Authoring Methods for the Web-Based Intelligent CAI System CALAT and its Application to Telecommunications Service

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Abstract

This paper discusses courseware authoring for CALAT, a Web-based intelligent CAI system, mainly from the standpoints of courseware design methods and authoring tools, then presents the results of application to courseware in the telecommunications service field. A feature of an intelligent CAI system is its ability to adapt to individual learners, dynamically selecting the material to be presented based on each learner's comprehension and other parameters. Conventional intelligent CAI systems, however, required nearly the same effort and know-how for courseware authoring as for system development, making it difficult for specialists in the field of learning to create courseware. This paper presents a design method based on courseware knowledge structured around learning targets and a scenario, and shows how courseware with a high degree of adaptation to the individual can be created readily by people whose specialty is the courseware field rather than programming. It further describes tools supporting efficient courseware design and for automatically generating courseware. This system has been used to create more than 300 courseware packages in the telecommunications services field, which have better learning effectiveness than conventional CAI systems.

Introduction

The spread of the Internet has rapidly turned the World-Wide Web into a readily available means of communication. A chief appeal is that in addition to browsing for information, both individuals and companies can easily create and publish their own information, aided by the wide availability of easy-to-use content creation tools.

The use of computers as learning support systems, meanwhile, goes back many years to the days of drill-based systems that were little more than page-turning machines. In time these developed into intelligent CAI systems, able to adjust their contents to individual learners based on comprehension success and other learner-specific factors. The research devoted to intelligent CAI systems, however, has traditionally focused on obtaining a detailed model of student characteristics and developing teaching strategies accurately pegged to this model (Wenger 1987). Creating courseware for these systems requires nearly the same degree of effort and know-how as for system development. By no means is courseware authoring something that can be performed easily by instructors whose specialty is in the particular field of learning rather than programming. Recently some authoring tools are trying to make it easier to create courseware for ICAI (Brusilovsky, Schwarz, and Weber 1996).

NTT is a Japanese common carrier providing telecommunications services nationwide, with a huge number of employees. Their jobs range from technical development and equipment maintenance to customer service and many other areas. Employee training takes place frequently, not only when personnel are newly hired or transferred to a new position, but whenever new technologies or services are introduced. One of the means that has been used for this training is a CAI system for self-study, and the courseware for this system is created in the training division. Because of the many different skill levels of employees, there is a strong need for a training system capable of adapting to the individual. At the same time the courseware authoring system must provide a general framework in which courseware development can be carried out readily by those whose specialty is the field of study itself, whether equipment maintenance or sales or any other area of work, and who are not necessarily computer professionals.

With these needs in mind, we have been carrying out a program of research and development aimed at achieving both a high degree of adaptation to individual learners and a courseware authoring system that can be used readily by specialists in the courseware field even without system or programming skills. This paper describes the courseware authoring system for CALAT (Nakabayashi et al. 1995), a distributed intelligent CAI system developed by us. CALAT was designed to take advantage of the distributed multimedia and hypertext features of the World-Wide Web, while at the same time realizing adaptation to individual learners. In the following sections we give a brief introduction to CALAT, outline the approach to CALAT courseware authoring, explain the courseware structure and design methods, and describe authoring tools. We then present some results of applying this technology to telecommunications service fields, and discuss further developments in courseware authoring support technology.

Courseware Authoring Requirements

From CAIRNEY to CALAT

NTT developed the intelligent CAI system CAIRNEY (CAI Expert System for New Technology) for improved efficiency in employee training (Fukuhara and Kiyama 1993). The CAIRNEY learning system is geared to self-study, with individuals at standalone computers studying on their own schedule and at their own pace. The learner's comprehension is measured based on practice exercises and simulations, and on this basis the system selects and orders the materials presented to each learner. A learner who is relatively slow to comprehend is therefore given detailed, repeated instruction and practice, with remedial lessons as needed, whereas a learner who is quick to grasp the contents is moved along at a more efficient pace. CAIRNEY requires a courseware CD-ROM for each student, which limits the place of study as well as the number of students. Another disadvantage of this type of study is that, unlike a classroom, students cannot ask questions or engage in dialog with real human teachers. To overcome these limitations, we developed an intelligent CAI system that makes use of the Internet.

