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ABSTRACT

This document contains the following full and short papers on knowledge construction and navigation from ICCE/ICCAI 2000 (International Conference on Computers in Education/International Conference on Computer-Assisted Instruction): (1) "An XML-Based Tool for Building and Using Conceptual Maps in Education and Training Environments" (Juan-Diego Zapata-Rivera, Jim E. Greer, and John Cooke); (2) "CedarLearning: The Development of Learning-Centred Environments" (Tanya Wilson, Jeanette Muzio; Roger Mundell, Denise Stockley, and Laureen Vickery); (3) "Controlling Problem Progression in Adaptive Testing" (Roger E. Cooley and Sophiana Chua Abdullah); (4) "Cooperative Monitoring System Using Mobile Agent" (Young-Gi Kim, Sun-Gwan Han, and Jae-Bok Park); (5) "Development and Evaluation of a Mental Model Forming Support ITS--The Qualitative Diagnosis Simulator for the SCS Operation Activity" (Toru Miwata, Tatsunori Matsui, Toshio Okamoto, and Alexandra Cristea); (6) "Domain Specific Information Clearinghouses--A Resource Sharing Framework for Learners" (Wong Pei Yuen, Yeo Gee Kin, David Crookall, and Lua Tse Min); (7) "The Gathering and Filtering Agent of Education Newspaper for NIE" (Chul-Hwan Lee, Sun-Gwan Han, and Gee-Seop Han); (8) "Learners' Structural Knowledge and Perceived Disorientation in a Hypermedia Environment: The Effects of Information Conveying Approaches and Cognitive Styles" (Jim Jiunde Lee); (9) "Learning Protocols for Knowledge Discovery: A Collaborative Data Mining Approach to Creative Science Education" (Feng-Hsu Wang); (10) "Navigation Script for the World Wide Web" (Sachio Hirokawa; Kengo Nishino; and Daisuke Nagano); (11) "Proposal of an XML-Based Knowledge Sharing and Management System Supporting Research Activities" (Kyoko Umeda, Takami Yasuda, and Shigeki Yokoi); (12) "Scientific Revolutions and Conceptual Change in Students: Results of a Microgenetic Process Study" (Benson M. H. Soong and Yam San Chee); (13) "The 'Half-Life' of Knowledge in the University of the 21st Century" (Roger Mundell, Denise Stockley, Jeanette Muzio, Tanya Wilson, and Laureen Vickery); (14) "The Artistic Interface--A Transition from Perception to Screen" (Peter D. Duffy); (15) "The Discussion on the Dynamic Knowledge Generation and the Learning Potential Ability" (Chao-Fu Hong, Chiu-e Chen, Ming-Hua Hsieh, Cheng-Kai Huang, and Shih-Hsiung Chang); (16) "A Distance Ecological Model To Support

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Self/Collaborative-Learning via Internet" (Toshio Okamoto); (17) "The Internet-Based Educational Resources of the U.S. Federal Government" (Andy Wang and Krishelle Leong-Grotz); and (18) "The Network Learning Supported by Constructivism" (Song-Min Ku). (MES)

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An XML-Based Tool for Building and Using Conceptual Maps in Education and Training Environments

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Conceptual maps have been used in many areas as a means of capturing and representing knowledge. Several authors have explored the use of visual tools to enhance the learning process. *Thinking maps* as well as *frame games* use visual patterns of relationships (learners thinking processes) to structure knowledge. Based on their graphical structure it is possible to recognize the thinking process(es) employed in the map. Several software applications have been created to support different kinds of maps, but they use proprietary files to represent their maps. It makes sharing of knowledge difficult and jeopardizes the widespread use of maps. This paper proposes XML (Extensible Markup Language) as the language to describe maps. A knowledge construction and navigation tool (KVT- Knowledge Visualization Tool) has been implemented using XML to represent the kinds of maps supported by *thinking maps* and/or *frame games*. This paper describes the uses of KVT in education and training environments.

Keywords: **Knowledge Construction and Navigation Systems, Conceptual Maps, Thinking maps, Frame Games, XML, and Learner Models.**

1 Introduction

Conceptual maps have been widely used in many disciplines for different purposes. Concept maps have been used in education and training as a means of capturing and representing knowledge. Concept maps are just one of a variety of visual tools employed in schools and corporations. Several authors [2,4,5,6,7,9,10, and 14] have explored the use of conceptual maps to enhance the learning process.

Several authors [1,3,7, and 14] have used map adaptation techniques in hypermedia systems to offer a pertinent group of links to a particular user in a particular situation. Existing map-based navigation systems use different adaptation techniques to change the structure of the map according to the users' goals or preferences.

In this paper, we present KTV (Knowledge Visualization Tool), a knowledge construction and navigation tool that allows students and teachers to create XML-based maps in which they can add different kinds of links to the nodes on the map and navigate throughout the content using their own map. In addition, learners can introduce their own links or use links suggested by the teacher and/or other learners. Students and teachers can remove any unwanted link and define the sequence in which the links will appear. XML-maps are viewed as an important step in the creation of an open representation of maps that facilitates sharing of knowledge and assessment of students' knowledge by comparing their maps.

2 Visual Concept-Mapping Tools

A Visual concept-mapping tools (maps) have been used for constructing knowledge and capturing information about people's thinking processes. Because of the many types of maps available, people may get confused about what kind of map to choose for a specific problem. Hyerle [4] classifies maps in three categories:

- **Informal representations**, such as *brainstorming webs, web maps*, and *mind maps*, which are used mainly to support association and creative processes.
- **Task specific maps or organizers**, such as *life cycle, text structures*, and *decision trees*, which are used in specific content areas or tasks.
- **Thinking process maps**, such as *concept maps, system thinking maps*, and *thinking maps*, which are used to represent not only content relationships on a specific area, but also the thinking process or kind of reasoning behind the map.

Web maps, *mind maps*, and *brainstorming maps* have been used to support creative processes. Their informal structure is useful in areas, such as: brainstorming sessions, decision making, problem solving, taking notes, public speaking and planning. Figure 1 shows an example of a mind map created using Mind Manager® MindJET, LLC [8].

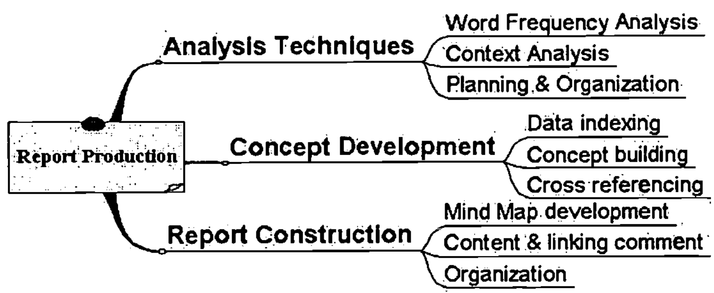


Figure 1. Example of a mind map [8].

Task-specific maps or *organizers* are designed to structure knowledge on a specific area. Figure 2 shows an example of a simple task-specific map (a classification tree) used in a biology class.

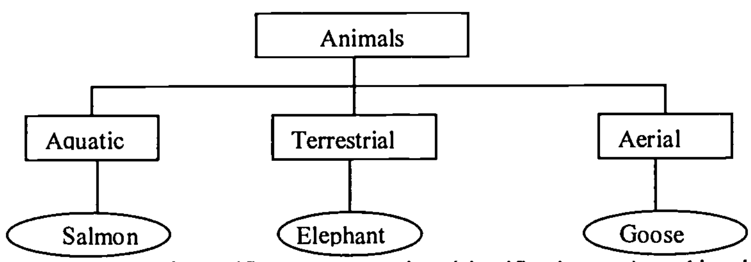


Figure 2. An example of a task-specific map or organizer (classification tree) used in a biology class.

Thinking process maps include concept maps, system maps and thinking maps. Thinking maps [4] are similar to frame games [6]. They use various kinds of visual patterns to represent information relationships and mental processes such as: sequencing, identifying attributes, cause-effect reasoning, analogical reasoning, part/whole reasoning, and classifying information.

Using *concept maps* [5,6,9, and 10] with different types of links, it is possible to represent more or less the same mental processes that thinking maps represent. The main disadvantage of *concept maps* over *thinking maps* is that their graphical structure does not necessarily reflect the thinking process. Figure 3 shows a simple example of a concept map.

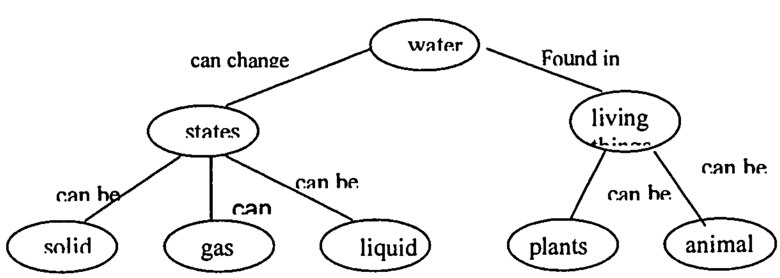


Figure 3. An excerpt of a concept map [10].

Thinking maps and *frame games* integrate knowledge views and make explicit fundamental human cognitive processes. According to Hyerle [1], by using *thinking maps*, it is possible to create any map that can be created using *brainstorming webs* and *task organizers* without being as informal as *brainstorming webs* and less content dependent than *task organizers*. Not only do *thinking maps* support structuring of content but also thinking processes, meta-cognitive abilities and reflection. Figure 4 shows some of the visual patterns supported by *thinking maps* and/or *frame games*.

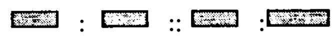
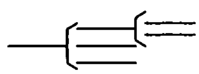
Thinking map	*Frame game*	*Reasoning*
 Bridge map	 Analogy pattern	Metaphorical
 Multi-Flow map	 Cause-Effect pattern	Systems dynamics
 Brace map	 Part/Whole pattern	Inductive and deductive

Figure 4. Some of the maps (visual patterns) supported by thinking maps and/or frame games.

3 Proprietary Map File Formats vs. XML-Maps

Most of the available commercial products (i.e. [8,11, and 13]) support *mind maps* or variations of them for multiple purposes (i.e. brainstorming sessions, decision making, problem solving, taking notes, public speaking, etc.). These products provide links to external applications, to other maps, and to content on the web. Although, ThinkingMaps® [12] is a software tool for the creation of thinking maps in education and training environments, it does not provide links to external applications, to other maps, or to the web. All these products use proprietary map file formats to represent their maps. It makes difficult sharing of knowledge and jeopardizes the general use of maps.

Using XML as the language to represent maps it is possible to eliminate proprietary files. The creation of a DTD file (Document Type Definition) to validate XML-maps should consider the main characteristics of the maps, such as: linking nodes to external applications, to content on the web, and to other maps. The DTD file proposed in this paper ('XMLmaps.dtd') covers all of the eight kinds of maps supported by *thinking maps* [4] and the ten kinds of maps (visual patterns) supported by *frame games* [6]. We have chosen to work with *thinking maps* and/or *frame games* because of their property of providing different visual patterns to represent different thinking processes. Figure 5 shows a fragment of the DTD file created to validate XML-maps.

Some of the benefits of using XML as the language to represent *thinking maps* and/or *frame* games are:

- XML provides an open format to maintain and share maps as opposed to proprietary file formats.
- By using a common vocabulary in conjunction to XML-maps, it is possible to compare maps. That is, maps can be compared to find similarities and differences in the type of structure employed (thinking process(es) used by the learner to analyze the topic), relation among nodes and types of links and documents attached to each node.
- Any XML query language such as XML-QL or XQL can be used to create queries to compare maps. By comparing maps it is possible to assess learners' knowledge and determine possible misconceptions, or gaps on a specific concept or group of them. By analyzing the type of map used to represent the knowledge it is possible to identify possible problems of the learner with a specific kind of reasoning.
- XML permits collaborative viewing of maps. See section 4.3 (KVT- Navigation System).
- By maintaining the student's knowledge information (XML-maps) in the learner model, new interesting opportunities for assessment, collaboration, adaptation, and inspection can be explored.

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- Opening visual knowledge representations is an important step towards the goal of capturing, sharing, and using knowledge across disciplines.

Figure 6 shows a fragment of an XML-map used to study Anatomy. This map has been validated using the grammar rules encoded in 'XMLmaps.dtd'. Figure 7 shows the graphical representation of the same XML-map. This map can be classified as a 'brace map' following the notation of *thinking maps* or as a 'parts-whole' pattern using the *frame games* representation. In both cases, they represent part-whole relationships among concepts and inductive/deductive kinds of reasoning.

```
# Author: Juan Diego Zapata Rivera
# Version: XMLmaps.dtd 1.0
<!--*******************************************************************
ELEMENT: XMLmap
COMMENT: thinking maps structures and frame games->
<!ELEMENT XMLmap  (CircleMap* | BubbleMap* |DBubbleMap* |
BridgeMap* |FlowMap* | BraceMap* | TreeMap* |MultiFlowMap* )
<!ATTLIST XMLmap
<!--*****************************************************************
ELEMENT: BraceMap
COMMENT: Brace map. whole/ part. Inductive and Deductive Thinking->
<!ELEMENT BraceMap (BraceNode+,Link*)
<!ATTLIST BraceMap
MapId CDATA    #REQUIRED
Type   CDATA    #REQUIRED
Name  CDATA    #REQUIRED
Description  CDATA    #REQUIRED
<!--******************************************************************
ELEMENT: Link
COMMENT: Link description-->
<!ELEMENT Link (FromNode,ToNode,LinkMedia)
<!ATTLIST Link
LinkId CDATA    #REQUIRED
Type   CDATA    #REQUIRED
Name  CDATA    #REQUIRED >
```

Figure 5. Fragment of DTD for XML-maps

```
<?xml version="1.0" encodirg="UTF-8"?>
<?xml-stylesheet type="text/xsl" href="XMLmaps.xsl"?>
<!DOCTYPE XMLmap SYSTEM " XMLmaps.dtd">
<XMLmap>
    <BraceMap Type="'BraceMap'" Description="'Example of an XML-map'" Name="'The human body'"
    MapId="'Map001'">
        <BraceNode NodeId="02" Type="'BraceMap'" Name="'head'" XMLthinkingMapLink="''">
            <LinkMedia XMLConcept="'head'" Text="''" Application="''" URL="'1'" Sound="''"/>
            <Chlidren>05</Chlidren>
            <Chlidren>06</Chlidren>
            <Parents>01</Parents>
        </BraceNode>
        <BraceNode XMLthinkingMapLink="''" Name="'ears'" Type="'BraceMap'" NodeId="05">
            <LinkMedia XMLConcept="'ears'" Text="''" Application="''" URL="'www.body.xml'"
Sound="''"/>
            <Parents>02</Parents>
        </BraceNode>
        <BraceNode XMLthinkingMapLink="''" Name="'eyes'" Type="'BraceMap'" NodeId="06">
            <LinkMedia XMLConcept="'face'" Text="''" Application="''" URL="'www.body.xml'"
Sound="''"/>
            <Parents>02</Parents>
        </BraceNode>
        <BraceNode XMLthinkingMapLink="''" Name="'torso'" Type="'BraceMap'" NodeId="03">
            <LinkMedia XMLConcept="'trunk'" Text="''" Application="''" URL="'1'" Sound="''"/>
            <Parents>01</Parents>
```

Figure 6. Fragment of an XML-map about 'Anatomy'.

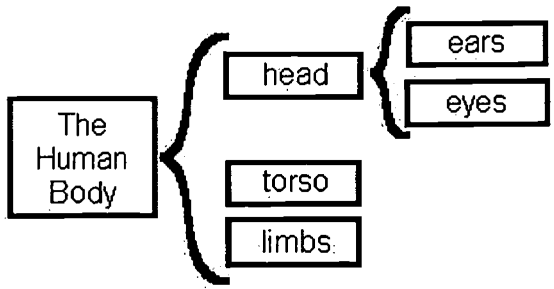

Figure 7. Graphical representation of an XML-map about 'Anatomy'.

4 KVT (Knowledge Visualization Tool)

KVT is a map construction and navigation system that allows the creation of XML-based *thinking maps* or *frame games*. KVT also provides the possibility to link different kinds of resources to specific nodes. In this way, KVT supports personalized navigation throughout the class content. Students can create their own knowledge structure using a set of predefined concepts (*common vocabulary* given by the teacher) and use their own map to access class resources. These resources are suggested by the teacher (*initial links*) or by his/her classmates during the creation of their maps (*collaborative browsing using XML-based maps*).

The class content is not limited to a specific group of pages, videos, sounds, etc. On the contrary, any student or teacher in the class can navigate through the map via the WWW, can add links, and can add new resources. Every participant has access to all of the resources that are associated with the nodes in his/her map. The list of resources attached to a node can be ordered arbitrarily by the learner.

4.1 KVT's Architecture

KVT (see figure 8) is composed of the following modules:

- ***Map Construction Tool***. KVT supports the ten kinds of maps identified in the context of *frame games* [6] and the eight types of *thinking maps* proposed by Hyerle [4,12]. Students select concepts from a predefined list and create their own structure. Having a predefined list of concepts (*common vocabulary*) makes it easier to share, compare, analyze and evaluate maps. Students can link different resources (course materials, web pages, documents stored on different applications, etc) to their map. They can even include other maps in a recursive manner. Students' maps are stored in the learner model for further modification, analysis and evaluation.
- ***The Browser***. This is the main interface to visualize one's map and its associated class content. Students can navigate throughout the content by clicking on any node of the map and selecting one of the links/documents that are available for this node. Furthermore, students can navigate freely and add links and documents to any of the nodes in the map. Students can navigate using links suggested by other students/teachers in a hyperspace created collaboratively for a particular topic and encoded on the map.
- ***The Learner Model***. The Learner module maintains basic learner information as well as their XML-maps (XML files including map structure, links, and order preferences). Students can add, order, modify, or remove links and nodes. Students and teachers contribute to populate each node with different sort of resources, but it is up to each person to remove unwanted resources and define the sequence in which he/she prefers to see the resources.
- ***Course Materials***. Class resources are classified into three main categories: web content, XML content, and general documents (text, sound, images, videos, etc.). They comprise an open range of materials that are organized first by the teacher. Using KVT, students and teachers can create different representations of the knowledge, and as a result of their contributions a highly refined subset of useful documents will be attached to each of the nodes. KVT supports the cooperative creation of information spaces to be used in educational contexts.
- ***Learners and Teachers Share Maps***. Learners and teachers can use KVT in a number of ways. For example, Teachers and learners can visualize maps using different levels of granularity. Learners can use an existing map as a guide to study the content, or use this system as a learning tool to facilitate remembering, create maps collaboratively, share their maps, and engage in interesting discussions

about a particular topic. Teachers can create maps to serve as 'guided tours', which can be used by students to navigate throughout the content. Teachers can use XML-maps to assess the student's knowledge. This can be done by comparing different maps (visually or through queries) to determine problems in the learning process for a particular student or groups of them. Finally, teachers can use this system as an adequate environment to promote reflection among students on a specific topic (map structure and content).

