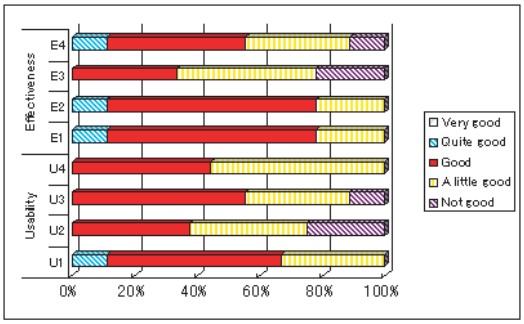

Fig. 15 Diagram of the results without any support.

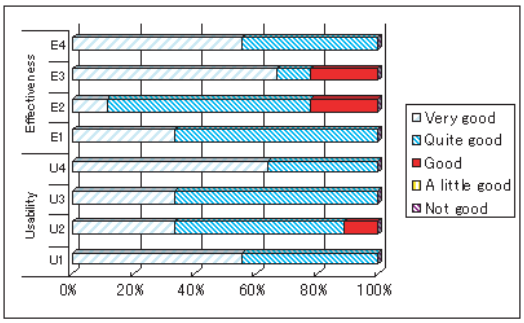

Fig. 16 Diagram of the results with both tools and navigations supporting.

E4: whether the support can make materials easy understood.

Here, we show the results of the following cases:

case 1: learning without any support (**Fig. 15**);

case 2: learning with the support of both tools and navigations (**Fig. 16**).

As shown in Fig. 15 and Fig. 16, contrasting to about 60% of learners evaluated the usability and the effectiveness to "Good" in case 1 (Fig. 15), almost 80% of learners evaluated that to "Quite good" in case 2 (Fig. 16). From these data, we can say that the provided tools and navigations can improve the usability and effectiveness of the system.

The integrated usability and effectiveness at each situation are compared (**Fig. 17**). From Fig. 17, we can see that a higher usability and effectiveness can be gained while learning with both tools and navigations support than that without any support.

Besides the above mentioned results, we also obtained the following results by asking learners to freely write their comments: "Supporting with navigation, learners' weak points are pointed. Learners can just concentrate on

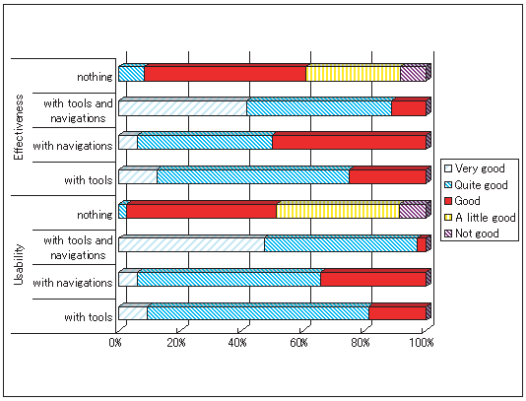

Fig. 17 Diagram of the results about the usability and effectiveness.

learning, having no necessary to worry about the missing of main points." Especially, "supporting by the combination of tools and navigations, learners felt that the resistance to the learning was reduced", and so on.

On the other hand, learners pointed out some shortcomings, such as, "the review navigation is difficult to use when the learner did not log in the system for a long time."

Many other valuable suggestions were given by learners. For example, "if the navigation messages can be shown in the text window instead of another pop up window, it will be easier to use, and let the learner know the weak actions timely." These comments and suggestions will be considered in the future versions of the Web education system.

6. Concluding Remarks

In this paper, we proposed a Web education system and three types of agent-based navigations to support and suggest learners to learn as per the SQ3R schedule. The proposed system and navigation agent have been implemented, and an experiment of the agent-based system has been carried out. The usability and effectiveness of the learning system and the three types of navigations have been evaluated. In the future, we will do further works and experiments, get more detailed learners' data, and improve the Web education system.

Acknowledgments The authors would like to thank anonymous referees for their careful reading, valuable advice and useful comments. The authors also express their sincere thanks to all the members of the computer network laboratory at the University of Aizu, who

gave us much convenience and cooperation at the period of system implementing and at the system experimenting period.