CALAT (Computer Aided Learning and Authoring environment for Tele-education) is a client-server type distributed intelligent learning system using the World-Wide Web, which provides intelligent CAI services similar to those of CAIRNEY but on a computer network. Students using a Web browser such as Netscape Navigator or Microsoft Internet Explorer simply access the CALAT server. By presenting their own ID, they can enjoy the CAI services from anywhere in the world, at any time. All the courseware is located on the server. While the student is on line, the server monitors "Next screen" requests and exercise results, determines the next material to be presented, and sends the screen images and audio information to the student terminal. This approach also means students always have access to the very latest courseware, without the need to distribute each courseware update by traditional media.

While CAIRNEY and CALAT differ in being standalone and network-based systems, respectively, they adopt essentially the same courseware structure and learning control mechanism. The courseware authoring discussion below therefore applies to both systems.

Courseware authoring requirements

As a common carrier, NTT provides telecommunications services throughout Japan. The huge number of NTT employees perform a wide diversity of jobs, which include developing and maintaining telecommunications and other systems, marketing and sales activities, dealing with customers, and office administration. Telecommunications technology undergoes innovation at a staggering pace, with new technologies and services being introduced all the time. Recent examples are services relating to the Internet and mobile communications. For this reason employee training takes place at a high rate of frequency, not only when personnel are newly hired or transferred but also whenever new technologies or services are introduced. Recently CALAT has been introduced as one of the means for in-company training. The courseware development for this training is carried out in the human resources development division, where the following requirements exist for courseware authoring.

- Creation of individually adaptive courseware

The courseware should do much more than simply present information in a fixed sequence for rote learning. It must reflect a deep familiarity with the courseware field and be able to adapt its contents to individual learners. It must allow learners, who vary widely in their skill levels, to study efficiently and effectively.

- Courseware authoring by experts in the field of learning

School or in-company instructors, and experts in the field being taught, need to be able to create courseware easily and in a short time, without specialized knowledge in computer science and without being required to perform a high-level task analysis based on cognitive psychology.

- A general-purpose framework usable in a wide range of fields

It should be possible to use the same tools for creating courseware in a variety of study areas, since work in the telecommunications field ranges from technical and maintenance work to customer services.

- Training in procedures

Besides intellectual knowledge, employees need to be taught equipment operation and other procedures. Courseware for this purpose, using simulations, should be created easily.

- Ease of courseware maintenance

It should be possible to revise the courseware easily to keep up with new developments in an ever changing world. This is especially important in telecommunications, where the rapid pace of technical innovation can render courseware obsolete in a short time if it is not updated regularly.

Courseware Structure

Overall configuration

This system is configured of courseware knowledge, which is the systematic knowledge in the particular field of learning, teaching strategy knowledge relating to how instructors impart learning, and student information keeping track of each learner's comprehension of the material and other learner-specific factors (see Figure 1). Of these, the courseware author need be concerned only with courseware knowledge; the others are provided in the system itself as generalized knowledge not dependent on

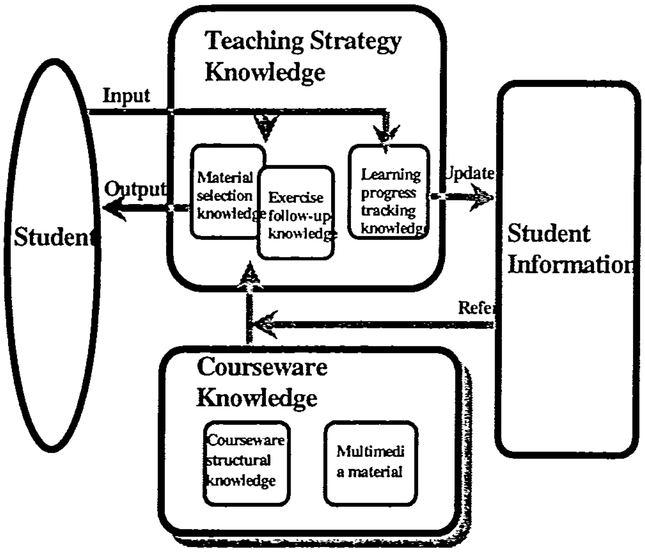

Figure 1. Overall configuration

the courseware contents. Input by learners is passed to the teaching strategy part, where teaching strategy inference is carried out based on the courseware knowledge and student information, and the material to be presented to the learner is decided. The student information itself is continuously updated by the teaching strategy part so that the latest learning status is always reflected (Fukuhara et al. 1995).