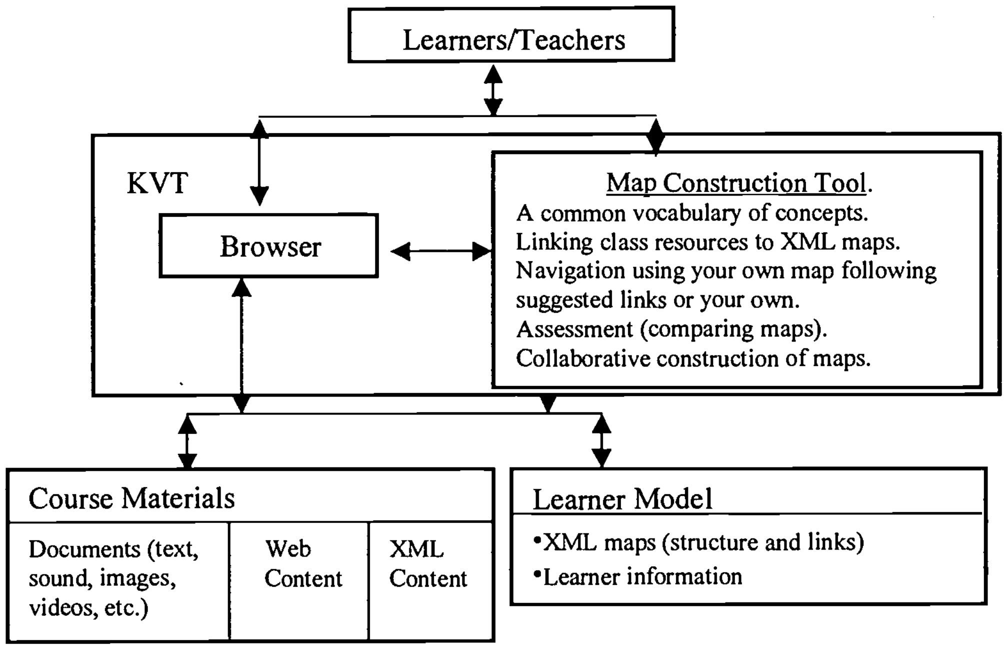

Figure 8. KVT- System Architecture.

4.2 KVT- Linking Documents to Nodes

Using KVT it is possible to add different kinds of documents to the nodes of the map. Figure 9 depicts the user interface provided by KVT to add, modify and remove documents. This interface allows students/teacher to attach a web page, XML document, video, sound, or image to any node on the map. KVT also provides the option to test any of the documents, edit the description and document fields and remove any unwanted link from the map. By clicking the headers on the grid it is possible to change the order in which the links will be presented to the student when navigating using the map. Order preferences are stored in the learner model for further use.

New links/documents for a particular node are automatically shared with all of the maps that contain such a node. This can affect maps of several students/teachers in the system. However, individual sequencing or removal of resources affects only the student's own map. Maps are stored as XML files in the learner model. The example on figure 9 shows a Brace-map that is used to organize information related to Anatomy. The grid of current documents shows the currently available links for the concept 'ears'. It is possible to visualize who included each link (user type/user), the document type location and description.

4.3 KVT- Navigation System

Figure 10 shows how students and teachers can navigate on the web using their own maps and their own links or the ones suggested by others. Just by clicking the concept, a list of current links/documents appears to be selected. If the student has not chosen any particular sequence of resource presentation, this list is initially ordered by type of user (teacher/student). In this environment, it is also possible to navigate freely on the web by entering a URL or just following the links on the current page. When an interesting page is found, it can be attached to any concept on the map by selecting the target concept and pressing the button 'Add Link' located at the bottom of the window.

The example in Figure 10 shows how the student uses the map to navigate by the links related to the concept 'ears'. The current web page corresponds to the first link suggested by the teacher 'Anatomical Tour of the Ear'.

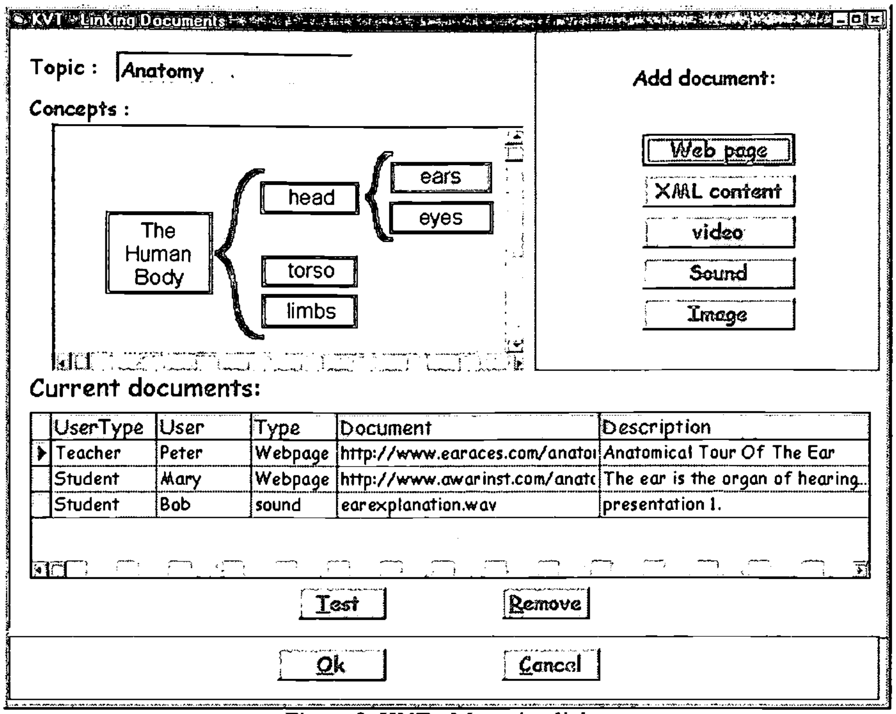

Figure 9. KVT - Managing links.

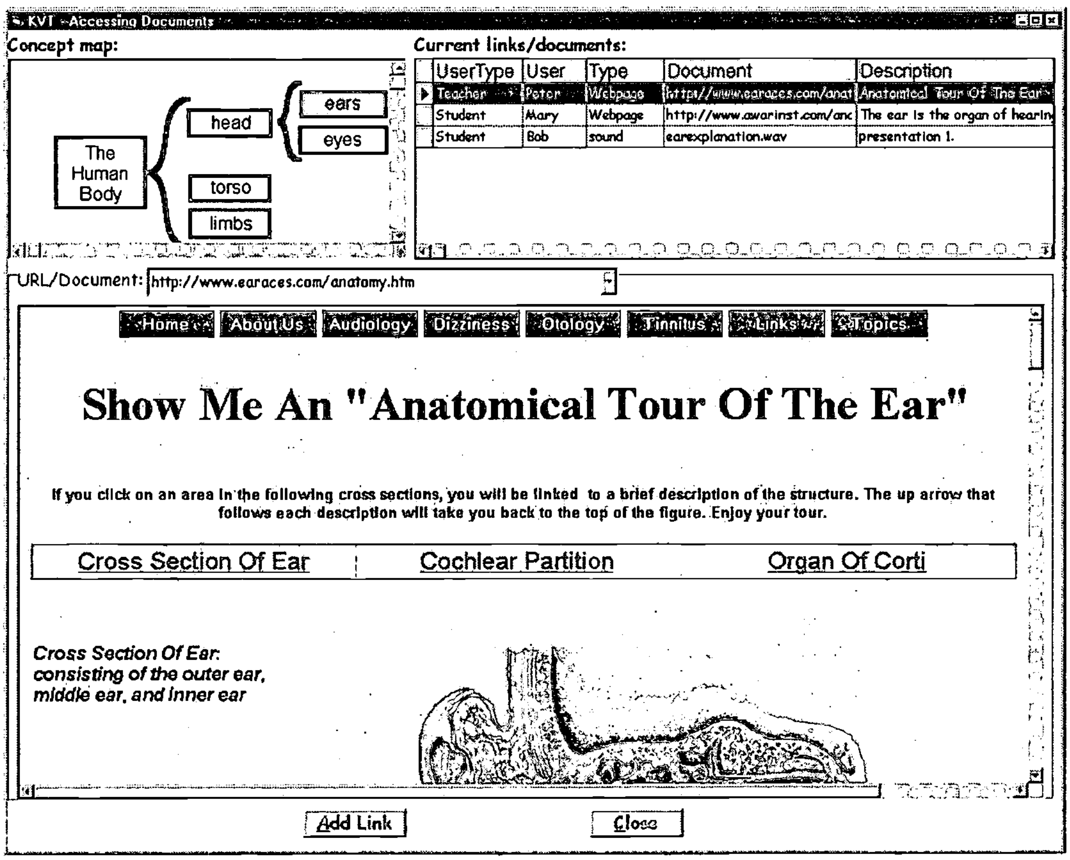

Figure 10. KVT- Navigating on the web using XML-maps and suggested links/documents.

5 Conclusions and Future Work

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XML offers an excellent language to represent maps. Using XML maps, it is possible to support knowledge sharing without the problems of having proprietary files. By using a common vocabulary for the content and XML maps, it is possible to compare map structures.

XML-maps (*thinking maps, frame games*) are very useful in education and training environments because they support content structure and make explicit fundamental human cognitive processes.

KVT offers an attractive tool for the creation of maps and supports collaborative navigation throughout the content. By using XML-maps, KVT provides a better support to education or training setups that uses maps to create, share and assess knowledge. By including XML-maps into the learner model, new possibilities for visualization and inspection of XML-maps can be exploited in order to improve the learning process.

References

[1] Brusilovsky, P. "Methods and Techniques of Adaptive Hypermedia". In Adaptive Hypertext and Hypermedia. Brusilovsky, P., Kobsa, A., and Vassileva, J. (eds.) Kluwer Academic Publishers, pp. 1-41 (1998).

[2] Buzan, T. "Use both sides of Your Brain". Ed. Dutton. New York (1979).

[3] Gaines, B. R. and Shaw, M.L.G. "Web Map: Concept Mapping on the Web". (1995). Available on-line:http://ksi.cpsc.ucalgary.ca/articles/WWW/WWW4WM/WWW4WM.html

[4] Hyerle, D. "Visual Tools for constructing knowledge", ASCD press. Alexandria, Virginia, (1996).

[5] Jonassen, D., Wilson, B., and Cole. P. "Cognitive Approaches to Instructional Design". G.M. Piskurich (ed). The ASTD handbook of instructional technology. McGraw–Hill. New York, pp. 21.1-21.22. (1993). Also available on-line:http://www.cudenver.edu/~bwilson

[6] Jonassen, D., Beissner, K., and M., Yacci. "STRUCTURAL KNOWLEDGE. Technique for Representing, Conveying, and Acquiring Structural Knowledge". Lawrence Erlbaum Associates, Publishers. Hillsdale, NJ (1993).

[7] Micarelli, A., and Sciarrone, F. "A case-based toolbox for guided hypermedia navigation". In Proceedings of the Fifth International Conference on User Modeling, pp. 129-136 (1996).

[8] MindManager® by MindJET LLC. Test version V3.5.5.SP2. Apr 8, (1999).

[9] Novak., J. D.. Learning, Creating, and using Knowledge. Concept Maps as Facilitative Tools in Schools and Coorporations". Lawrence Erlbaum Associates, Publishers. Mahwah, NJ (1998).

[10] Novak., J. D., and B. D., Gowinn. "Learning how to Learn". Cambridge University Press. Cambridge, England (1984).

[11] THE BRAIN® by Natrificial Software Technologies. Free version 1.73. 9/1/99, (1999).

[12] ThinkingMaps® by Innovative Learning Group. Trial version 1.0.1, (1998).

[13] VisiMap® by CoCo Systems Ltd. Trial version 2.5 c. Nov 1999.

[14] Zyryanov, M. "Adaptive local maps in the hypermedia components of intelligent learning environments'". In: P. Brusilovsky, P. Kommers and N. Streitz (eds.): Multimedia, Hypermedia and Virtual Reality: Models, Systems, and Applications. Lecture Notes in Computer Science, Berlin: Springer-Verlag, pp. 306-310 (1996).

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CedarLearning: The Development of Learner-Centred Environments

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Royal Roads University (RRU) is a four year old University situated on a 640 acre historic site featuring beautiful grounds and a nineteenth century castle. The mission of the University is to deliver world-class applied and professional programs to Canadian and international adult learners. RRU's degree programs are designed for the mid-career professional and its graduate programs combine periods of on-campus instruction and semesters of distance education. This delivery model (a) aligns with the needs of mid-career professionals, and (b) is dictated by the size of the physical buildings at RRU; currently only 250 learners can be accommodated on-campus at any one time. At RRU's Centre for Economic Development and Applied Research (CEDAR) we have developed tools that allow simultaneously for both knowledge-building, collaborative learning and for individual, self-paced learning in the same course. This flexibility provides the opportunity for just in time and just enough information that creates the truly learner-centred environment. These tools are used in several of the MBA courses, such as finance and e-commerce.

Keywords: **Knowledge Construction and Navigation, Lifelong Learning, Web-Based Learning**

1 Introduction

Royal Roads University (RRU) in British Columbia, Canada is a five year old University situated on a 540 acre historic site featuring beautiful grounds and a nineteenth century castle. For 40 years the facility was used as a campus for Military officers, and became a public University when the Department of National Defense closed the facility and leased the space to the Province of British Columbia.

Although beautiful and steeped in history, The physical facilities limit the on-campus population to only 325 students at any one time. This forced the University to explore alternate delivery methodologies from the very beginning, and has resulted in an innovative and highly effective model that targets mid-career learners.

The University focuses primarily on Masters level programs which are offered at a distance to learners who are still in the workforce and continuing at their jobs. These students come together for a series of brief residencies and complete the remainder of their degree through Web-based distributed learning.

With busy mid-career learners, several issues had to be addressed. In addition to accommodating the usual issues of time and place, the University wanted to adopt a Learner-centred approach that would adjust for such variables as prior learning level; Learning Styles and use of granular knowledge objects. At the same time, designers were cognizant of the significant body of research evidence that points to learning communities and collaborative discourse as critically important components of any online courseware.

The resulting courseware seemed to effectively combine the best of the highly learner-centred techniques used in private sector training with the collaborative techniques that have proven effective in most successful post-secondary online courses.

Using commonly available web development tools the team at Royal Roads University created courses that are database-driven, and use dynamic templates to easily populate and modify course content. They devised a number of online assessment and feedback tools, as well as innovative "jig-saw puzzle" style group assignments to stimulate collaboration. They developed a navigation system to allow learners a choice of delivery styles to suit personal learning style preferences, and a self-assessment mechanism to help learners move through online material on a need-to-know basis.

Additionally, the system provides easy management tools for the instructors to control and modify content, as well as monitor the students' progress, without needing any knowledge of web page creation or HTML.

The development team at Royal Roads University is part of the Centre for Economic Development & Applied Research, (CEDAR). They are continuing to explore and evolve the understanding of what works and what doesn't in online learning. At RRU, the team is fortunate to have a "live" laboratory of more than 900 active online students, and a University-wide commitment to Web-based delivery.

In this presentation, we will demonstrate actual delivered courses, present our findings, and demonstrate our course design. We will show how the use of templates and database driven content allows course designers to adjust for variables of learning style, prior knowledge, and level of effort, in addition to time and place.

CEDAR's methodology is applicable to all forms of electronic distributed learning (EDL) regardless of the delivery mechanism – distance education or classroom delivery, over the Internet or via CD-ROM, instructor-led or instructor-free. Learner-centred EDL courses can be easily designed using commercially available software tools. These tools allow simultaneously for both knowledge-building, collaborative learning and for individual, self-paced learning in the same course. This flexibility provides the opportunity for just in time and just enough information that is demanded by busy professionals seeking a learner-centered environment. These learners have a lifetime of experiences and want a course that is tailored to their needs and takes advantage of their prior knowledge.

Our methodology allows learners to navigate through the content according to learning style. Pre-testing on learning outcomes allows for prior learning assessment, adaptive self-assessment quizzes provide feedback, and technical assistance is built into the course. On-line communities are created through group jigsaw assignments and forum discussions. This allows learners from diverse backgrounds to participate in an on-line environment that is geared to their individual needs.

Some of our unique features include:

1. Learner-centred approach allows learners to navigate throuth the material based on their preferred learning style. This is in contrast to most EDL courses which follow a sequential text-book like approach,
2. Learners can pre-test for prior knowldege. This saves them time as they study only those parts of a course that they do not already know,
3. Self-assessment quizzes allow learners to monitor their progress throughout the course and review as needed,
4. The outcomes-based design of the database allows for the use of shareable courseware objects for different learning needs in different courses.

2 Design and Development of the E-Commerce Course

The development process began with the course designer showing the instructor previously completed courses. By seeing exemplars the instructor was presented with different teaching options that the technology facilitates and allowed the instructor imaginative application of the construction process. (integrating real world/live data, interactive diagrams, and animated examples).

The design and development of the e-commerce course was a three-way communication between the content expert, an instructional designer (who is a specialist in learning styles) and the technical designer. The instructor was actively involved in the course development and provided the learning outcomes for the course. The instructional designers established the appropriate navigation for the different Learning Styles and those navigation methodologies were then tagged into the database templates.

The Web based Discussion Forums were setup and the instructor was given early access. The course

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underwent a period of testing before the students were given access and any noticeable glitches were corrected at that time.