References

1) http://www.kantei.go.jp/jp/it/index.html
2) Okawa, K., Ijuin, Y. and Murai, J.: School of Internet-Building a University on the Internet, *Trans. IPSJ*, Vol.40, No.10, pp.3801–3810 (1999).
3) Wu, A.: Collaborative ACM for Adaptive Instructional Planning, *Proc. ICCE'99*, pp.271–276 (1999).
4) Zhu, Z., Wang, Q., Kondo, K. and Far, H.B.: WWW-CALIST:A General Purpose Tool for Constructing Web-Based Individualized Adaptive CAL Systems, *Journal of JSiSe*, Vol.16, No.1, pp.14–23 (1999).
5) Kuwabara, T., Tamaki, M., Yamada, K., Nakamura, Y., Mitsunaga, Y., Konishi, N. and Amano, K.: Support functions for stalled students and their effect in a multi-media assisted education system with individual advance (MESIA), *IEICE Trans. D-I*, Vol.J83-D-I, No.9, pp.1013–1024 (2000).
6) Hasegawa, S., Kashihara, A. and Toyoda, J: Reorganizing learning resources on WWW and its application to an adaptive recommendation for navigational support, *IEICE Trans. D-I*, Vol.J83-D-I, No.6, pp.671–681 (2000).
7) http://teachers.teach-nology.com/web_tools/graphic_org/
8) Zhang, G., Cheng, Z., Huang T., He A. and Koyama, A.: A Distance Learning Support System Based on Effective Study Method SQ3R, *IEICE Trans. D-I*, Vol.J83-D-I, No.6, pp.671–681 (2000).
9) Simpson, M.L.: PORPE: A writing strategy for studying and learning in the content areas, *Journal of Reading*, Vol.29, pp.407–414 (1986).
10) Eanet, M.G. and Manzo, A.V.: REAP: A strategy for improving reading/writing/study skills, *Journal of Reading*, Vol.19, pp.647–652 (1976).
11) Carr, E.G. and Ogle, D.: KWL Plus: A strategy for comprehension and summarization, *Journal of Reading*, Vol.30, No.7, pp.626–631 (1987).
12) Robinson, F.P.: *Effective study* (*4th ed.*), New York, Harper & Row (1970).
13) http://www.umpqu.cc.or.us/counsel/stuskill.htm
14) http://www.demon.co.uk/mindtool/sq3r.htm
15) http://mentalhelp.net/psyhelp/chap13/chap13r.htm
16) http://206.140.149.2/gms/SQ3R.htm
17) http://www.u.arizona.edu/ic/wrightr/other/sq3r.htm
18) Nishiyama, S. and Yamauchi, M.: *New Educational Psychology*, Published by Kananishiya (1990).
19) Zhang, G., Saitou, K., Cheng, Z., Koyama, A., He, A. and Huang, T.: Design of SQ3R-based Support Method for Course Contents Provison in Distance Learning Systems, *Proc. 21st IEEE International conference on Distributed Computing Systems Workshops*, pp.326–331 (2001).
20) Takahashi, S. and Matsunaga, K.: Design of distance learning environment for programming, *Technical Report of IEICE, ET2000-85*, pp.65–70 (2000).
21) Tanaka, K., Yano, Y., Yamamoto, N. and Kurose, Y: The microworld to support understanding on measurement system with operation, *Japanese Society for Information and Systems in Education (JSISE) Trans.*, Vol.18, No.1, pp.24–33 (2001).
22) Takeuchi, A., Yoshida, H., Fujita, T. and Ishibashi, K: Intelligent learning environment for acquiring knowledge application ability, *IEICE Trans.*, Vol.J83-D-I, No.6, pp.523–530 (2000).
23) Zhang, G., Saitou, K., Koyama, A. and Cheng, Z.: A Proposal for Agent Based Construction and Presentation Methods of Active Courseware According to the Situations of Learners, *IPSJ Symposium Series*, No.15, pp.67–72 (2000).
24) Inomata, A. and Ochimizu, K: Organizing Electronic Teaching Materials for On-Demand Learning, *IPSJ SIG, Computers in Education*, No.52-5, pp.33–40 (1999).
25) Gonzalez, J.A. and Dankel, D.: *The engineering of knowledge-based system theory and practice*, Prentice-Hall, Inc. (1993).
26) Durkin, J.: *Expert systems design and development*, Prentice-Hall International, Inc. (1994).
27) Puppe, F.: *Systematic introduction to expert systems — Knowledge representations and problem-solving methods*, Springer-Verlag. (1993).

(Received May 20, 2003)
(Accepted December 2, 2003)

Guozhen Zhang received her Bachelor in Dalian Institute of Light Industry, China in 1992. She joined the University of Aizu in 1998 and obtained her M.E. degree in Computer Science and Engineering in 2001. She is currently pursuing her Ph.D. degree in the same university. She is a member of IPSJ.

Zixue Cheng received the M.E. and Ph.D. degrees from Tohoku University in 1990 and 1993, respectively. He was an assistant professor from 1993 to 1999 and an associate professor from 1999 to 2002, and has been a professor since Feb. 2002 at the Department of Computer Software, the University of Aizu. Currently he is working on distributed algorithms, psychological agents, and distance education. Dr. Cheng is a member of IEEE, ACM, IEICE, and IPSJ.

Aiguo He received M.E. and Ph.D. degrees from Nagoya University, Japan in 1985 and 1988, respectively. Now he is an assistant professor at the Department of Computer Software, the University of Aizu, Japan. He currently is working on distant education, computer science education and network. He is a member of IEEE, IEICE, and IPSJ.

Akio Koyama was born in Yonezawa, Yamagata prefecture. He received the B.E. and Ph.D. degrees from Yamagata University in 1987 and 1998, respectively. Until March 1999, he was working as a technical staff at Faculty of Engineering, Yamagata University. From April 1999 to March 2002, he has been an Assistant Professor at Faculty of Computer Science and Engineering, the University of Aizu. Since April 2002, he has been Associate Professor at Faculty of Engineering, Yamagata University. His research interests include high-speed network protocols, network agent systems, traffic control in Internet and distance learning systems. He is a member of IEEE Computer Society, IPSJ and IEICE.

Tongjun Huang received M.E. degree from the University of YanShan in China. Since 1993, she has been a research associate in the Information Systems and Technology Center at the University of Aizu. She is interested in distributed algorithms, meeting scheduling, and distance education.