Courseware knowledge

Courseware knowledge consists of the multimedia materials (expression layer) presented as courseware "scenes" to the learner, and courseware structure knowledge describing the logical structure of the courseware itself (logical layer). The latter knowledge is essential information making up intelligent CAI courseware. The expression layer and logical layer are of course different in representation, but ideally they should describe the same contents. In reality, however, the logical layer descriptions tend to be highly complex, imposing too great a burden on most courseware authors. An important requirement in courseware authoring is to realize a high level of teaching effectiveness while defining courseware structural knowledge that allows for ready implementation. Our system describes the courseware structural knowledge as follows.

1) Learning targets

The learning targets list the knowledge to be taught to students, in specific statements such as "be able to do x" or "understand what y is." This is also called "what" knowledge. Once the courseware subject is determined, the list of learning targets should be practically the same regardless of the courseware author.

2) Scenario

The scenario defines the courseware story (what will be taught in what sequence). It corresponds to the chapter and section arrangement of a book. This is also called "how" knowledge, and will likely be different for each courseware author even if the field is the same.

3) Relational information mapping the scenario to the learning targets (Figure 2)

This information defines the correspondence between the learning targets and the scenario chapters and pages. Since one page may teach two or more learning targets and one learning target may correspond to two or more pages (taught in different ways), the two have a many-to-many

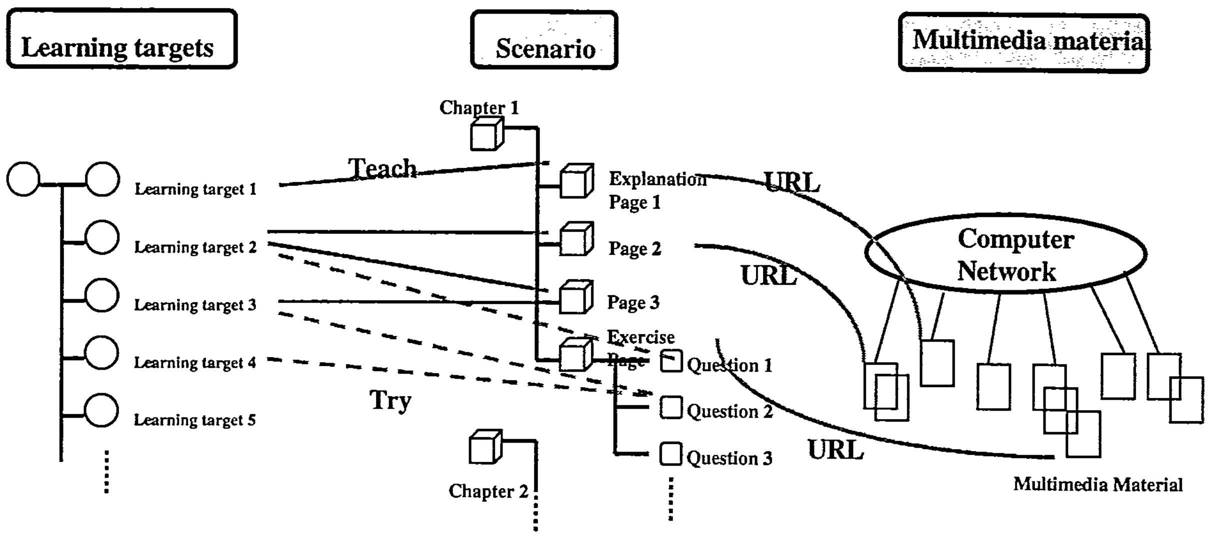

Figure 2. Courseware knowledge

correspondence. A relationship is likewise defined between each of the questions asked in a practice exercise and the learning targets they cover.

4) Relational information mapping the scenario to multimedia materials (Figure 2)

Defined here is the screen information presented to students on each page of the scenario. In CALAT the relation to screen information is designated as a URL (Uniform Resource Locator), so potentially any multimedia information available on the Internet could be designated (Maruyama, Nakabayashi, and Fukuhara 1996).

In the process of conveying knowledge (for example, when writing up a plan or a report, or writing a book), the above systematization of knowledge into learning targets and a scenario occurs quite naturally. In many cases the learning targets may not be laid out explicitly, but we can always expect them to exist in the thought process. This kind of courseware structural knowledge is both natural and clear-cut, so it enables an individually adaptive learning environment to be provided with little burden on the courseware author.