3 Student Engagement

Instructional materials are delivered to distance-learners via the Internet or to classroom-based learners via CD-ROM. The primary thrust behind the methodology was to produce courseware that is truly learner-centred rather than content-driven or instructor-centred. The course material is navigated in a variety of database-driven, learner-selected methods, depending upon individual preferences. Students also have access to a 24-hour online support available for any technical problems that they may experience. PDF files or screen prints are available for offline browsing of the course content.

Each course module has a number of self-assessment questions, which allows the learner to measure themselves against the desired learning outcomes for that granule. A learner may choose to try this assessment before working through any of the material, or afterwards for self-formative evaluation of the module content. At the end of the assessment, the learner is informed which areas of the module require study. Learners returning later to the self-assessment questions are asked questions only on those areas incorrectly answered the first time.

The web application allows the learner to optionally take a learning style test that provides information about their preferred learning style. After completing the test, the individual is provided with information about their preferred style and each unit can be approached according to that style. Users can switch freely between styles at any point.

To enhance critical thinking and process skills, and the development of community, the courses have included:
(a) residency,
(b) group jigsaw assignment,
(c) case-based reasoning,
(d) electronic forums, newsgroups and live chat
(e) peer to peer and self evaluation
(f) real-world, just in time articles for on-line discussion,
(g) instructor acting as a guide on the side and not as a sage on the stage.
(h) Integration of real-world projects.

These opportunities provide for (a) immediate transferability to the workplace, and (b) building a knowledge network that extends long beyond the end of the degree program.

4 Lessons Learned

The results of the project were gathered from learners through formative feedback, summative evaluation, and focus group discussions.

In general, it was found that learners reacted positively to
(a) the different navigation styles for the four learning styles,
(b) the look and feel of the user interface
(c) the on-line technical helps,
(d) the internal consistency of links,
(e) the ability to pre-test prior knowledge,
(f) the on-line immediate feedback given in the self-assessment quizzes
(g) collaborating with their peers at a distance, and jigsaw style assignments.
(h) the flexibility of doing the course at a convenient time and place.

Some learners relied heavily on offline reading of the printed material, particularly those with poor connectivity or minimal familiarity with computers.

Some complained that the course required them to do too much on the computer, and they would have

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preferred more offline work.

Very technically literate students suggested more use of multimedia in the content. In the finance course, several exercises required the student to use a separate spreadsheet, and it was felt that this functionality should have been incorporated into the online exercise. This can be easily done with the technology that was used.

Some saw the self-assessments as more threatening, (they carried no marks) while most saw them as a tool.

Some suggested allowing the student to mark up the content online, such as with the use of electronic "sticky notes". This suggestion will be implemented in the next course.

Three main lessons that we have learned from this project are:

1. It is possible to produce EDL courseware that is learner-centred and not content-driven or instructor-driven. This results in more satisfied learners who feel that their time, prior knowledge, and learning preferences have been considered,
2. Using off-the-shelf tools save on production time and costs and ensure that tried-and-tested software is utilized,
3. Courses that are database-driven provide opportunities for re-using data elements in different courses.

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Controlling Problem Progression in Adaptive Testing

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Adaptive testing has, in recent years, been used as a student modelling technique in intelligent tutoring systems. One of the main issues has been to optimise the progression of problems posed as the student performs the adaptive test. Previous research has concentrated on finding a structure in a fixed collection of problems. This paper describes an algorithm for problem progression in adaptive testing. After describing current approaches to the progression problem, the paper discusses the role of expert emulation. It then describes a knowledge elicitation exercise, which resulted in a solution to the progression problem. Part of the knowledge elicitation process was supported by software based on constraint logic programming, clp(FD), and the paper concludes with an assessment of the prospects of developing an extended knowledge elicitation support system.

Keywords: **intelligent tutoring system, knowledge construction and navigation, adaptive testing, constraint logic programming**

1 Introduction

The major advantages of adaptive testing over fixed item testing are that a student's knowledge is explored thoroughly and efficiently, and with a minimum of redundancy. By asking an appropriate number of problems at appropriate levels of difficulty, adaptive testing neither bores by unnecessary repetition nor intimidates by posing a series of inappropriately difficult problems [1]. This makes adaptive testing attractive for student modelling in intelligent tutoring systems [2],[3].

This research was conducted in the context of providing remedial help in mathematics to a transient population of prisoners in a local prison. Here the students are studying courses such as City and Guilds (Key Skills), City and Guilds (Number Power) and for GCSE level examinations. Working with prisoners can face tutors with problems not normally encountered in more conventional settings. Unlike school students, the prisoners not only lack uniform prior knowledge in mathematics, but tend also to join or leave the prison at individual times. This makes the job of the human tutor difficult because of the need to assess the knowledge level of each prisoner before assigning them the appropriate level of one or more of the above courses and examination. Currently, fixed item testing is used as an assessment tool. This approach has a major disadvantage. Many prisoners are 'math anxious' and the use of fixed item testing may undermine their confidence and motivation in the subject. Adaptive testing avoids this danger by presenting problems at an appropriate level of difficulty.

One of the main issues in adaptive testing is the determination of an efficient progression from one problem to another. Previous proposals have included hard-wiring prerequisite relationships between knowledge items [3], and preparing an indexing framework for problems [4]. Section 2 of this paper reviews the major lines of research; and the paper then describes an approach to the progression problem based on the knowledge acquisition techniques used for expert systems. In doing so, it continues in the vein of Khuwaja & Patel's work [5]. The paper presents a rationale for this approach, describes briefly a semi-automated

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method of eliciting syllabus content and characteristics, and then presents a progression technique elicited by standard techniques with an expert. It concludes with a discussion of the feasibility of automation in this area.

2 The Progression Problem

In a problem-solving environment, *problem progression* is concerned with the strategy in which the next problem is selected. In adaptive testing, this is usually based on the student's response to the current problem, as the process of selecting the next appropriate problem is crucial to the efficiency and precision of the whole student modelling process. Also, presenting *the right question at the right time* maintains the motivation of the student.

The structure of the domain, that is the way in which problems are related to one another, determines problem progression in adaptive testing; and the two significant and distinctive approaches to determining such structures are discussed in this section.

2.1 Item Response Theory

For adaptive testing systems which adopt the *Item Response Theory* or IRT [6], such as SIETTE [7] and CBAT-2 [8], the domain is made up of test items which are kept in an *item pool*. The construction of an item pool usually involves major empirical studies for content-balancing, to ensure no content area is over-tested or under-tested, and for item calibration. Each test item is associated with one or more of the following parameters – the *difficulty level, the discriminatory power and the guessing factor.* The *difficulty level* measures the difficulty level of a test item, the *discrimination power* describes how well the test item discriminates students of different proficiency, while the *guessing factor* is the probability that a student can answer the test item correctly by guessing.

Problem progression takes place like this. The adaptive test starts with an initial estimation of the student's proficiency, è. A *best* item or problem is selected. This is one which provides the most information about the student, and is calculated from the item's three parameters and current proficiency, è. An ideal item should have a difficulty level close to è, a high discriminatory power and a low guessing factor. A new proficiency, è', and its confidence level are calculated based on whether the student has answered the problem correctly or not, the old è, and the item parameters. The test continues until a stopping criterion is met, for example, when the confidence level of è' has reached a desired level.

2.2 Knowledge Space Theory

There are adaptive testing systems built on the theory of *knowledge spaces [9]*. Examples include a web-based, domain-independent system called RATH [10], a web-based system for the domain of mathematics called ALEKS [11], and a general purpose system for testing and training called ADASTRA [12].

Like the IRT-based systems, the domain is made up of test items of an academic discipline, each of which can be a problem or an equivalence class of problems that the student has to answer. The student's *knowledge state* is defined as the set of items in the domain that the student is capable of solving. For example, if a student has the knowledge state *{a,b,d}*, this means that he can solve items ***a***, ***b*** and ***d***. Not all possible subsets of the domain are feasible knowledge states. Consider the example shown in [13]. In a domain of mathematics, if a student can solve a percentage problem, (item ***d*** say), then it can be inferred that the student can perform single-digit multiplication, (item ***a*** say), and thus any state that contains item ***d*** would also contain item ***a***. The collection of all feasible knowledge states is called the *knowledge structure.* The knowledge structure must also contain the *null state {},* which corresponds to the student who cannot solve any item, and the *domain,* which corresponds to the student who can solve or master all items. When two subset of items are knowledge states in a knowledge structure, then their union is also a state. This means that the collection of states is *closed under union.* When a knowledge structure satisfy this condition, it is known as a *knowledge space.*

In practice, items for a domain are derived from instructional materials and systematic knowledge elicitation with teachers. This is also the case with establishing knowledge states where query procedures systematically elicit from human experts the prerequisite relationships between items [3], [14].

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Once the domain is represented as a knowledge space, the adaptive testing strategy is then to locate as efficiently and as accurately as possible, a student's knowledge state. Problem progression becomes straightforward. For example, if a student has answered an item correctly (incorrectly), it can be inferred that he can (cannot) answer a prerequisite item and will thus not be asked to solve the latter.

2.3 Other Approaches

The domain can be represented as a *granularity hierarchy* [15] where items which represent a topic, subtopic or skill, are described at various grain sizes and connected together into a granularity hierarchy which allows focus shifts along either *aggregation* or *abstraction* dimensions. In this way, the ability to recognise student behaviour at varying grain sizes is important both for pedagogical and diagnostic reasons.

Other examples include an *indexing framework* for the adaptive arrangement of problems in the domain of mechanics [4], a problem-simplification approach [16], an optimisation expert system where both the knowledge structures of the student and the teacher are represented by structural graph, and problem progression is controlled by the relationship between the student's knowledge structure and that of the teacher's [17]. Evidence of a strong use of a student model in controlling problem progression can also be found in a system called TraumaCASE [18] which automatically generated clinical exercises of varying difficulty, and in the work of Beck, Stern & Woolf [19] who recorded information about a student using two factors – *acquisition* and *retention*. *Acquisition* records how well students learn new topics while *retention* measures how well a student remembers the material over time.

3 Knowledge Elicitation

The concern of the researchers discussed above is to exploit a structure of a syllabus to improve the efficiency of tests. The structure may either be revealed through elicitation, as was done by Dowling and her co-workers, or may be derived from a statistical analysis of student behaviour, (IRT), or it may be seen as being derived from the nature of the problem domain. Though there may be, from some given point of view, an optimal way of structuring a syllabus, the view adopted in this research is that it is a subjective matter to be determined by an expert teacher. Such a teacher might make use of informal statistical information, subject domain information as well as pedagogic information in determining a suitable structure. Studies of intelligent tutoring systems have shown that, as one would expect, it is difficult to transfer systems from one setting to another, because there is considerable cultural variation in both teaching and learning [20]. This provides the prime motive for investigating techniques based on expert emulation for the production of tests for local consumption.

Moreover, this is a natural extension of the *intelligent tutoring systems* endeavour, and it has an additional advantage. A lack of homogeneity amongst a student body can weaken the effectiveness of techniques based on population statistics; and the target body of students with which this paper has been concerned is, educationally, not very homogeneous.

4 Eliciting the Syllabus

There are several problems to be confronted when adopting an expert emulation approach to designing an adaptive test. They include the problems of finding suitable experts [21], selecting appropriate forms of knowledge representation and choosing appropriate methods of knowledge acquisition.

The approach to knowledge acquisition in the research described here is to separate the task of designing an adaptive test into the following sub-tasks:

- describing classes of problems,
- describing the skills used to solve problems,
- describing responses to problems,
- problem generation,
- problem progression based on student responses.

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For the particular domain tackled, namely the arithmetic of elementary fraction addition, software has been developed to support the first four of these subtasks using Constraint Logic Programming, clp(FD), embedded in Prolog, [22]. This work has been described in a recent conference paper [23], and is briefly summarised here.

Clp(FD) is actively used by the knowledge engineer conducting knowledge acquisition interviews. The teacher, who is the target of the emulation, is not expected to write constraints, but is more than likely to take an interest in them. During discussions, which involve the production of example problems, the knowledge engineer enters the necessary constraints, or modifies existing constraints, to describe the particular class of problem under discussion. The set of constraints is then solved interactively to produce example problems. These form the basis of a discussion, and may lead to further rounds of discussion and modification.

The description of a class of problems is treated as a set of constraints. This consists of a set of variables, a statement of the domains of the variables, and a statement of the relational constraints that hold between the variables. For example, during an interview, the human tutor wanted to represent a class of problems, which involved the addition of two proper fractions with a common denominator of the form,

$$N1/D1 + N2/D2 = N/D$$

and he wanted to use single-digit integers.

This can be represented in clp(FD) as a code fragment:

```
domain([N1,D1,N2,D2],1,9),      % Single digit integers
N1 #<  D1,                      % First operand - proper fraction
N2 #<  D2,                      % Second operand - proper fraction
D1 #= D2.                       % A common denominator
```

The following is an example of the use of clp(FD) to describe skills. The *cancel fraction* skill can be represented in clp(FD) as:

```
% Simplify the fraction N/D into its lowest form to give X/Y
% Example:  63/81 gives 7/9
cancel(N,D,X,Y) :-
      domain([N,D,X,Y,F], 1,99),
      F*X #= N,
      F*Y #= D,
      maximize(labeling([], [F,X,Y]), F).
```

Here, variable F is the common factor to be cancelled. This is specified by the two relational constraints. The *maximize* predicate in the final line ensures that the largest value of F will be found.

5 Eliciting the Progression

The knowledge elicitation exercise involved approximately 20 hours of interviews spread over a period of three months. Conventional knowledge elicitation techniques, such as structured interviewing, task analysis and construct theory [24], were used.

Early interviews revealed the significance to the expert of the *skills* that students needed to exercise in order to solve particular problems. The following were identified:

a. Add equivalent fractions
b. Cancel fraction
c. Make proper
d. Find the lowest common multiple
e. Find equivalent fractions

The number of discrete skills required to solve a problem was considered as a measure of the difficulty of

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the problem; and this measure was used to classify problems, and in so doing reveal a structure of the domain. This coincides with the findings of Beck, Stern & Woolf [19]. However, it is useful to note that this is only one of the many factors in measuring problem difficulty used by Lee [25], who identified, amongst others, the student's degree of familiarity with a particular type of problem.

In eliciting progression information, it is necessary to avoid the problem of combinatorial explosion. A *head on* approach requires the expert to provide a tree structure of sequences of problems indicating the appropriate *next* problem depending on the outcome of all previously asked problems. Such an approach is unattractive to both expert and knowledge engineer. Instead, an approach adopted was to attempt to uncover the underlying *algorithmic* strategy of the expert.

In general terms, the strategy of the expert is to test the students' abilities to exercise the identified skills at a particular level of difficulty. Failure to return a correct answer causes the questioning process to be resumed at a lower level of difficulty, that is, with problems requiring the demonstration of fewer skills. Whereas successful demonstration of all the identified skills causes the questioning process to be resumed with problems at a greater level of difficulty. The expert started with problems of middling difficulty and adopted a *binary chop* approach to selecting the next level. Within each level of difficulty, the selection of the *next* problem depended on the skills already demonstrated. Each available problem was scored using a set of weights, which favoured previously undemonstrated skills at that level. If the progression problem is viewed as a variant of state-space search, the expert's strategy has more in common with a *constrain-and-generate* paradigm [26], at a given level of difficulty, rather than a naïve *generate and test* approach. A schematic example of the use of this strategy is given below.

In a Prolog implementation of this strategy, a record of students' skills, demonstrated at each tested level of difficulty is recorded, and used to prepare a revision plan.

6 An Example

The human tutor first prepared the adaptive testing strategy for a domain of five skills described above. This is shown in Figure 1 for a domain of five skills.

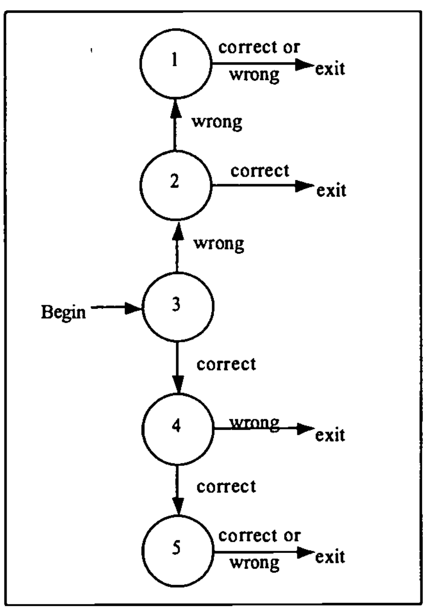

Figure 1: Human tutor's strategy in adaptive testing for a domain of 5 skills

In Figure 1, the adaptive test begins at node 3 which contains problems each of which can be solved by exactly three skills. If the student gets any problems wrong within that category, he moves onto node 2 which contains problems each of which can be solved by exactly two skills. If he gets all the problems correct within that category, he will exit the adaptive test. The rationalisation for this is described below.

If each of the skills were labelled as a,b,c,d,e, as in Section 5, then at node 3, there are ${}^5C_3$, that is 10 possible combinations of skills. For example, the combination [a,b,c] would involve a set of problems which each require all the skills **a**, **b** and **c** to be used. Skills **a**, b and **c** correspond to *add equivalent fractions, cancel fraction*, and, *make proper* respectively. However in practice, not all these combinations will be found in a valid problem type.

We introduced weights to each combination to enable the choice of the next best combination. We also imposed the following criteria for calculating the weight of each candidate set:

- If a skill has been not been asked yet, it carries a weight of 2
- If a skill has already been asked once, it carries a weight of 1
- If a skill has been asked more than once, it carries no weight
- Select the first set amongst the candidate set with the highest score

The following process shows how problems, each of which, require a combination of three skills are presented to the student.

a. Select [a,b,c] and scores are assigned to the other combinations, based on the above rules:

	[a,b,c]	[a,b,d]	[a,b,e]	[a,c,d]	[a,c,e]	[a,d,e]	[b,c,d]	[b,c,e]	[b,d,e]	[c,d,e]
1	*	4	4	4	4	5	4	4	5	5

b. Based on these weights, combination [a,d,e] becomes the next best choice and is thus chosen. The scores for the remaining combinations are recalculated.