5) Expressing procedural knowledge

The method described above for expressing courseware knowledge is geared to the learning of conceptual knowledge but cannot adequately represent procedural knowledge, such as simulated equipment operations. This system represents procedural knowledge at two layers, the target model knowledge layer, consisting only of the simulated actions of the equipment, etc., and the operation procedures knowledge layer describing the correct operation procedures to be learned. Target model knowledge is expressed using state transition graphs so it can be written out simply by the courseware author even without programming skills. The target model knowledge is written as an array of input events making up the correct operation procedures (Kiyama and Fukuhara 1993).

Student model

An overlay model is adopted, which represents the space of which the student is aware as a subset of the space that is the object of learning.

Teaching strategy knowledge

Teaching strategy knowledge is based on educational engineering and educational psychology methodology, and is the knowledge for checking the learner's status and on that basis selecting the optimal material for presentation at each point. It is equivalent to the know-how of teaching professionals. The contents of this knowledge is generalized so as to be independent of any courseware field, and consists of the four types of knowledge below. Figure 3 shows an example of the inference process when teaching strategy knowledge is applied.

- Material selection knowledge

In accord with the learner's input (learning control commands), the optimal material to be presented next is selected and presented, depending on the student information.

- Exercise follow-up knowledge

The causes of a learner's wrong answers are analyzed to determine which learning targets are not understood. Optimal hints are selected and presented to the learner.

- Learning progress tracking knowledge

Based on learner input (learning control commands, exercise answers, etc.), the learner's comprehension success and other learner-specific factors are estimated and reflected in the student information.

- Procedure teaching knowledge

Operation procedures are taught by presenting samples, helping and advising with hands-on experience and so on, using a tutorial approach.

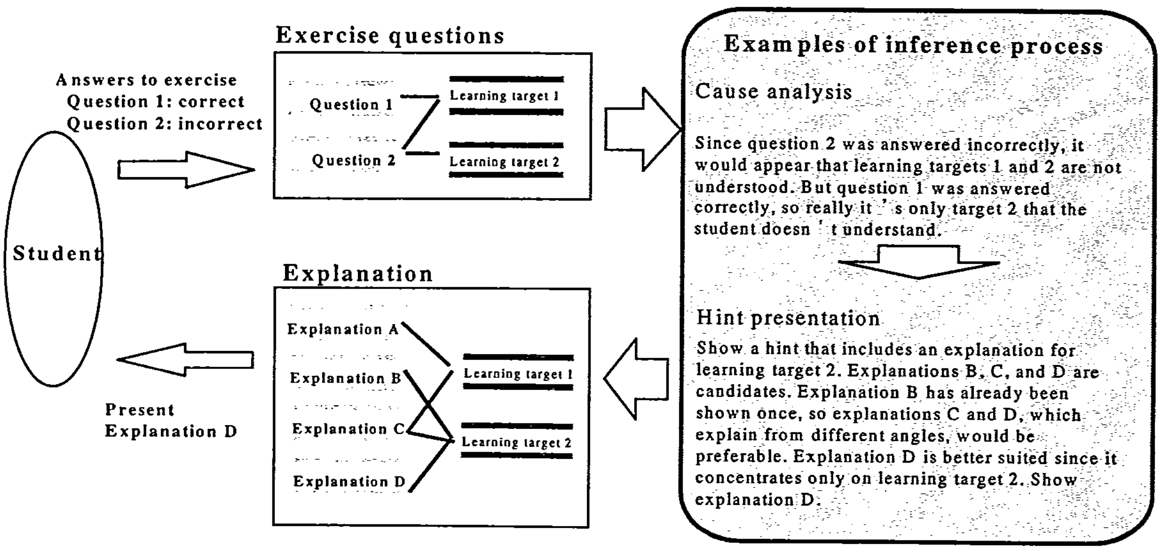

Figure 3. Inference process applying teaching strategy knowledge

Courseware Authoring System

Courseware creation procedure

When courseware is created for CALAT, there are four main steps: (1) courseware planning, (2) courseware design, (3) multimedia materials preparation, and (4) testing and evaluation (see Figure 4).

1) Courseware planning

Determine the intended users of the courseware to be created and the primary learning targets.

2) Courseware design

Carry out the following steps in order. Of these, 2-2) and 2-4) may be carried out in parallel.

2-0) Gathering information: Obtain and study information on the courseware field.

2-1) Organizing the learning targets: Make a list of things to be taught (learning targets).

2-2) Designing the scenario: Decide the courseware story (sequence in which the learning targets are to be presented; the chapter-section arrangement) and then make the relation between the scenario and learning targets.

2-3) Creating exercises: Make exercise problems for each learning target, and define their relation to the learning targets.