	[a,b,c]	[a,b,d]	[a,b,e]	[a,c,d]	[a,c,e]	[a,d,e]	[b,c,d]	[b,c,e]	[b,d,e]	[c,d,e]
1	*	4	4	4	4	5	4	4	5	5
2	-	2	2	2	2	*	3	3	3	3

c. Combination [b,c,d] becomes the next best choice and is thus chosen.

	[a,b,c]	[a,b,d]	[a,b,e]	[a,c,d]	[a,c,e]	[a,d,e]	[b,c,d]	[b,c,e]	[b,d,e]	[c,d,e]
1	*	4	4	4	4	5	4	4	5	5
2	-	2	2	2	2	*	3	3	3	3
3	-	0	1	0	1	-	*	1	1	1

d. Combination [a,b,e] becomes the next best choice and is thus chosen.

	[a,b,c]	[a,b,d]	[a,b,e]	[a,c,d]	[a,c,e]	[a,d,e]	[b,c,d]	[b,c,e]	[b,d,e]	[c,d,e]
1	*	4	4	4	4	5	4	4	5	5
2	-	2	2	2	2	*	3	3	3	3
3	-	0	1	0	1	-	*	1	1	1
3	-	0	*	0	0	0	0	0	0	0

e. As there are no more candidate sets, no more problems are presented.

The above example shows that out of the ten combinations, only problems of combinations [a,b,c], [a,d,e], [b,c,d] and [a,b,e] were chosen. As described previously, the human tutor would consider the student's previous performance and if any answers to problems were found to be wrong, he would assign problems at node 2 (see Figure 1). Conversely, if all the answers were found to be correct, he would assign problems at node 4 which require problems to be solved with exactly four skills.

The human tutor took the view that if a student has already tackled problems of three skills, whether he got them right or not, information gathered in packets of three skills need not necessarily apply to problems involving two skills. He considered that students may become anxious about problems which require more skills, and although some of the skills may well have been demonstrated in *easier* problems, the student may find it difficult to apply them in *harder* problems.

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7 Conclusion

The paper describes the development of an adaptive test in the domain of elementary arithmetic, which required two styles of knowledge acquisition. The first is concerned with describing problems and skills, and it is computer-assisted; whereas the second is entirely manual and is concerned with the ordering, or progression, of problems to be posed to the subject of a test. However, based on this experience, work is currently underway to develop software to aid with eliciting details of progression. A valuable insight gained is that some degree of formalisation of the problem, as well as being convenient for the knowledge engineer, is also acceptable to the expert who helped with this work.

A possible significant difference between the research reported here and the work reviewed in Section 2 is that the approach to progression is not restricted to a fixed collection of problems. In view of Lee' s findings [25], it would be inappropriate to enforce the equating of difficulty with the number of skills. Evidence encountered during the knowledge acquisition experience suggests that the sheer clerical complexity of mapping out sequences of problems, lead to some draconian simplification on the part of the expert. The task ahead, is to find an appropriate balance between convenience and efficiency.

References

[1] Vispoel, W. P., Rocklin, T. R., & Wang, T., "Individual differences and test administration procedures: a comparison of fixed-item, computerized-adaptive, and self-adapted testing", Applied Measurement in Education, 7, pp. 53-79, (1994).

[2] Collins, J. A., Greer, J. E., & Huang, S. X., "Adaptive assessment using granularity hierarchies and Bayesian nets", Proceedings of the Third International Conference on Intelligent Tutoring Systems (ITS'96), Montréal, Canada, June 12-14, pp. 569-577, (1996).

[3] Dowling, C.E. & Kaluscha, R., "Prerequisite relationships for the adaptive assessment of knowledge", Proceedings of the Seventh World Conference on Artificial Intelligence in Education (AI-ED'95), Washington DC, USA, August 16-19, pp. 43-50, (1995).

[4] Hirashima, T., Niitsu, T., Hirose, K., Kashihara, A., & Toyoda, J., "An indexing framework for adaptive arrangement of mechanics problems for ITS", IEICE Transactions on Information and Systems, E77-D, pp. 19-26, (1994).

[5] Khuwaja, R. & Patel, V., "A model of tutoring: based on the behavior of effective human tutors", Proceedings of the Third International Conference on Intelligent Tutoring Systems (ITS'96), Montréal, Canada, June 12-14, pp. 130-138, (1996).

[6] Wainer, H., "Computerized adaptive testing: a primer", NJ: Lawrence Erlbaum Associates, (1990).

[7] Rios, A., Millan, E., Trella, M., Perez-de-la-Cruz, J.L.,& Conejo, R., "Internet based evaluation system", Proceedings of the Ninth International Conference on Artificial Intelligence in Education (AI-ED'99), Le Mans, France, July 19-23, pp. 387-394, (1995).

[8] Huang, S. X., "A content-balanced adaptive testing algorithm for computer-based training systems", Proceedings of the Third International Conference on Intelligent Tutoring Systems (ITS'96), Montréal, Canada, June 12-14, pp. 306-314, (1996).

[9] Doignon, J. P. & Falmagne, J. C., "Spaces for the assessment of knowledge", International Journal of Man-Machine Studies, 23, pp. 175-196, (1985).

[10] Hockemeyer, C. & Dietrich, A., "The adaptive tutoring RATH: a prototype", Proceedings of the International Workshop on Interactive Computer aided Learning (ICL'99), Villach, Austria, (1999).

[11] ALEKS 2000, http://www.aleks.com (accessed on August 15 2000).

[12] Dowling, C. E., Hockemeyer, C., & Ludwig, A. H., "Adaptive assessment and training using the neighbourhood of knowledge states", Proceedings of the Third International Conference on Intelligent Tutoring Systems (ITS'96), Montréal, Canada, June 12-14, pp. 578-587, (1996).

[13] Villano, M., "Probabilistic student models - Bayesian belief networks and knowledge space theory", Proceedings of the Second International Conference on Intelligent Tutoring Systems (ITS'92), Montréal, Canada, June 10-12, pp. 491-498, (1992).

[14] Kambouri, M., Koppen, M., Villano, M., & Falmagne, J. C., "Knowledge assessment - tapping human expertise by the query routine", International Journal of Human-Computer Studies, 40, pp. 119-151, (1994).

[15] McCalla, G., Greer, J., Barrie, B., & Pospisil, P., "Granularity hierarchies", Computers & Mathematics with Applications, 23, pp. 363-375, (1992).

[16] Hirashima, T., Kashihara, A., & Toyoda, J., "Toward a learning environment allowing learner-directed problem practice - helping problem-solving by using problem simplification", Proceedings of the Third International Conference on Intelligent Tutoring Systems (ITS'96), Montréal, Canada, June 12-14, pp. 466-314, (1996).

[17] Matsui, T., "Optimization method for selecting problems using the learner's model in intelligent adaptive instruction system", IEICE Transactions on Information and Systems, E80D, pp.196-205, (1997).

[18] Carberry, S. & Clarke, J. R., "Generating clinical exercises of varying difficulty", Proceedings of the Sixth International Conference on User Modeling (UM97), Ch ia Laguna, Sardinia, Italy, June 2-5, pp. 273-275, (1997).

[19] Beck, J., Stern, M., & Woolf, B. P., "Using the student model to control problem difficulty", Proceedings of the Sixth International Conference on User Modeling (UM97), Chia Laguna, Sardinia, Italy, June 2-5, pp. 277-289, (1997).

[20] Payne, S. J. & Squibb, H. R., "Algebra mal-rules and cognitive accounts of error", Cognitive Science, 14, pp. 445-481, (1990).

[21] Lightfoot, J. M., "Expert knowledge acquisition and the unwilling expert: a knowledge engineering perspective", Expert Systems, 16, pp. 141-147, (1999).

[22] Clp(FD) 2000, http://www.sics.se/isl/sicstus/docs/latest/html/sicstus.html#CLPFD (accessed on August 15 2000).

[23] Chua Abdullah, S. & Cooley, R. E., "Using constraints to develop and deliver adaptive tests", Proceedings of the Fourth International Conference on Computer Assisted Assessment (CAA), June 21-22, Loughborough University, UK, (2000).

[24] McGraw, K. L. & Harbison-Briggs, K., "Knowledge acquisition, principles and guidelines", NJ: Prentice-Hall, (1989).

[25] Lee, F. L., "Electronic Homework: an intelligent tutoring system in mathematics", PhD Thesis, The Chinese University of Hong Kong, (1996).

[26] Marriott, K. & Stuckey, P., "Programming with constraints: an introduction", Cambridge, MA: MIT Press, (1998).

Cooperative Monitoring System using Mobile Agent

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This paper is a study on the design and implementation of the cooperative monitoring system using a mobile agent for an educational portal site. Generally educational portal sites have many addresses of teacher's homepage related education. Therefore, portal site has a very difficult task with maintaining a consistent address of site as well as it is impossible that administration of portal examines all dead sites in searching education site and DB. In order to solve this problem, we designed and implemented a mutual cooperative monitoring system to filter off dead site using a mobile agent. This monitoring system applies to the Korean educational portal site (KEPS) for elementary students and teachers. For efficiency this system, we made an experiment that compared a cooperative monitoring agent system with a stationary monitoring agent system.

Keyword: **Education Portal Site, Cooperative Monitoring System, And Mobile Agent**

1 Introduction

Today, the advent of the web that can easily be connected through the "Internet" is known to be an easy and popular method for teaching and learning. Web-based educational homepages are used in many computer assistance medias and also the numbers of educational sites are on the increase extremely.

An extremely increase in number of homepage raises a question whether a student can search appropriate homepage for learning. In case of finding educational contents using a general searching engines, the searched site can exist an irrelevant contents against a student's request. Moreover the result of searching content fell into learning confusion, because the contents are difficult to apply at learning intact.

In order to overcome this problem, an educational portal site was constructed to gather only educational homepages that had been made several times before. An advantage of educational portal site is that content is used correctly and rapidly in learning because searching site is well constructed. In addition student can easily get suitable contents. For gathering of an educational homepage, an educational portal system, called KEPS, was constructed by the EDUNET and Inchon National University of Education.

While walking past a type of the gathered homepage in KEPS, it can be seen as to make not by an expert institution or a special company but by a teacher and a private person. As a result, characteristic of the homepages have to be petty and is frequently updated. Because the educational homepage can disappear easily, portal site faces difficulty to maintain consistency of the site address. If a hyperlinked address of a portal site is not connected or the retrieval site is disappeared to user, then this portal site may bring discredit to student. In order to maintain consistency of portal, the administrator of portal site must validate all addresses of site. But this examination is impossible work that man completely manages and finds. Consequently, a monitoring of a site address for finding the dead site can be process by an intelligent agent instead of human.

A single agent needs comprehensive amount of time required for the monitoring of a portal site. If a single agent examines extremely a many site addresses, the monitoring work may be inefficient. Because a mobile agent is possible with decentralization and a parallel processing, the monitoring works using a mobile agent

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can be process effectively [5].

Accordingly, this study designed and implemented a mutual cooperative monitoring system to filter off dead site using a mobile agent. In the following section, the mobile agent and monitoring scheme will be surveyed and the overview of the structure of monitoring agent will be designed. And the next section will be focused on implementation and experimentation of monitoring agent system. Finally the conclusion and future works will be described.

2 Mobile Agent and Cooperative Monitoring

The agent is a program with intelligent characteristics to help the users with the use of computers and take the user's place. The intelligent agent perceives any dynamic stimulation or condition and interprets the data collected for a solution to the problem and exercises reasoning for a final decision. It also acts to change the conditions within its environment in order to perform assigned duties. It has autonomy, social ability, reactivity, pro-activeness and a cooperative relationship, learning, mobility, and so on [9].

Generally an agent divides a kind of two by the mobility, a stationary agent to be executed roles in single system, while the mobile agent is executed at various systems after moving through the networks. An execution example of the mobile agent is shown in figure 1 and the mobile agent based environment is viewed figure 2. The mobile agent server must be installed to act a mobile agent as figure 2.

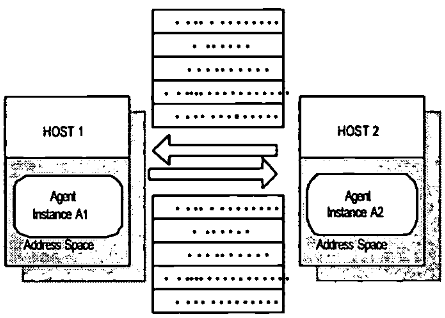

Figure 1. Execution of mobile agent

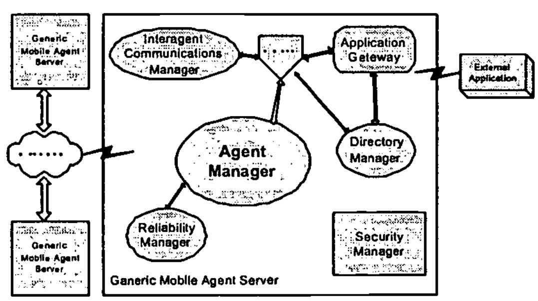

Figure 2. Mobile agent based environment

The mobile agent has a specific characters listed below compared with a stationary agent [5][6].

- The mobile agent reduces the network load.
- The mobile agent overcomes network latency.
- The mobile agent encapsulates protocols.
- The mobile agent executes asynchronously and autonomously.
- The mobile agent adapts dynamically.
- The mobile agent is naturally heterogeneous.
- The mobile agent is robust and fault-tolerant.

In the information retrieval, a monitoring work ascertains a state of gathering sites for the maintenance of data consistency. Generally, because the information of the web is changed frequently, a monitoring job by human is an impossible or inefficient work. This monitoring job can be processed by intelligent a computer program instead of a human. Such a program is called the web robot or an intelligent agent system [10][11].

In case of examining many sites in the monitoring work, if a single agent of the only server processes monitoring work, then the monitoring work may be needed long time and overloading of a monitoring server. The mobile agent has made possible cooperative and speedy monitoring job from distribution and parallel processing [8][11].

3 Cooperative Monitoring System

3.1 Overview of System

Overview of the KEPS system, including the temporary monitoring agent system is shown figure 3.

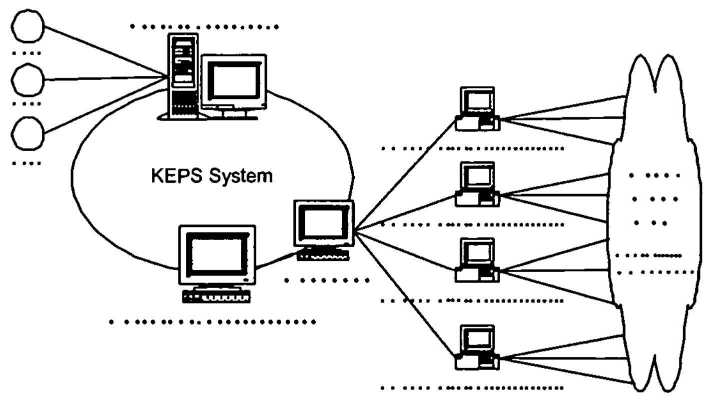

Figure 3. Overview of system

The portal system is consisted of four parts. There are the portal web server (PWS) and the monitoring agent server (MAS), the temporary monitoring server (TMS), a mediator. For using educational portal service, user must be connected with the Portal web server. Gathered address of an educational homepage is supported searching service of an education contents to user through the Portal web server. The Portal web server has searching engine, site DB and a query processor. The monitoring agent server has a stationary monitoring agent and a cooperative mobile agent, error DB, a mobile agent server. Also the monitoring agent server performs works as a creation and an allocation, a control, a gathering of the monitoring mobile agent. For the mobile agent perform it's task fully, each server is installed the mobile agent server necessarily.

The temporary monitoring servers are in existence out the KEPS system. In order to process a fast monitoring work, the TMS have function of distributed and parallel processing. The number of TMS is not fixed but dynamic by amount of monitoring job. Furthermore the TMS is used in temporary palace which mobile agent examines each a state of the registered site. At ordinary times, the TMS is not used usually for examining a state of the registered site. However the TMS can be only used when is requested by the mediator agent server.

The mediator is situated between the monitoring agent server and TMS, and acts as the role of mediation with the mobile agent and servers. All agents and agent servers must be registered in the mediator.

3.2 Design of KEPS System and Cooperative Work

The structure of the KEPS System is detail shown figure 4. The portal web server is consisted of searching engine and query processor, is shared the gathering DB of portal site. The searching engine provides searching service about education content and the query processor is shown the result searching at DB. The monitoring agent server is consisted of inference engine and agent manager, error DB. The monitoring system in monitoring agent server has a stationary agent and a mobile agent for distribution and parallel working. A stationary agent examines the state of gathering site and the confirmation of HTML documents through HTTP connection. After a failure sites are saved at temporary error DB, these will be deleted from site DB of portal web server. A permanent deletion of fail sites is executed by inference engine of the monitoring agent server.

When a monitoring agent server is overloaded or the stationary monitoring agent has difficulty processed by examination with many site, the monitoring agent server requests to the mediator about information of the registered TMS. If the number of the TMS is lacking, the monitoring agent server waits until the TMS becomes sufficient. Having sufficient number of the TMS, the mobile agent is created to divide as a suitable size of address by inference engine. And then the mobile agent has been created by a monitoring agent server, will be cloned with suitable number. Each mobile agent is allocated a monitoring work and will be dispatched to the TMS through ATP connection. The mediator agent can grasp each work states of an agent by using the agent finder.

Each agent is moved to temporary monitoring server and examines the allocated addresses of sites through HTTP. When a mobile agent is finished all checking of sites, it sends to the monitoring agent server with the result of observation. If the job of the mobile agent is occurred some problem, monitoring agent server creates a new mobile agent and re-dispatches to the TMS. All results gathers, result of examination saves at site DB and error DB. Finally, dispatching the agents retracted by the monitoring agent.