2-4) Making drafts of the multimedia materials: Create a rough sketch of the scenes to be presented to students, and define the relation between scenes and the scenario.

3) Multimedia materials preparation

Create the scenes presented to students using tools for each of the media used. Note that materials created by others can be reused by pointing to information resources elsewhere on the Internet as URL.

4) Testing and evaluation

Check the courseware data to make sure it is complete, consistent and suitable. Have it evaluated also by prospective users.

The amount of time required for each of the above steps is estimated in Figure 5. The support functions currently provided by the courseware authoring system are for steps (2) Design and (4) Testing.

Courseware knowledge design

With the original authoring system used for CALAT, all courseware design is done on paper. The courseware author, following the procedures outlined above, organizes in table format the courseware knowledge consisting of learning targets, scenario, practice exercises, and the correspondence between learning targets and scenario, etc. Only after this work is completed and found to be free of any inconsistencies is the design information entered in the authoring system, using table-based editors. This approach, however, has certain drawbacks.

At the design stage the courseware author has to go through a repeated process of trial and error to refine and develop the courseware knowledge. For example, arranging the learning targets and scenario involves repeated breaking down and grouping in order to achieve the desired results, yet the process of refining the courseware knowledge during the design stage is not given any support functions.

Since system entry takes place only after the design is completed, the courseware operation cannot be checked until the final stage of authoring. In other words, the steps of design, entry and testing proceed sequentially in a so-called waterfall development style, making it difficult for the courseware author, let alone others, to get a good grasp

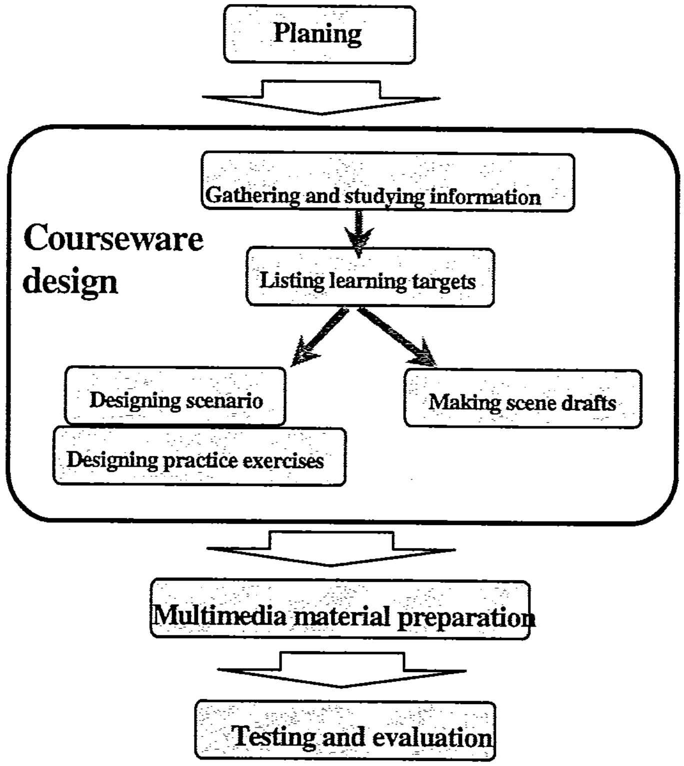

Figure 4. Courseware authoring

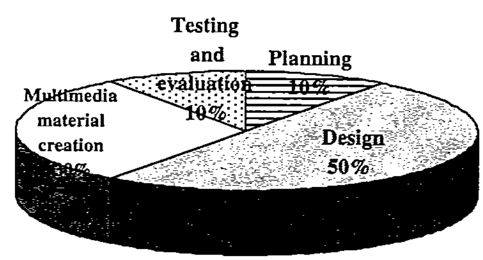

Figure 5. Relative weight of each authoring step

of the overall courseware image at an early stage.
We therefore implemented the following two courseware design support functions to alleviate these difficulties.

- Design information editing support

The courseware design support tool, as shown in Figure 6, consists of an outlining function (left part of the screen) and detail design function (right part). The outliner shows the learning targets (lower part) and scenario hierarchy (upper part), while the detail design function displays the detailed attributes of each learning target and scenario division. The outliner enables the moving of any part up or down the hierarchy or to any place, insertion and deletion, the making items void temporary and so on. It is therefore useful for refining the learning targets and scenario by changing the breakdown and grouping as necessary. The detail design function already has default values set for each of the attributes, making it possible at the initial design stage to create working courseware simply by editing with the outliner, without having to make any other entries. Data entry for attributes can be made as the design work proceeds and details become fleshed out. In this way a spiral-type RCD (Rapid Courseware Development) design approach is realized, enabling courseware operation to be checked as soon as the basic and essential information has been entered, followed by a gradual refining and improving of the quality. In addition, the knowledge mapping (relating learning targets to scenario and relating scenario to multimedia materials) is carried out visually, with the scene draft shown and edited in the same window as the scenario attributes.