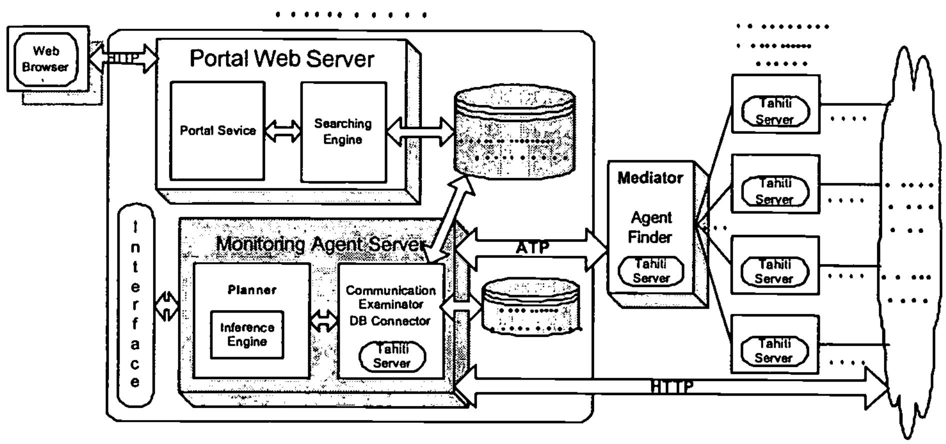

Figure 4. Structure of the KEPS system

The processing algorithm of execution about monitoring working is shown figure 5. The job of monitoring using the mobile agent has advantages that prevent an overloading of a single server and lessen monitoring time by distribution and parallel processing. Because agents are not used stationary server but are dynamically used in other servers, all servers performed share resources of monitoring system. Accordingly, each agent can do cooperative parallel processing using autonomous and society properties of agent.

4 Implementation and Experiment

4.1 Implementation and Application of System

The monitoring agent system proposed in this study was implemented two types. The stationary monitoring agent was implemented by using VC++ and CLIPS. Also the mobile monitoring agent system proposed in this study was implemented using JAVA based Aglet API and JESS. Aglet is the java class library for that can easily design and implement all the properties of the mobile agent. Moreover the Aglet provides with the Tahiti server and Agent finder for helping research of users.

The stationary monitoring agent interacts with the mobile agent of Tahiti server based environment. Inference engine of the stationary monitoring agent was used the CLIPS dynamic linked library and the mobile monitoring agent system was used the JESS class library. The CLIPS and JESS are rule based inference engine and was used to infer planning and allocation of the mobile agent. SQL was used for the gathering DB of portal site. ODBC and JDBC were used to connect the monitoring agent system and the gathering DB of site.

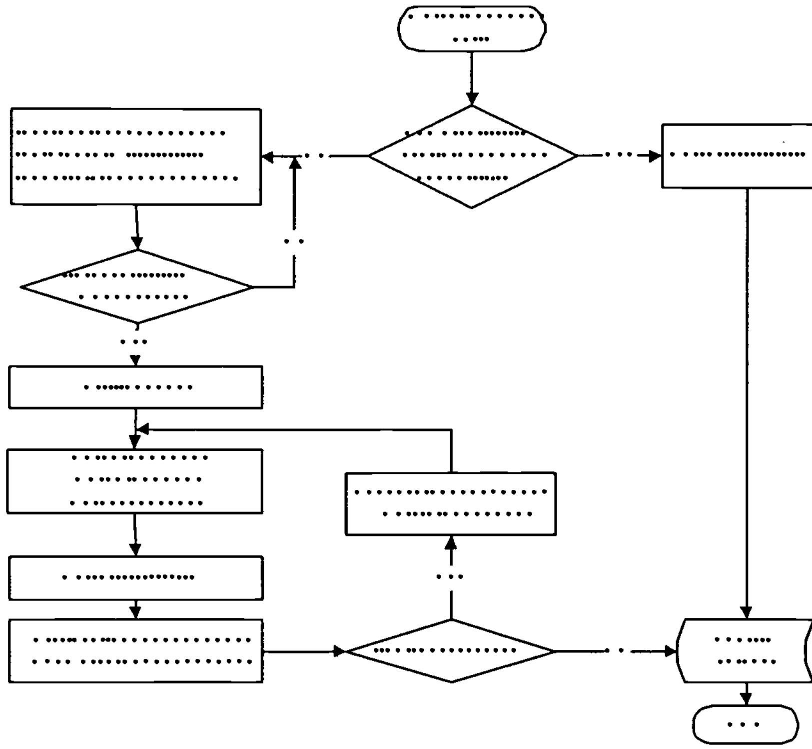

Figure 5. Algorithm of monitoring procedure

Figure 6 below is image of the interface of the stationary monitoring agent by making VC++. Figure is shown that the single monitoring agent is examining each site. The stationary monitoring agent was consisted of three parts mainly. The left screen of figure is represented list that the agent will examine site of DB. Also the center of screen is viewed results of a successful site and the right screen is represented results of a failure site.

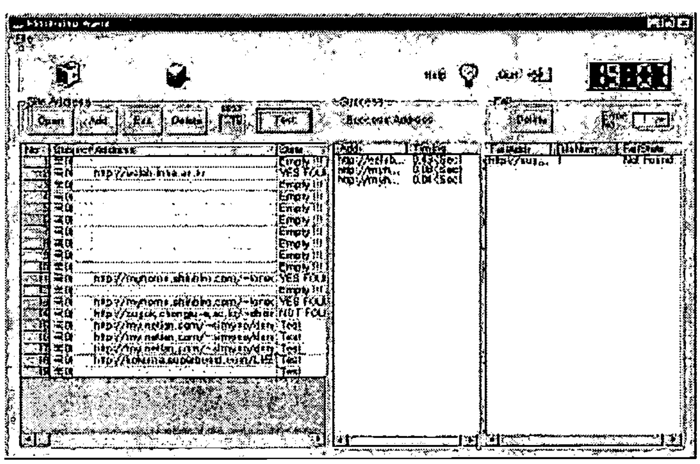

Figure 6. Stationary monitoring agent

Figure 7 is shown screen that the mobile monitoring agent is examining each site with distribution and parallel processing. If the numbers of sites are many in existence, the stationary monitoring agent executes the mobile agents to interact with the Tahiti server as followed image. Above window of figure is represented the stationary monitoring agent. Black screen below is viewed that mobile agent sever is executed by the stationary monitoring agent. Small screen below is shown the Aglet viewer. The Aglet viewer perform an important role as a creation, dialog, dispose, cloning, dispatching, retracting of a mobile agent.

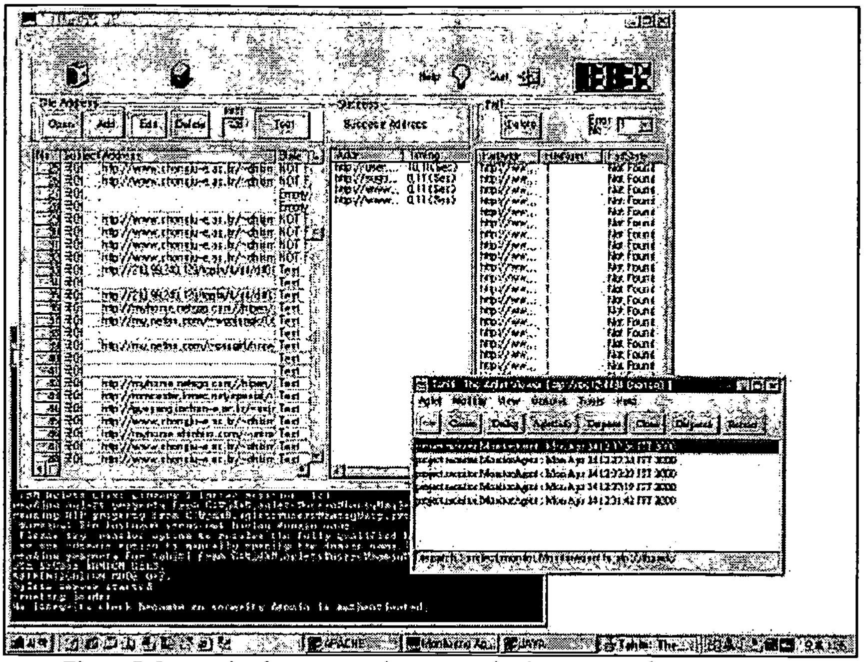
Figure 7. Interaction between stationary monitoring agent and Tahiti server

In order to use the implemented monitoring system in this study, we applied at the educational portal system and the KEPS system in the EDUNET server. Figure 8 is shown the searching screen of the web browser using KEPS system. This portal site in the EDUNET was constructed for the Korean elementary student and teacher. Also this site contains all contents about the curriculum of the Korean elementary school.

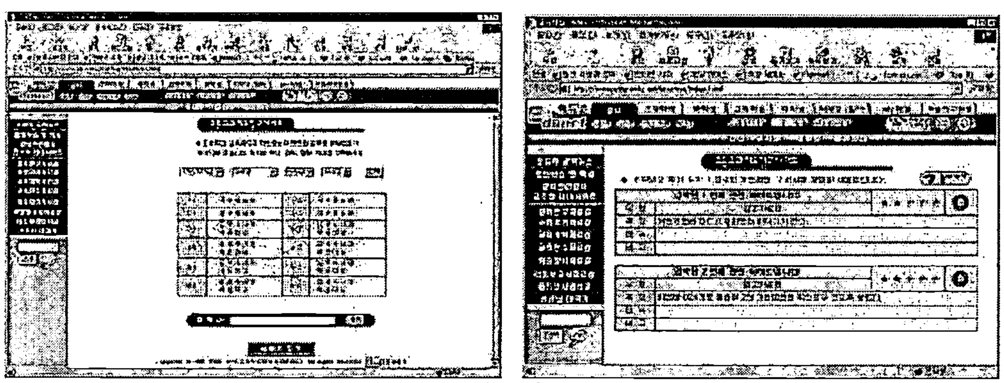
Figure 8. Searching of KEPS system

4.2 Experimental Results

For examining the efficiency of the cooperative monitoring system using the mobile agent, we compared and evaluated a monitoring time of each agent system. A comparative and estimative items listed below are as followed.

- Comparative item
  - *The single stationary monitoring agent vs. the cooperative monitoring agents.*
- Estimative items
  - *The monitoring time of the single monitoring agent*
  - *The monitoring time of the cooperative monitoring agents(3)*
  - *The monitoring time of the cooperative monitoring agents(7)*
  - *The number of sites: 10,30,50,70,90,110,130,150,170,190 ..etc.*

The experiment measures examination time of sites using a comparative and estimative items above. The estimative result is shown Table 1 and is represented figure 9 with form of graph. The horizontal axis of graph is represented the number of site and the vertical axis of graph is represented monitoring time of each agent.

In case of the number of an examine site is small, the result of experiment is viewed that the single stationary agent is faster speed of examination than the mobile monitoring agent. Also, when mobile agent is dispatched to three servers, speed of examination is faster than is dispatched to seven servers. The reason is caused by overtime occurred because the many mobile agents are created, allocated, gathered.

However, the more the number of site increases, the faster the mobile monitoring agent gets speed of checking than the single stationary agent. In particular, when the cooperative monitoring system using many agents, experimental result is shown that a speed of examination is very fast. If a single stationary agent processes very many sites, the result of execution can be useless though the result is very accurate.

Consequently, the cooperative monitoring agent can become higher execution speed by distributed and parallel processing and an overload of network by using a mobile agent can be decreased. If a server has an active environment of the mobile agent, the servers can be used with an active space of a searching agent and a monitoring agent.

Table 1. Result of monitoring time

Number of Agent / Agent Type	10	30	50	70	90	110	130	150	170	190
Stationary Monitoring Agent	42	137	201	261	374	412	518	592	645	743
Mobile Monitoring Agent(3 Servers)	120	132	143	165	221	253	262	282	316	335
Mobile Monitoring Agent(7 Servers)	130	121	124	122	148	143	147	183	186	182

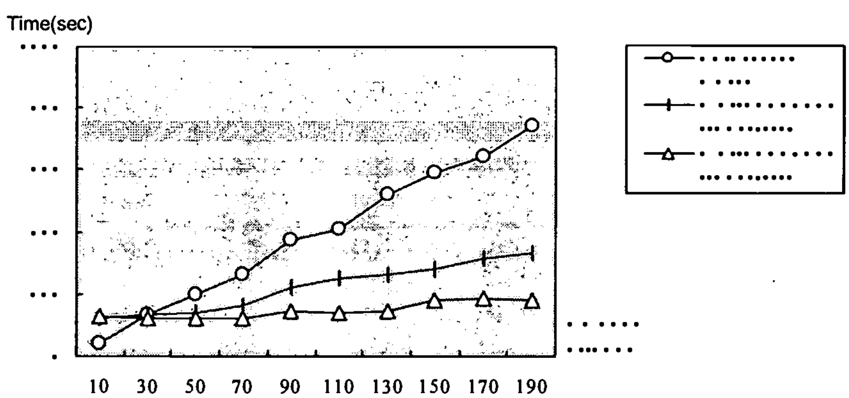

Figure 9. Graph of monitoring result

5 Conclusion and Future works

This study is on the efficiency of cooperative monitoring agent using mobile agent for educational portal site. The monitoring job has been getting difficulty processed by human. Thus, an intelligent agent can process the monitoring of the portal site instead of human. A monitoring work by using a single stationary agent needs long time for checking of many sites.

In order to overcome the problem in this study, the mobile agent is used in monitoring job. The monitoring job of educational portal site can be processed by collaborative method of decentralization and parallel using the mobile agent. The monitoring system was implemented by using the Aglet and Tahiti server. This system could execute cooperative monitoring job through an intelligent interaction between the stationary agent and a mobile agent. Also the KEPS system is possible with the mediation and the registration of agents by using the mediator agent between the monitoring server and the temporary agent sever.

The temporary agent sever is not fixed with the number but can be dynamically changed. Therefore all servers are by resources of monitoring job and each server can exe cute its role by inference.

More studies are required on research that constructs knowledge base for inference engine of the mobile agent. For effective portal site constructed, future work needs researches about not only intelligent monitoring but also intelligent searching and gathering of educational information. In order to interact between the mobile agents, we require research about KQML, language for sharing and exchange of knowledge between agent and agent.

References

[1] Akhil Sahai, Christine Morin INRIA-IRISA, • Mobile Agents for Enabling Mobile User Aware Applications• ; Just Research, 1998.

[2] Barbara Hayes-Roth. "An Architecture for adaptive intelligent agent systems", Artificial Intelligent, Vol 72, pp.329-365, 1995.

[3] Bryce L. Allen, Information Tasks: Toward a User-Centered Approach to Information Systems:, Academic Press, San Diego, CA, 1996.

[4] B.Venners,"Solve Real Problems with Aglets, a Type of Mobile Agent", Java World, www.javaworld.com/javaworld/jw-05-1997/jw-05-hood.html.

[5] Chang, D., Lange, D. "Mobile Agent: A new paradigm for distributed object compuing on the WWW. In Proceedings of the OOPSLA96 Workshop: Toward the Integration of WWW and Distributed Object Technology, ACM Press, N.Y., pp 25-32, 1996.

[6] Danny Lange and Mitsuru Oshima "Programming and Deploying Java Mobile Agents with Aglets", Addison-Wesley Longman, Mass., 1998.

[7] David Pallmann, "Programming Bots, Spiders, and Intelligent Agents in Microsoft Visual C++", Microsoft Press,1999.

[8] J.White, "Mobile Agents," in Software Agents, J. Bradshaw, ed., MIT Press, Cambridge, MA,1997.

[9] M. Wooldridge, M., Jennings, N. R., "Intelligent Agents: Theory and practice. The Knowledge Engineering Review, 10(2)", Springer-Verlag, pp 115-152, 1995.

[10] Ricardo Baeza-Yates, Berthier Ribeiro-Neto, "Modern Information Retrieval", Addison-Wesley, 1999.

[11] R. Tolksdorf, "Intelligent Information Agent: On Coordinating Information Agents and Mobility", Springer-Verlag, pp 396-411,1998.

Development and Evaluation of a Mental Model Forming Support ITS

- the Qualitative Diagnosis Simulator for the SCS Operation Activity-

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In this study, we built an educational qualitative diagnosis simulator, which models SCS (Space Collaboration System: system the remote conferences and education via satellite communications) conferences. A student engages in the conference, by operating a control panel and proceeds by making the necessary selections according to the agenda of the virtual conference, and its intention and purpose, which can change at any time. The purpose of this study is supporting the student to form a correct mental model in this environment. Therefore, we incorporate an abstract model of possible computations as a logical circuit attached to the SCS system. Using this model, the system has two functions: to diagnose the student' s conceptual understanding mistakes about the SCS system and to explain to him/her the cause of these mistakes. With these functions, we expect to be able to support the student in forming a correct mental model and in understanding the SCS essentials.

Keywords: **Mental Model, Space Collaboration System, Remote Conference**

1 Introduction

Recently, with the increased awareness of the necessity of individual, subjective learning, a change occurred in the building of computer based educational systems. The existing learning supporting systems are based on automatically generating the learning method, according to the relation between the state defining parameters and the subject' s (learner' s) behavior. However, in recent years, the trend to construct systems, that positively encourage the student to work, and allow him/her to change the current state parameters by him-/herself, offer system behavior simulation, moreover, verification and correction of the student inputs, emerged. In this type of subjective/ individual learning environment, it is necessary to add a causality explanation function of the target environment. This is important due to the fact that, by letting the student/ learner adjust and change the system parameters, and then showing him/her the system behavior simulation, as derived from the current configuration and structure, fundamental system comprehension can be supported and achieved [2..11]. We have, therefore, used the above mentioned specifications and background information, to implement an educational qualitative diagnosis simulator, for supporting fundamental system comprehension and understanding. For this purpose, we have based our mental model design on the object oriented approach. The mental model is a representation of the individual comprehension about the structure and functions of the objects involved in the simulated system model. Moreover, depending on the simulation of the object functions within the learner' s mental model, it becomes possible to predict the problem solving act results. Therefore, important learning can occur and, at the same time, causality explanation within the virtual learning environment can be offered. We based the mental model used in our system on the qualitative modeling. The qualitative model is a fundamental model representation based on the causality relations that generate the target system' s behavior. The causality relations are reflected in the relations between the system' s structure, behavior and functions. Here we consider the following definitions. The **structure** reflects how the elements of the target organization are combined. The **behavior** shows how the system characteristics, expressed by the object structure, change in time. The **function** expresses how the goal, related to the object behavior, is achieved. By modeling the causality relations between the system' s structure, behavior and functions, and designing a qualitative model, the causality relation simulation becomes possible. In our system, we have constructed a qualitative diagnosis simulator for conferences via SCS. SCS, standing for Space Collaboration System, is a remote conferences and distance education system via satellite communications. The learner/ student follows the progress of the conference, by operating a control panel, and making the necessary selections, according to the agenda of the virtual conference, and its intentions and purpose, which can change in time. In this environment, we integrate a computable model abstraction of the remote conference via communication satellites, as a logic circuit. Moreover, based on this abstraction, we add a causality explanation function, and a diagnosis system of the student' s/ learner' s operation mistakes, which generate the appropriate guidance information for the student. In this way, we support the fundamental comprehension of the SCS system.

2 Qualitative reasoning

Qualitative reasoning is one of the most vigorous areas in artificial intelligence. Over the past years, a body of methods have been developed for building and simulating qualitative models of physical systems (bathtubs, tea kettles, automobiles, the physiology of the body, chemical processing plants, control systems, electrical circuits, and the like) where knowledge of that system is incomplete. Qualitative models are more able than traditional models to express states of incomplete knowledge about continuous mechanisms. Qualitative simulation guarantees to find all possible behaviors consistent with the knowledge in the model. This expressive power and coverage are important in problem-solving for diagnosis, design, monitoring, and explanation. Qualititative simulation draws on a wide range of mathematical methods to keep a complete set of predictions tractable, including the use of partial quantitative information. Compositional modeling and component-connection methods for building qualitative models are also discussed in detail [1].

3 SCS

Figure 1 displays the SCS based remote conference concept. SCS was established as a satellite communication network between universities, to enable real-time remote video conferences. Each participant' s station (called VSAT station) is enabled with a satellite communication control panel, an image and sound transceiver control panel, multiple video-cameras, monitors, and so on.

3.1 SCS constrains and limitations

The SCS conference can take place as an inter-station, bi-directional communication between two stations, or as a mult iple VSAT stations communication, where only one station has the role of the moderator, and has authority upon transmission control. In the latter case, all the other station, with the exception of the moderator station, are called client stations, and can participate as such in the conference. The moderator station is decided in advance, before the actual conference, by the conference organizer, according to the requested time-schedules and conference contents. The line control is usually under the sole authority of the moderator station. However, a client station can send a request for line usage for transmission to the moderator. This operation is enabled by the proposal request button existent on each VSAT station panel. By pushing this button, a proposal request notification is sent to the control panel on the moderator station. Moreover, during the conference, it is possible for two different stations to send image and sound, namely, the carrier, at the same time, so there can be up to two distinct proposing stations. The respective client stations are depicted in the lower part of figure 1.

The communication satellite has two reception parts, and a converting switch that allows the selection of the received carrier. Depending on the existing constrains and conditions, a decision mechanism is involved, before actually sending the carrier selection from the satellite. After verifying the current constrains and conditions, the carrier is sent from the satellite. This carrier is sent without exception to all client stations. In figure 1, the sending of the carrier to all the client stations is depicted. The station carriers depicted in figure 1 as a black solid arrows show the connection between the individual stations and the transmission part of the satellite. The figure shows also that the satellite receives only two carriers at a time. However, as all stations are connected with the satellite, as depicted by the solid black arrows, all stations are prepared to send a carrier.

The satellite reception part is built of a receptor, and a converting switch. In this way, by means of the restrictions set by the converting switch receptor, the satellite can receive, all in all, only two carriers. Moreover, these have to be from two distinct stations only. Also, in the case of multiple carrier reception, the moderator station operator can decide, according to his/ her free will, to commute to the receiving of one carrier only, disregarding the choices and modes of the client stations. These constrains, limitations and specifications, and the fact that the client stations can all in all send only two carriers, are depicted in the figure as dotted thick arrows. The two carriers that can be sent are named [send 1] and [send 2]. Their contents is re-sent from the satellite. The restriction that the two carriers, [send 1] and [send 2], should not come from the same station is enforced before this re-transmission. Only when al the above restrictions are fulfilled, can the received carriers be broadcasted from the satellite to all stations. At the reception of the broadcast signals, each client station can separate the two carriers, [send 1] and [send 2]. The station sending the carrier is also receiving the broadcast, without exception. Therefore, the sound and image received by the transmitting stations are:

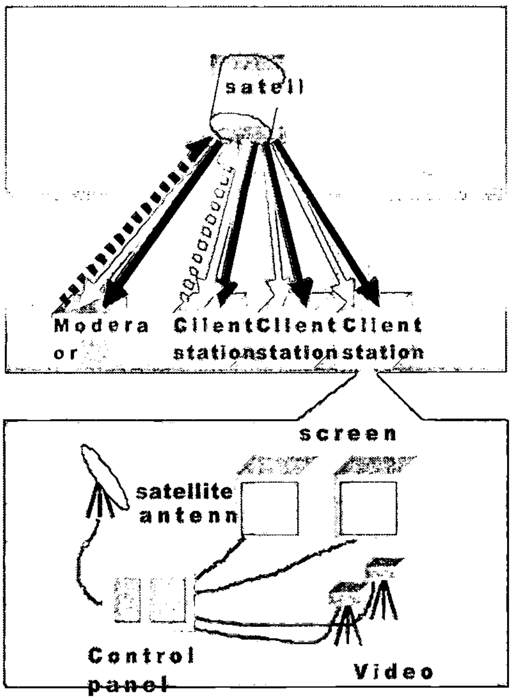

Fig. 1 Conference with SCS

(1) image+sound from the other transmitting station (if existent);
(2)the image and sound sent to the satellite by the station itself.

Moreover, as it is impossible to send the image and sound carrier to a specific station directly, by sending them to the satellite, they are broadcasted automatically to all stations. Bi-directional communication is also possible, but is actually a quasi-bi-directional communication, as the broadcast carrier of the two communicating stations is sent, at the same time, as a broadcast signal to all client stations.

3.2 SCS system frequent user errors

In table 1, the error types for different user skill levels of SCS conference practice, as gathered by surveying 4 domain specialists with over 2 years of SCS system operation experience, is shown. They were asked to give us first a list of frequently appearing user errors during the SCS usage and managing. This list is displayed in table 1 in the column headed by the label "Error/ misconception". Next, they were asked to evaluate the frequency of apparition of these errors for beginner, medium and advanced user. In table 1 their replies were represented as follows: [•] means high, [• •] means medium, and [•] means low frequency of errors. The table presents therefore the specialists' primary classification of errors according to the operation skills. To this classification, we have added a new error classification, based on the previously explained SCS system constrains and limitations. We have managed to group all errors enumerated by the specialists into four big classes of errors and misconceptions: A, B, C and D. The definitions of these classes are given below.

Table 1 Error types

Error/ misconception	beginner	medium	advanced	Error classification
Disregarding the function of the satellite• • believing direct/ dedicated transfer between fellow stations is possible.	• •	• •	• •	A,B,C, D
Believing that the sending of two carriers from the same station is possible.	• •	• •	• •	A
Believing that receiving two carriers from the same station is possible.	• •	• •	• •	A
Not understanding that, by switching the carrier to a different station, the current proposing	• •	• •	• •	B

station carrier will disappear.				
Believing that all stations can send a carrier at the same time.	. .	. .	. .	C
Not understanding the concept and necessity of the carrier request proposal.	. .	. .	. .	C
Assigning carriers to three or more stations.	. .	. .	. .	C
Not understanding why the image and sound signal sent by ones own station is received again.	. .	. .	. .	D
Believing that bi-directional communication is possible only with a specific station.	. .	. .	. .	D
Assigning the carrier to each station consecutively.	. .	. .	. .	D
Believing that only one broadcast is possible.	. .	. .	. .	D
Not making the distinction between the moderator station and the other client stations.	. .	. .	. .	static state
Believing that the client station is in charge of the transmission control.	. .	. .	. .	static state
Not making the distinction between the two wave forms (signals), [send 1] and [send2].	. .	. .	. .	static state
Believing that the [send 1] wave form is the signal coming from the moderator station.	. .	. .	. .	static state

Class A: Misconception/ incomplete information about the sending of two different waves/ signals with the help of the judgement/ decision mechanism.
Class B: Misconception about the sending of one carrier to one station with the help of the converting switch.
Class C: Misconception/ incomplete information about the receiving of two carriers.
Class D: Misconception/ incomplete information about broadcasting to all stations.

4 The SCS qualitative model

Figure 2 shows the qualitative model of the SCS conference abstraction, in the form of a logic circuit. This qualitative model can express the structure, behavior and functions of the SCS system. In this figure, we displayed four client stations and one communication satellite. As can be seen, the satellite has two receptors, and one judgment/ decision mechanism, as a converting XOR switch between the two receptors. The two client stations sending carriers at one time can therefore have a pseudo- bi-directional communication. The structure, behavior and functions, so, the objects of the original SCS system are expressed, in this way, as a qualitative model.

The characteristics of this model make it possible to simulate the dynamic changes occurring during a distance conference, allowing to decide and evaluate the proper parameter settings for each station, moreover, to simulate the system behavior in the case of mistaken parameter settings. By using the XOR function, it is ensured that each reception part of the communication satellite can receive only one carrier from only one station. This station has sent a prior transmission proposal to the moderator station, which was accepted.

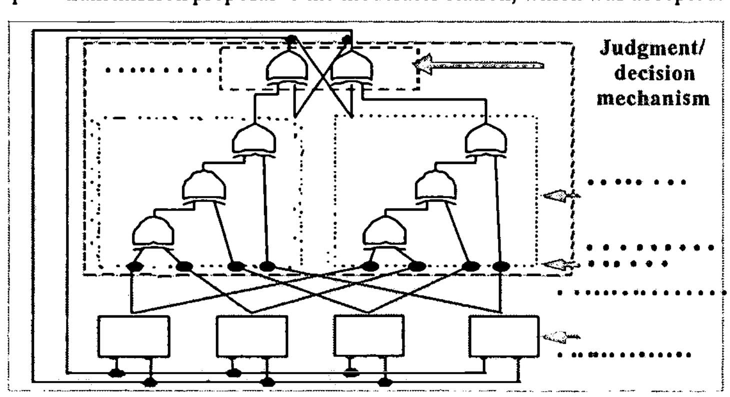

Fig 2 The qualitative model of the • • • system

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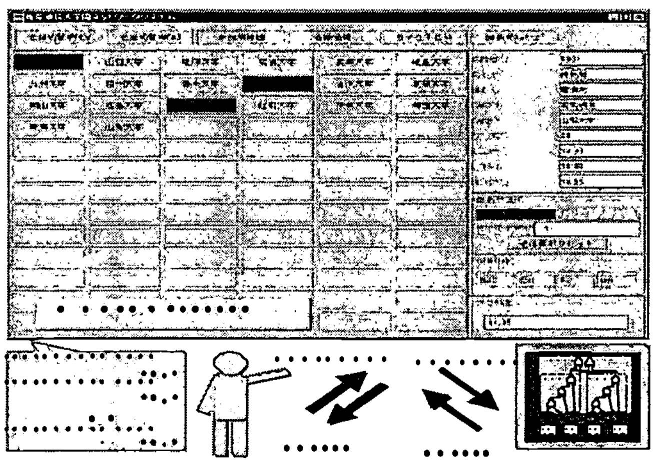
Next, it is necessary to make sure that the two accepted carriers come from two distinct stations. This restriction is enforced by the judgment/ decision mechanism. The judgment/ decision mechanism eliminates via an extra XOR function the possibility that the two carriers were sent by the same station. If the two carriers, 1 and 2, are validated by the judgment/ decision mechanism, the communication satellite broadcasts one or both to all VSAT stations. Therefore, all VSAT stations will receive the two carriers 1 and 2 and will not be able to receive any other carriers from other stations, or any wrong transmissions. Moreover, by using this model it is possible to infer the error source, as shown previously, based on the SCS system structure. The previous A, B, C, D classification can be thought of as: (A) sending of two distinct waves by using the judgment/ decision mechanism, (B) sending of maximum one carrier per station by means of the converting switch, (C) using of two carriers by means of the satellite reception mechanism, (D) existence of broadcast type of transmission only. In this way, the virtual model enables the learner to derive the cause and source of the operation error, as related to the SCS system structure. Furthermore, we have presented here a model based on only 4 client stations, that is implemented via the XOR module, but as in the case of more than 4 client stations, we can increase the number of the reception part XOR modules, adapting them to the number of stations, we can express, cope with and model therefore the converting switch for any arbitrary, greater than 2 number of client stations.

5 Learning Environment

5.1 System outline and overview



Figure• ·Learning environment

Figure 3 shows the overview of the system. The learner/ student is performing the conference steps by taking over the role of the moderator station operator. The goal is to cope with the dynamically changing agenda of the conference, proposed by the system. The agenda presents a description of a dynamic conference state, where bi-directional communication is required. The student can take decisions about the SCS system state and change parameter by operating the control panel. The previously described qualitative model evaluates these settings and parameters.

Next, disregarding if the parameter setup and assignment is appropriate or not, the result of the new user choices is reflected on the control panel of the interface, changing the current representation. The control panel displays also the transmission requests coming from other stations. The student has to choose the appropriate response to these requests. The student has to be able to judge the appropriateness of his/her own operations and actions, by interpreting the information presented on the control panel. By repeating the above steps, the student can learn the constrains and usage of the SCS system. Moreover, to prevent deadlock situations, where the student is unable to judge his/her own errors, due to misunderstandings regarding the SCS system constrains, an explanatory function was added. This is implemented via an explanation button, which can be pressed by the student in need. The student guidance follows as has been previously shown, conform with the SCS qualitative model. In this way, the student can achieve not just a quick, superficial understanding, but also a deep, structure related knowledge about the SCS system. For example, explanation are given such as: "There are only two satellite receptors.", "There is an exclusive OR switch on each receptor, so each receptor can receive from one only station at a time.", "The judgment/ decision mechanism does not allow 2 carriers from the same station.", and so on. By leading the student to understand the connection between the parameter setup and the way the SCS system is actually built, as well as the real system components and the relations between them, via messages and state representations on the control panel, the student can be expected to perform the parameter setting by him/herself successfully in the future.

5.2 System flow

Figure 4 shows the system flow. The rapidly changing conference goal and intention of the agenda is described in chronological order. The contents of this description are on one hand, the conference state change requirements that have to be performed by the student, put into words that can be easily understood by him/her, and on the other hand, the description of the current SCS system state. In figure 4, this is expressed as [word] utterances, at the different moments in time (t0, . ,. tn):

word : state(t0) ~ word : state(tn)

For example, [word] can be a prompting message about the conference state change, with the value of "Please reply to the question from university A!", and so on. As shown in figure 4, the operation panel managing module receives from the agenda, or from the other client stations the current parameter for each given conference state, and then reflects the resulting state on the panel. For example, the button of the station, which is currently in charge of a carrier, turns red. Also, in the case of requests from other stations, the button of the station sending the carrier request signal turns also red.

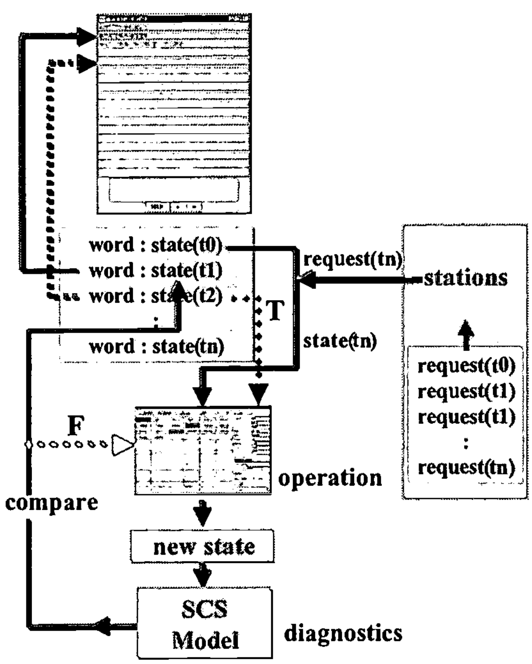


Figure 4 System flow

The student infers the present conference state from the state of the panel. Moreover, from here the student can notice if it is necessary to change the state of the conference, according to the agenda requirements. Next, to change the conference state, the student has to operate the control panel. By doing this, the parameters determining the conference are changed, and a new conference state emerges. This new state is evaluated with the SCS qualitative model. When evaluating with the SCS model, the result is compared with the next agenda. It is, in principle, possible to perform such comparisons on the SCS system without the computable module, and to judge if the operation is appropriate or not, but, in that case, the student cannot achieve a deep understanding of the SCS conference, that is, s/he cannot identify the SCS behavior as derived from structural constrains. In order for the learner to achieve a deep understanding, it is necessary to perform the parameter evaluation with the help of the SCS computable model. After the parameter evaluation, if the settings are judged as appropriate, the system moves to the next agenda. In figure 4, this is the case of "T" (True). In this case, the setup parameters decided by the student are handed over to the administrating module, which, in turn, reflects these changes on the operation panel. On the other hand, if, after the parameter evaluation, the settings are judged as not being appropriate, the system does not move to the next agenda. This case is shown in figure 4 as the "F" (False) case. In such a case, the wrongly set parameters are displayed on the operation panel. In this way, the deficient, real SCS state can be represented.

For example, in the case when three or more stations ask for the carrier at the same time, and the carrier is passed over to them, the moderator station's carrier disappears. The student notices that the respective state is not appropriate, and corrects the setup parameters. Moreover, in the case that s/he doesn' t notice the errors, s/he cannot continue with the next agenda. When entering a deadlock situation, the SCS qualitative model can, at the student' s request, explain to the student what kind of error s/he has done. In this way, by explaining not the protocol and process steps, but the SCS system behavior, as a result of the structural constrains, our system supports the formation of the SCS learner mental model. For instance, let us consider a case where the present transmission rights belong to universities B and C, and a proposal request is received from university A. This request is represented on the panel by the button representing university A turning red, together with a simultaneous indication message appearing in the agenda window, stating "Please answer the question from university A". If the student decides to assign a carrier to university A, without previously modifying the state of one or both stations B and C, which have the current transmission rights, the result is that the system will have 3 or more simultaneous carriers at the same time. In this case, the system represents the buttons of universities A, B, C on the panel with red color, and lets the student therefore know that the parameter setup is not appropriate.