- Automatic generation of courseware knowledge

Even with the design information editing support functions, there is still a large amount of information to be created, compared to a traditional CAI system. Automatic generation of courseware knowledge is another possible way of advancing RCD. Here automatic generation means creating courseware knowledge based on other existing courseware knowledge, for example, generating a scenario from the learning targets. The results of the automatic generation process do not have to be perfect; it is assumed that the courseware author will make corrections and adjustments as necessary.

We indicated a courseware design procedure that starts by listing learning targets and then creating a scenario. That, however, is simply a typical approach. Analyzing the actual courseware authoring tasks, we can see that there are three possible cases described below. The automatic generation input and output are different for each case.

[Case 1]: A specialist in a given field creates the courseware from scratch.

The courseware author should be able to list the learning targets easily, but in many cases will find the task of making a scenario difficult or troublesome. In this case support can be given for generating the hierarchical

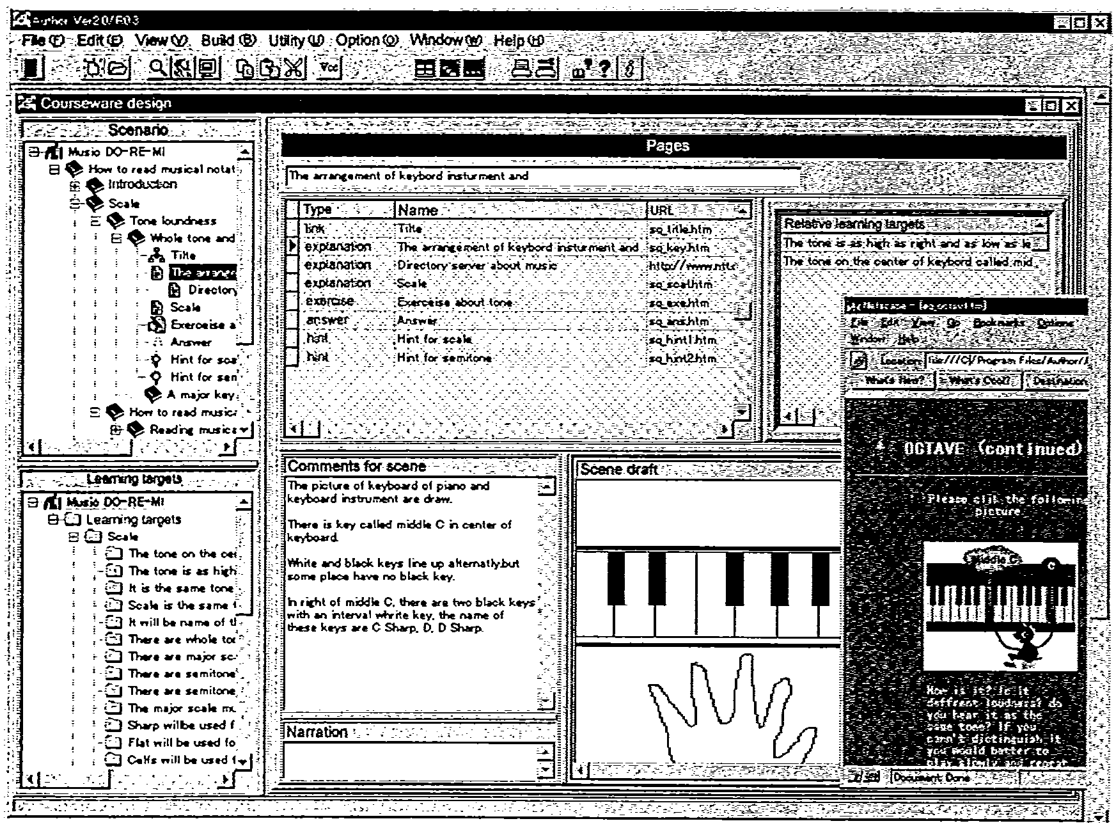

Figure 6. Courseware entry screen

scenario structure from the learning target structures. The relation between learning targets and scenario sections is 1-to-1 simply.

[Case 2]: Courseware is created based on textbooks and reference works.

The author can make use of the existing table of contents and organization for the scenario, but may need help drawing up learning targets and mapping them to the scenario. Here support is given for automatic generation of learning target structures from the scenario layers. The relation between learning targets and scenario sections is 1-to-1 simply.

[Case 3]: Courseware is created based on actual test problems.

The author can readily prepare exercise information, but the problem will be organizing the courseware sections corresponding to the exercises, creating explanations and other parts of the scenario, and mapping learning targets to the scenario. Support functions will take the form of automatic generation of the scenario organization from the test problem configuration, and generation of information mapping scenario explanation pages to learning targets based on the learning targets of the answers and problems. Each question may be categorized in a few groups.

Obviously, courseware generated in these ways will not be very good courseware. These functions can, however, serve the purpose of providing the courseware author with an initial design proposal as part of a spiral design process.

Creating and referencing multimedia materials

CALAT uses HTML files for its courseware scenes. Where a plug-in is used, animations such as those created on Director can be handled in addition to GIF or other still images and moving images such as AVI and MPEG2. Essentially the authoring system does not provide any tools for creating multimedia materials, instead allowing the author to use any desired multimedia editing tools available. As noted earlier, the mapping of multimedia materials to the scenario is done by URLs, which means existing materials from other parts of the Internet can be incorporated in courseware simply by providing a URL. Examples are photography collections and encyclopedia sites. CALAT can also be used along with email or Internet phone to allow communication between the learners and human instructors, rather than simply self-study. The quality of the courseware can be improved by sending emailed questions or by presenting report-format exercises, for example.

Courseware testing

- Checking the formal consistency

The learning targets, scenario and other courseware knowledge are interrelated in complex ways. It is therefore important to check for inconsistencies in the information (such as setting a learning target but failing to teach it in the scenario), and this authoring system provides functions for detecting such problems.

- Checking the content suitability

In the case of individually adaptive intelligent CAI, the courseware presented changes depending on learner-specific circumstances, making it difficult for the author to test the suitability of the courseware contents. Until now the only option was to actually try studying with the courseware, but for this authoring system we have devised a more efficient approach using simulated learning. The author sets the some parameters managed by the student model, creating a wide range of virtual students, and simulates the display sequences.

Once the courseware has been tested, it can be transferred to the CALAT server immediately and used for actual study.

Application and Evaluation

Courseware authoring

At NTT, courseware is planned and created in a number of different organizations, such as the Training Institutes, Regional Communications Sectors and human resources development division. The courseware content includes basic training in telecommunications, installation and maintenance of switches and other equipment, sales support and many other aspects of telecommunications business (see List1). The number of courseware packages available today is around 300 (NTT 1996a). These accomplishments demonstrate the very real feasibility of courseware authoring by specialists in the field of study. The amount of labor for producing intelligent CAI courseware is approximately equal to that for conventional "page-turning" CAI, but the increase in learning effectiveness is well worth this amount of additional investment.

List1. Examles of telecommunications service courseware

Maintenance work
- ISDN service protocol
- Service restoration manual for D70 switch
- Digital subscriber loop

Sales support work
- Basics of ISDN sales
- OCN overview
- Basics of leased line service sales

Customer service
- Service order flow

Basic knowledge in telecommunications
- Basics of digital technology
- Introduction to traffic
- Overview of related laws and regulations

General education
- Business etiquette
- General accounting overview

Learning

The courseware created in NTT is used not only for training new employees but for pre-study as part of the training programs in all the NTT Training Institutes and Regional Communications Sectors, and for self-edification. With a CAI system like this, once courseware is created there is no need to have instructors give the same lectures over and over or worry about scheduling. Learners can study at their own desired times. Moreover, since this an individually adaptive intelligent CAI system, students who are quick to learn can achieve their goals in a short time (in just 60 percent of the time required to complete a conventional CAI course in the case of the fastest students), whereas those who are slower to comprehend get the benefit of full attention to their needs (with the slowest students learning 1.6 times as much in an intelligent CAI program as with a conventional CAI course in our evaluations; see Figure 7). Some types of courseware were went public and can be tried to use on the Internet (NTT 1996b).