At the same time, the agenda window will also display a message for the student. The content of this message is something like: "There are only two receptors on the satellite.", so is an explanation of the behavior, as resulting from the structural constrains.

6 Agenda

Table 2 Agenda example

agenda(t0)	The conference starts.
agenda(t1)	The moderator station is the University of Electro-Communications.
agenda(t2)	Please allocate carrier • •to Yamagata University• •
agenda(t3)	Please start sending from the lecturer camera• •
request(t4)	Carrier request • Tsukuba University• •
agenda(t4)	Please reply to the question from Tsukuba University• •
agenda(t5)	The conference has ended• •

The SCS conference is based on a general agenda. Our system offers SCS based remote conference simulation environment and, moreover, stores typical SCS agenda models, in order to dynamically produce conferences that require conference state changes.

In this way, the student becomes the operator of the moderator station, and has to take decisions compatible to the agenda, engaging therefore in the simulated steps of the SCS conference. In table 2 we show an example of a model agenda for our system. In this table, agenda(tn) represents the agenda at moment (tn) in time, and request(tn) represents the carrier request at moment (tn) in time. In the real SCS conference, the time moment concept exists, but, in our system, we have the supplementary restriction that, only after accomplishing the current agenda, it is possible to go on with the new one. As shown above, the agenda is organized as a time series, and the student receives indications and instructions from the agenda window. The changes occurring in the conference state in the respective agenda example above correspond to a respective intention and goal. Disregarding if these intentions and goals come from the original operator's decisions, or if they were prepared by the system from the beginning, the beginner student doesn't have to loose his/her way during the SCS conference proceedings, and can give the panel operation his/her undivided attention. In other words, the indications and instructions coming from the agenda window can be thought of as an experienced operator teaching the beginner student during the SCS conference proceedings. After receiving the indications and instructions from the agenda window, the student can decide on the next conference state that seems appropriate, given the present conference state and the indications received, and operates the control panel to perform the respective change. The new state that results as a consequence of the student's operations is checked by the system, to decode if it is appropriate or not, conform with the indications and instructions of the agenda. One agenda is recorded in the system as one word and 6 state descriptors. The words are the ones that appear in the agenda window. The six possible state descriptors are shown below.

- *station name (list of all client stations)*
- *carrier request (list of all client stations)*
- *carrier 1 (list of all client stations)*
- *carrier 2 (list of all client stations)*
- *reception 1 (list of all client stations)*
- *reception 2 (list of all client stations)*

The state descriptor called "station name" contains a list of all client station names. Next, the carrier request, carrier 1, carrier 2, reception 1 and reception 2 state descriptors contain respective lists of [on] and [off] states corresponding to each station. In figure 3, we show the correspondence between [1] and [0] and [on] and [off]. The reason of describing all client stations carrier and reception states with [off/on] descriptors is to be able to represent also the incomplete understanding of the learner/ student, as well as his/her mistaken parameter setups and assignments.

7 Testing, experiments and evaluation

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Table 3 comparison of situation before and after learning takes

Error	Pre Test	Post Test	Error classification
Disregarding the function of the satellite and believing direct/ dedicated transfer between fellow stations is possible.	N/A	N/A	A,B,C,D
Believing that sending of 2 carriers from one station is possible.	3 persons	1 person	A
Believing that receiving two carriers from the same station is possible.	3 persons	1 person	A
Not understanding that, by switching the carrier to a different station, the current proposing station carrier will disappear.	5 persons	1 person	B
Believing that all stations can send a carrier at the same time.	3 persons	3 persons	C
Not understanding the concept and necessity of the carrier request proposal.	5 persons	1 person	C
Assigning carriers to more than three stations.	5 persons	1 person	C
Not understanding why the image and sound signal sent by ones own station is received again.	5 persons	3 persons	D
Believing that bi-directional communication is possible only with a specific station.	5 persons	1 person	D
Assigning the carrier to each station consecutively.	5 persons	1 person	D
Believing that only one broadcast is possible.	5 persons	5 persons	D

We have performed an evaluation experiment of our system over a small sample. 5 beginner students with no SCS system experience were selected as the object of our SCS conference experiment. We have first explained them the control panel representations, meanings and operation mode, as well as the agenda window functionality, and the SCS system setup as a bi-directional communication system. They were able to consult the SCS user manual. Next, we have done a pre-test with the system without the diagnosis mechanism, and followed and checked the operations and mistakes of the beginner operator. Then, we have performed the same experiment, this time, with the help of the diagnosis mechanism. In the last step, we have compared the understanding level before and after learning. The result is displayed in table 3. A system screen display during the experiment is shown in figure 3. This figure displays a student deadlock situation, where the student has asked for an explanation about the deadlock, and the system has next checked the SCS system structure related error cause, and finally displayed it on the screen for the student to see. In the case presented in figure 3, the student hasn't realized the fact that there are only two receptors on the satellite, and has mistakenly allocated carriers to 3 stations. The explanation of his/her error is displayed on the control panel. The state of 3 stations having the carrier is represented on the panel as the respective stations' buttons turning all red (left corner of fig. 3, darkened buttons). However, if the student doesn't grasp the meaning of the representation and the cause and source of his/her errors, and asks therefore the system for help, the system will display the following message: "There are only two receptors on the satellite". With this explanation, the student understands that, as there are only 2 receptors on the satellite, s/he cannot allocate carriers to 3 stations, and will operate the panel correctly in his/her next steps.

According to our system's result shown in table 3, the students can understand the SCS system constrains and limitations, the fact that the signal has to be sent from different stations, the fact that there are only two carriers, and the concept of the XOR receptors of the satellite. However, the broadcasting mechanism was not completely understood. This is probably due to the fact that, in the current simulation system, there is no visual display of the broadcasting mechanism, of the time and direction of the transmission.

7 Conclusion

In this paper, we proposed an educational qualitative diagnosis simulator based on an object-oriented approach to mental model formation. In our model, the structure, behavior and functions of the SCS system are the objects, and from the description of the causality relations between these objects, the student can determine the cause of his/her error, based on system structure judgment.

From educational strategy point of view, QUAD implements and supports a combination of learning methods, like "Reinforcement learning", "Learning by exploring", "Learning by asking", "Learning by applying", "Self-monitoring", and so on. From educational depth point of view, the QUAD system doesn' t stop at the procedural surface level, but traces the structural implications, to gain a deep knowledge level.

For further research, we believe that, by expanding the current system, and identifying more precisely the mental model of the student, a more appropriate guidance system can be developed.

References

[1] B. Kuipers; Qualitative Reasoning: Modeling and Simulation with Incomplete Knowledge, Cambridge, MA: MIT Press (1994).

[2] T. Okamoto• O. Matsuda; About the mental model of the ITS based geometrical/ topological proof process, Japanese Journal of Education and Technology,Vol.4, No.15, pp.167-182 (1992)

[3] O. Matsuda, T. Okamoto; based on hypothesis inference/ deduction : about the ITS - student model and its recognition method, IEICE conference, A, Vol. J75-A, No.2, pp.266-274 (1992)

[4] T. Okamoto; Knowledge Processing Technology and Educational Engineering, Japanese Journal of Educational Technology 20(4), pp. 207-226, (1997)

[5] T. Nishida; The basis of qualitative inference/ deduction, Journal of the AI society, Vol.4,No.5,pp.522-527,(1989)

[6] T. Okamoto; Education, Media and Artificial Intelligence, Journal of the AI society, Vol.10,No.3,pp.361 – 367 (1995)

[7] T. Okamoto; Knowledge Processing Technology and Educational Engineering, Journal of the AI society, Vol.20, No.4, pp.207 – 226 (1997)

[8] T. Nishida; The common sense thinking way model of qualitative inference/ deduction• •Journal of the AI society, Vol.2, No.1, pp.30 - 43,(1989)

[9] T. Nishida; Towards applications of the thinking ways and intelligent problem solving techniques of qualitative inference/ deduction• •Journal of the AI society, Vol.32, No.2, pp.105 • •117 (1991)

[10] T. Nishida; Aspects of qualitative inference/ deduction, Asakura publishers (1993)

[11] K. Asai, H. Ohnishi, K. Kondo, K. Tanaka, O. Matsuda; Case base and Collaboration Application based on appropriate• • •(control) and the Internet system, technical Report of IEICE, ET97-24 (1997-05)

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Domain Specific Information Clearinghouses – A Resource Sharing Framework for Learners

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The World Wide Web has presented researchers and learners all over the world with unprecedented opportunities to find and distribute information. An increasing number of valuable resources are made available online. This provides an excellent knowledge base for learners. However it is often very difficult to find these useful resources. This paper describes the framework of a domain specific information clearinghouse and how these clearinghouses can collaborate with one another to enable cross-domain learning. The resources in a domain-specific clearinghouse are submitted by trusted domain experts to ensure its quality. Learners with multiple domain interests can also effectively retrieve the information they need using the cross-domain collaboration framework presented. This is achieved with a union agent that manages the collaboration and sharing of resources between different domains. We also present a toolkit that facilitates the rapid deployment of such clearinghouses by domain experts.

Keywords: **Collaborative Learning, Educational Agent, Knowledge Construction and Navigation, Web-Based Learning, Domain Specific Information Clearinghouse**

1 Introduction

The tremendous success of the Internet and the World Wide Web has resulted in a global information revolution. With more and more information easily available online, people are now increasingly reliant on the Web for their information needs. They are constantly faced with the problem of finding relevant information that will suit their learning needs. Most commonly used tools for finding information, in particular search engines and Web directories, often return huge amounts of information which are neither useful nor relevant to the learners' needs. A more effective way of assisting these learners in finding information is lacking.

A possible solution would be the use of a domain-specific information clearinghouse managed by human domain experts. In a nutshell, a *Domain Specfic Information Clearinghouse*, or *DSIC*, is a Web-based clearinghouse and resource repository for information resources available on the Web. Learners would be able to find relevant and higher quality information from these resources. However, most information and research nowadays do not dwell on a single domain. Cross-domain learning requirements need to be met. This can be achieved through collaboration between multiple DSICs. With this cross-domain collaboration, we are able to discover and learn more about how each domain is related to one another.

In the following sections we will discuss the various approaches that are currently adopted by learners and the concept of the Domain Specific Information Clearinghouse. Section 4 describes the framework of a Domain Specific Information Clearinghouse network to facilitate cross-domain learning. In Section 5, we describe a toolkit currently under development for the quick deployment of a domain-specific information clearinghouse. Finally, we would conclude with Section 6.

2 Current Approaches for Finding Information Online

The primary means by which learners find information on the Web are tools like search engines, Web directories and metasearch engines [1] [5].

Search engines operate by plowing through the Internet and indexing web pages. Typically, only keywords are indexed. Some examples of search engines are AltaVista[1] and Hotbot[2]. Using this method, a lot of information can be retrieved. However, there is a trade off between quantity and quality. In this huge list of results, though it may contain many relevant items, most of the search results are usually irrelevant. Learners will lose a lot of time following useless links.

Web directories like Yahoo![3] and Excite[4] are maintained manually by a dedicated group of catalogers. These directories contain user-submitted resources that are indexed categorically. These indices are usually human-created or computer-generated. They would usually include some description that helps the user in determining the usefulness of the resource. As the resources contained by Web directories are user-submitted, there is the problem of scalability: it is impossible to scale personnel to match the rate at which the Web is growing. Web directories are outdated rapidly due to the ever changing and ever growing Internet. Important resources for the different categories and topics are often missing.

Metasearch engines are web tools that poll multiple sources like search engines and Web directories. The compiled resources are then processed and returned as results to the user. Metacrawler[5] and SavvySearch[6] are examples of metasearch engines. However, as pointed out in [4], although metasearch engines can significantly increase coverage, they are still limited by the engines they use with respect to the number and quality of results.

After looking at the above approaches, the problem of finding relevant and useful resources is not solved. Although these approaches may be adequate for a casual Web user, they do not serve learners who require specific information from certain domains well. We shall discuss our proposed solution in the next section.

3 Domain Specific Information Clearinghouse

Figure 1 below depicts the DSIC model.

[1] http://www.altavista.com
[2] http://www.hotbot.com
[3] http://www.yahoo.com
[4] http://www.excite.com
[5] http://www.metacrawler.com
[6] http://www.savvysearch.com

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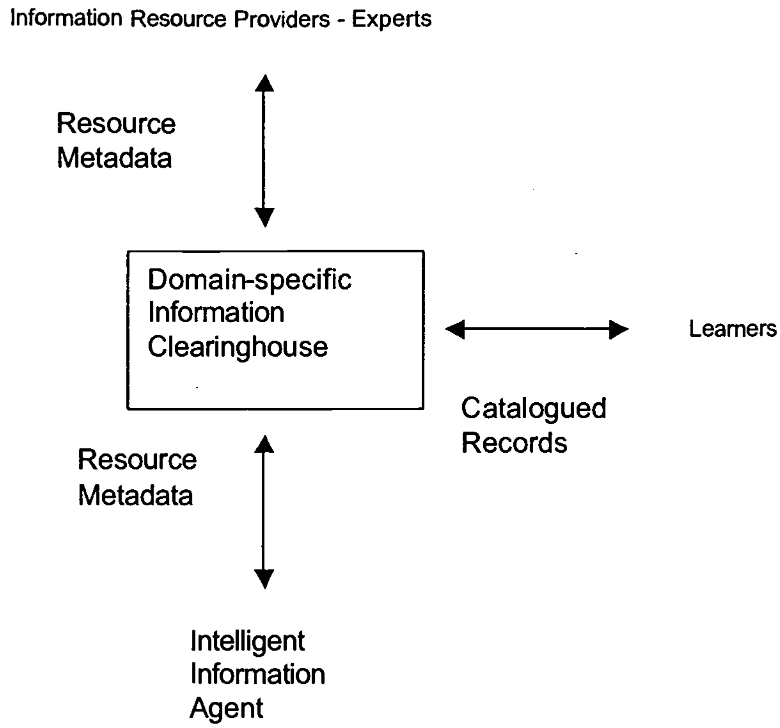

Figure 1: Domain-Specific Information Clearinghouse Model

As mentioned earlier, a Domain Specific Information Clearinghouse is a web-based clearinghouse and resource repository for domain-specific resources available on the web. One or more domain experts maintain the resources found in the clearinghouse. From now on, we will refer to *experts* as people who supply information to the clearinghouse and *learners* as people who access the clearinghouse for information.

The clearinghouse contains a classification of topics found in the domain and an intelligent information agent. With a good classification, the clearinghouse would be better organized and would increase learners' ease in finding the information they want. An intelligent information agent should be made available to facilitate the knowledge sharing and exchange both within and outside the clearinghouse.

An expert registers with the clearinghouse as a trusted information provider. He will then be able to submit resources that are in turn classified and cataloged. Using information found in these submitted resources, the intelligent information agent could scour the Web for more resources that can be added into the clearinghouse. The quality of these resources is much higher as they are being submitted by domain experts. What is useful and relevant to these experts are also usually useful to the learners as well. With all these information clearly classified, learners can then search or browse through the resource collection effectively in the domain specific clearinghouse.

4 Cross-Domain Learning

The DSIC caters to the needs of experts and learners in a single domain. However, learners often have not just one but multiple domains of interest. It would be useful for a learner with multiple domains of interest to be able to find the information he needs across all the different domains. Moreover, there are often no clear boundaries between domains, as the figure below shows. Resources from different but related domains may overlap.

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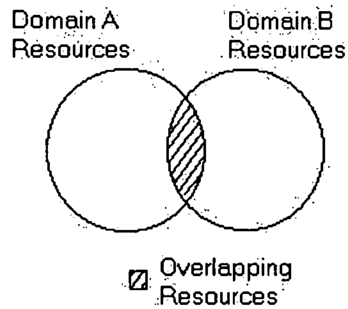

Figure 2: Overlapping Domain Resources

This potentially allows for different DSICs to collaborate and share resources with each other. To provide such a resource sharing framework, two issues needs to be addressed: distributed service and metadata exchange.

4.1 Distributed Service

The proposed framework for collaboration between multiple DSICs is essentially a distributed service. Domain experts maintaining each individual clearinghouse would register it with the *information union agent*, which is a central service that keeps track of all the existing clearinghouses that has been set up. This is illustrated in Figure 3 as follows:

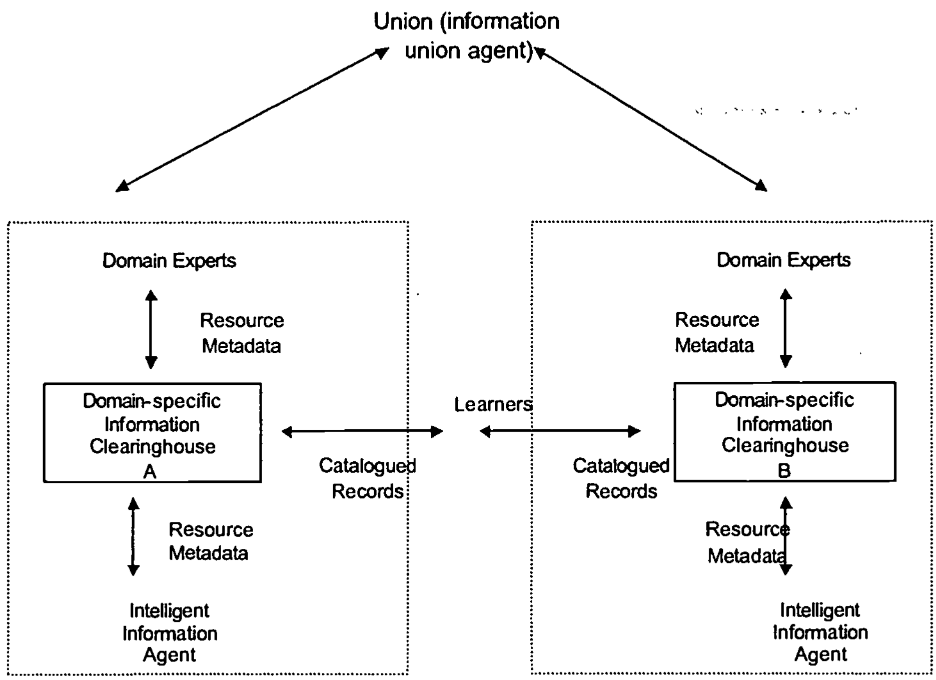

Figure 3: Multiple Domain Resource Sharing

Upon registration with the information union agent, each clearinghouse would declare the metadata attributes that are used to describe resources in that particular clearinghouse. Relationships with other domain clearinghouses are also declared. This information is then broadcasted to all the clearinghouses in the union to facilitate metadata exchange, which will be discussed in section 4.2

Besides maintaining the relationship links between the different domains, the information union agent would

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also apply data mining techniques to learn and discover relationships between resources in the different domains. For example, when the number of similar resources that are found in two different categories of different domains exceed a threshold value, the union agent would automatically update the union with this relationship if it has not already done so. Through this process, the union agent can learn and discover new information and relationships between different clearinghouses in the union and update the respective clearinghouses with the new information. This allows the clearinghouses to provide learners with higher quality information.