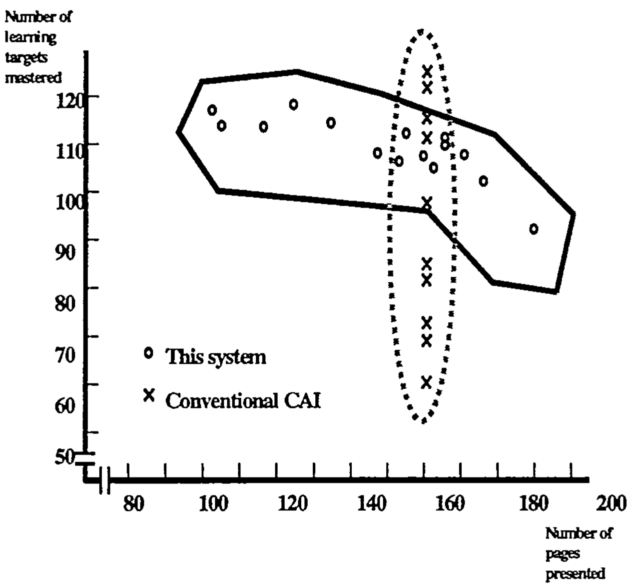

Figure 7. Comparative learning effectiveness

Further Advancements in Courseware Authoring

The goal of courseware authoring support functions is to reduce the work required to create courseware while raising the quality of the resulting courseware. The reduction of labor is being approached mainly by means of the editing support functions in the design process, as described in section 4; but for further reductions it will be important to achieve ways of reusing existing courseware (IEEE P1484 Working and Study Groups; ITS Workshop 1996). Also of interest is evolutionary courseware, as an approach to producing higher-quality courseware.

1) A global courseware database and reuse

A global courseware database is a means of managing the knowledge and information of a large amount of courseware, as well as relational information between courseware materials. It consists of two different kinds of databases. One manages existing CALAT courseware, while the other is a database of resources available on the Internet. The first database lends itself readily to reuse, since the knowledge structure is well organized. When, for example, the learning targets of new courseware to be created have been decided, the courseware database can be searched for possible scenarios and multimedia materials for reuse. This database, however, requires information as a pivot around which the relation between materials can be defined. We are planning to compile a database of common learning targets that can be shared by all courseware, and to use this as a pivot. The reuse of educational resources on the Internet is already possible, since CALAT uses URLs to designate multimedia materials. In practical terms, however, a major effort is required to locate suitable resources on the vast Internet. Besides linking this effort to Internet directories and search engines, it is important to increase the accuracy of searches by designating the search conditions intelligently so as to narrow down the search.

When it comes to courseware reuse, it would be desirable to make direct access to the courseware database during the study process, finding and presenting the optimal materials to learners; but with current technology it is difficult to find suitable material with sufficient accuracy. The most realistic approach at this point is to incorporate a reuse mechanism in the authoring system, use this function to search for reusable materials and then have the courseware author do the necessary selection and revision.

2) Evolutionary courseware

Computer networks and other leading-edge science and technologies progress at a dizzying pace. Since courseware in these fields tends to become obsolete soon after it is created, its contents need to be updated constantly. In many cases the work of updating this courseware cannot practically be carried out by the courseware author alone due to time and other restrictions. For this reason a method is needed by which courseware is maintained and evolved not by an individual but by a group. Learners progress through their studies of CALAT courseware, take the initiative in studying other related fields and eventually proceed beyond the knowledge of the courseware author. Also, through communication between the courseware author and learners, a relatively small learning community is formed, and a common desire for better courseware may be born. The distinction between learner and courseware author fades away, the group as a whole studies and carries out discussions, and their level goes up, with the courseware itself evolving at the same time. To these ends, technologies are need for cooperative group authoring and for support of community forming.

Conclusion

An intelligent CAI system using the World-Wide Web is attracting attention as a system that makes possible individually adaptive learning at any time or place. A conventional intelligent CAI system, however, requires a similar degree of effort and know-how for courseware authoring as for system development, and does not enable courseware authoring to be carried out practically by instructors or other experts in the field of learning. The authoring system described here makes use of a courseware knowledge structure consisting of learning targets and scenario, and enables courseware with a high level of individual adaptation to be created readily by specialists in the courseware fields. For efficient courseware design, we have proposed design support tools and automatic courseware generation tools, aimed at reducing the man-hours required for courseware authoring. Using this system, approximately 300 courseware packages have been created for telecommunications service fields and have demonstrated learning effectiveness superior to that of conventional CAI systems. Issues for the future include devising ways of reusing existing courseware and resources on the Internet, and creating a framework for courseware evolution.

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