4.2 Metadata Exchange

A DSIC union needs to provide a mechanism to facilitate the exchange of machine-understandable information among different DSICs. Being domain specific, each DSIC has its own set of metadata attributes and values. A mechanism needs to be provided for a DSIC to automatically interpret metadata that comes from another DSIC of a different domain and transform it to a human-readable form. This problem is non-trivial because classification schemes and metadata formats can vary widely between different DSICs.

The *Resource Description Framework* [7], or *RDF*, is an evolving specification developed by the World Wide Web Consortium. RDF's nucleus is an archetype for depicting named properties and their values. The properties are representations of resource attributes as well as the relationships between resources. This data model provides a syntax-independent means of representing RDF expressions.

We have developed a mechanism adapted from the RDF standard that would suit the needs of the DSIC union. We called this mechanism the *Metadata Schema*.

A metadata schema is simply a set of attribute names that is used to describe all the resources cataloged in a particular DSIC uniformly. Each DSIC is associated with exactly one metadata schema at any one time.

A metadata schema is unambiguously represented by an ordered n-tuple of the form

$$< N_1, N_2, N_3, \ldots, N_n >$$

In the above notation, each N_i, $i \in \{ 1, 2, 3, \ldots, n \}$ can be any sequence of alphanumeric characters, including spaces, that starts with a letter. Usually, these would correspond to attribute names such as "Author", "Company", "Description" and "E-mail Address".

The Metadata Schema, together with the information union agent, are the main mechanisms for interoperability between different DSICs. The following scenario illustrates how the Metadata Schema is being used.

A learner using a particular DSIC X to search for information can indicate that he wants to cross-search another DSIC Y. Through the union agent described in Section 4.1, DSIC X would already know the Metadata Schema of DSIC Y and would request DSIC Y for metadata records that correspond to the user's search request. DSIC Y would then respond with a set of results of the form

$$R = \{ R_1, R_2, R_3, \ldots, R_m \}$$

where each R_i, $i \in \{ 1, 2, 3, \ldots, m \}$ is an ordered n-tuple of the form

$$<V_1, V_2, V_3, \ldots V_n>$$

Each element in the set R is then mapped to the known Metadata Schema of DSIC Y, after which the results are formatted and displayed by DSIC X.

The above scenario can be extended to more than 2 DSICs by simply requesting metadata tuples from each DSIC in turn. In this way, the DSIC union can be regarded as a single, distributed service with multiple access points, providing high quality cross-domain information to learners seeking such information.

5 An Example

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An example of a domain specific information clearinghouse is the Simulation/Gaming eXchange [6]. This is a clearinghouse for resources in the simulation and gaming domain. Most of the resources in the clearinghouse are submitted by domain experts and are of high quality. Some entries are submitted by the *SGX Information Agent*, a software agent which uses techniques found in [2] and [3] to scour the Web and retrieve resource related to those submitted by the domain experts. A typical entry in [6] is show in Figure 4.

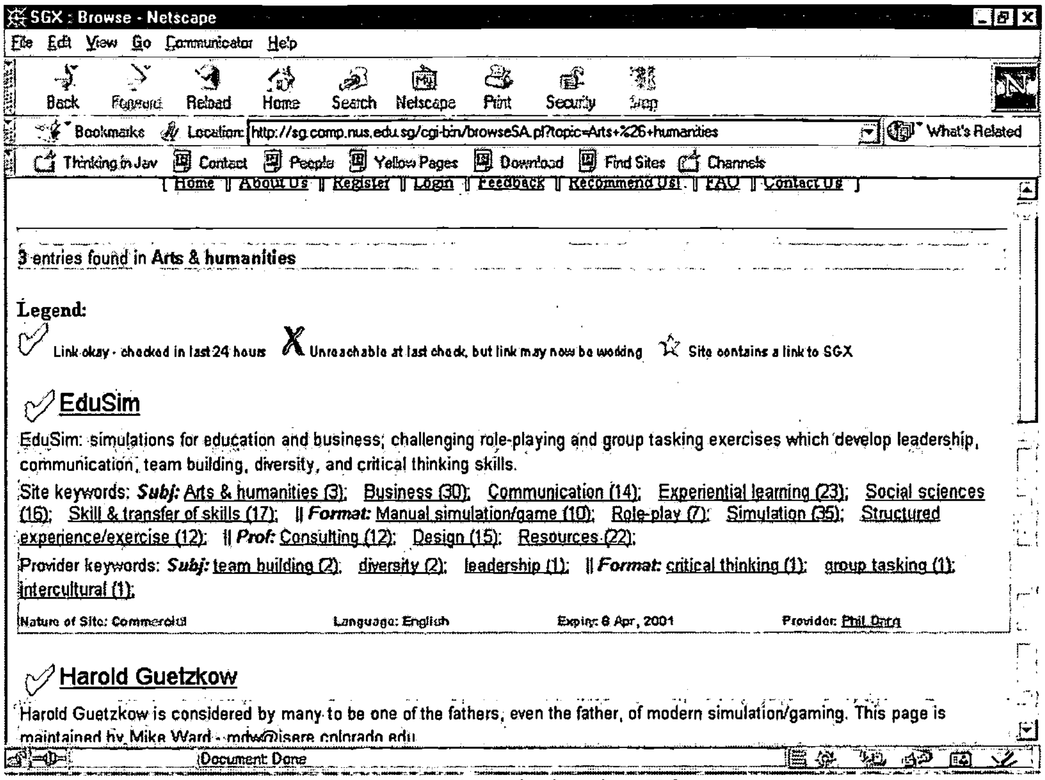

Figure 4: The Simulation/Gaming eXchange

Assuming that there is another information clearinghouse in the domain of CAI. This information clearinghouse also has its list of classifications and resources that have been submitted by experts. Upon registration into the union, the CAI clearinghouse will identify its relationship and links with the other clearinghouses that are already in the union. In this case, the CAI clearinghouse has to determine its relationship with the simulation/gaming domain. Some of the overlapping regions between CAI and simulation/gaming include edutainment, the use of simulations and virtual reality in learning. These resources can be applied to both the simulation/gaming domain and CAI domain when simulation/gaming is used as a tool in teaching using computers

Both CAI and simulation/gaming experts have submitted resources to their respective domain-specific information clearinghouses. Some of these resources are similar and will overlap each other. Using the overlapping regions as a starting point, the information agent in each clearinghouse will collaborate by sharing the resources they have. When a learner searches for virtual reality related resources in the CAI domain clearinghouse, he will be prompted that more resources are available in the simulation/gaming domain. He will also be linked and directed to these resources found in the simulation/gaming information domain. In this way, more resources can be retrieved without compromising on the quality of the results. This is very useful for learners with multiple domain interests. Furthermore, learners are also able to see how other domains relate to his domain interest. This sharing is done with the help of the union agent.

6 DSIC Toolkit

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Although different domain specific information clearinghouses catalog resources in different domains, they have the same main functionality as follows:

- **Registration** – Users can register as information resource providers via online forms
- **Catalog** – Registered domain experts can login to the system and catalog resources. In addition, an automated information agent is used to gather resources from the Web automatically. Authors are identified by the agent and invited to refine the catalog of their own resources.
- **Browse** – Web users can browse through the resources cataloged in the clearinghouse using the classification scheme employed
- **Feedback** – A feedback mechanism must be provided for users to give feedback to the DSIC administrator
- **Administration** – An authorized administrator is allowed to make administrative changes to the system as an administrator

These similarities in different clearinghouses provide the foundation for the development of a generic, flexible toolkit for the rapid deployment of a domain-specific information clearinghouse. Domain experts with little or no Web development expertise but wish to deploy and maintain an information clearinghouse can make use of this toolkit to rapidly set up one.

The DSIC toolkit is designed as an integrated package with the following components:

- Web server
- Classification Scheme Editor
- HTML Template Editor
- Administration Module
- User Module
- Information Agent Module

A set of default templates are provided together with the toolkit so that a domain expert who wishes to set up a clearinghouse can selectively use the components of the toolkit and set it up in a short time span instead of having to start from scratch.

7 Conclusions

In this paper we have proposed a framework that allows learners to collaborate and share resources. With the use of domain specific information clearinghouses, learners are able to find useful, valuable and related resources. The clearinghouse union is a mechanism that allows different domains to come together and share their resources. This is especially useful for researchers and learners who have multiple domain interests. They are able to find resources across the different domains without compromising on the quality of the results.

Knowledge discovery and sharing is also made possible with the help of the union agent that overlooks all the domain clearinghouses in the union. The union agent not only helps learners retrieve related resources in other domains but also searches through the huge databank of resources to find hidden relationships about the different domains, giving us information on how different domains are linked and related to one another.

Finally, we also presented a clearinghouse toolkit currently under development for the rapid deployment of an information clearinghouse. Through the use of the toolkit, domain experts can quickly specify a classification scheme and set up a clearinghouse. The newly deployed clearinghouse is automatically registered with the union and start sharing resources with other clearinghouses already in the union.

References

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[1] Loren T., Will H., and Brian A., "Constructing, Organizing, and Visualizing Collections of Topically Related Web Resources", in ACM Transactions on Computer-Human Interaction, Vol. 6(1), March 1999.
[2] Neri, F. and Saitta, L., "Machine Learning for Information Extraction", in Proceedings of the International Summer School on Information Extraction, SCIE '97 (Frascati, Italy, July 14-18, 1997.) Springer-Verlag Berlin Heidelberg, 1997, pp. 171 – 191.
[3] Theilmann, W. and Rothermel, K. "Domain Experts for Information Retrieval in the World Wide Web", in Proceedings of Second International Workshop on Cooperative Information Agents (Paris, France, July 4-7, 1998.) Springer-Verlag Berlin Heidelberg, 1998, pp. 216 – 227.
[4] Eric J.G., Steve L., William P. B. and C. Lee G., "Architecture of a Metasearch Engine that Supports User Information Needs", in Proceedings of CKIM 1999.
[5] http://www.usatoday.com/life/cyber/tech/review/crg842.htm
[6] http://sg.comp.nus.edu.sg
[7] http://www.w3.org/RDF

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The Gathering and Filtering Agent of Education Newspaper for NIE

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This paper presents the ENIG Agent to gather distributed information of educational newspaper in the web as well as student to provide the sound information for the NIE learning. The ENIG Agent gleans an appropriate newspaper headline of educational news portal site for real-time provision of the information. For gathering the optimized information, The ENIG agent performs the pre-process of educational news site, information noise filtering, pattern matching. The gathered educational newspaper information is removed a harmful data by using the pattern matching in the inference engine. The student can show the result of sound data through the web-browser as well as can use to learning with another application. For efficiency of this system, we evaluate the performance of the ENIG system by the experience of the NIE learning.

Keywords: **NIE, Newspaper Information gathering, Intelligent Agent, Supervised learning**

1 Introduction

These days, the web brings about a great change of education by a rapid growth of the Internet. It is not an easy work that a student finds the education information in the web. For searching the suitable information, a various search engines were developed and it provided a service for all. However, the general search engine is not fit that a student use at learning directly, because the information of search engine can contain a many data unconcerned learning. The learning requires the filtered information that can apply learning directly. Therefore, for efficient education, new type of search engine needs for the information retrieval and gathering [9].

Besides, the NIE means "Newspaper In Education", it is a method that student and teacher increases an efficiency of learning by using newspaper. The late web is used a good place for the NIE learning and a collaborative learning. However, when student and teacher study on the NIE learning through the web sites, they spend much time and repetitive efforts to find the newspaper contents. The student can lose a basic purpose of the NIE learning by the wasteful spending. The NIE learning needs an intelligent searching agent that searches automatically an important content about newspaper on the web. Moreover, because the gathered educational newspaper can contain harmful data, the data can remove by using the pattern matching in the inference engine [8].

Consequently, this paper describes about the ENIG Agent for the NIE learning. For providing the student just wants newspaper contents, we designed and implemented the intelligent agent system. In the following section, the NIE and the agent for information retrieval will be surveyed and the basic structure of the ENIG Agent will be designed. Furthermore, the next section will be discussed about implementation and experiment of ENIG Agent system. Finally the conclusion and future works will be described.

2 NIE and intelligent gathering agent

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The NIE is the initials of 'Newspaper In Education'. It is the education method for individual who make friend with newspaper and improves the achievement of learning using the contents of newspaper. The newspaper, "a living text book", is applied with open education through the NIE learning.

Roles of newspaper for education are listed below [5].

- The newspaper is a bridge that can connect the disparity gap between school and society.
- The newspaper is the reflective of actual world.
- The newspaper reappears the scene of the history and is researching material of present society.
- The newspaper is the most suitable of clear text model and is used with subject matter of language learning.
- The newspaper is the unique textbook that everybody can read in ones lifetime continuously.

For the reasons stated above, we can expect a advantages that the NIE learning is originality, thinking power, ability to read and understanding and writing text, the establishment of sociality through ones sense of values, ability to practical use of information and so on[8].

When teacher will teach using NIE content on the web, we must consider below list.

- The newspaper is not be made data for the NIE. Because it is made for adult, it has a very difficult vocabulary. Therefore, teacher must supply to student a vocabulary database.
- The newspaper has an article about negative contents of society. Such contents must be edited or deleted by using an intelligent agent.
- Because the web is opened to everyone, the newspaper may have contents that student never see. In special, an article of obscene, crime, violence must be deleted.
- The contents of a newspaper are best the events of the day. But the NIE is used the contents of old newspaper. Such contents are good saving at scraping DB.

The method of information retrieval is variety. For information retrieval of educational homepage, intelligent agent used a very suitable tool [9]. The intelligent agents having the characteristics of autonomy, social ability, reactivity, pro-activeness and cooperative relationship can provide the searching results of a user demanded through machine learning [11].

An agent gathers information instead of the user. Because the agent system does not deal with basic data, instead it deals with knowledge information, can easily process the knowledge of education homepage. Moreover, an agent system is capable of using effectively gathering of information on the dynamic web environment. Therefore, the web based instruction using the NIE learning needs intelligent agent system [3].

3 ENIG System

Generally, the web document has many added tag information in contents. This added tag can represent efficiently information and data of HTML document. However, the user does not use the tag information but can use only the text or the multimedia information. The tag information treats only an unnecessary noise to users. If an unnecessary noise tag in a content is removed, the filtered document is translated a regular expression in the ENIG system. The pattern of information is extracted at transforming regular expression by the string matching method.

The extracting information of content is interpreted the accuracy of information by inference engine. Inference engine has the knowledge base augmented with a rule-based system, and it has function of learning and inference by a supervised learning.

3.1 Structure of the ENIG agent system

The structure of the ENIC Agent system is shown figure 1. This system consists of four parts. The document of homepage on web filters tags by the noise-filtering module in analyzer. The information of filtered document is translated from HTML document into regular expression. The regular document is matched with the string pattern provided by string matcher in an agent and it extracts the information of articles in educational newspaper. The information of an articles is removed harmful data by the knowledge base in an inference engine. The interface module consists of two screens. The rule and knowledge is edited and added, deleted through the knowledge manager and gathering information is supplied to student by using the result viewer. The learning environment is a learning space that studies the NIE learning through web browser and a learning application programs.

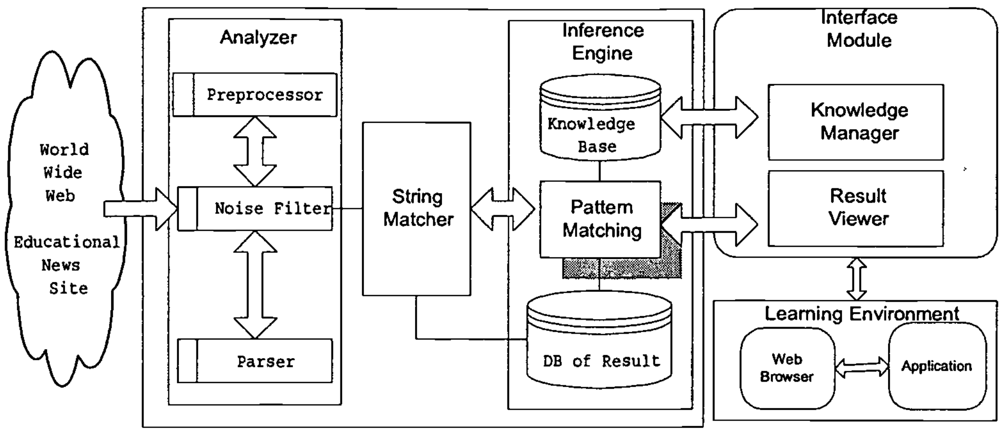

Figure 1. Structure of ENIG Agent

3.2 Noise filtering

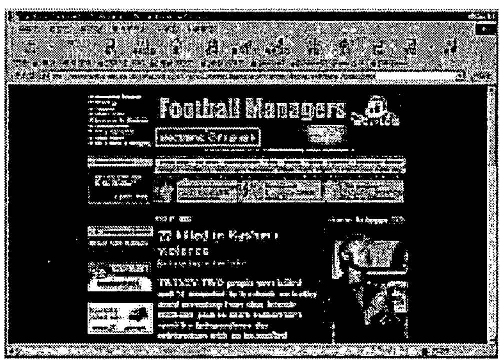

Figure 2. Homepage of educational newspaper

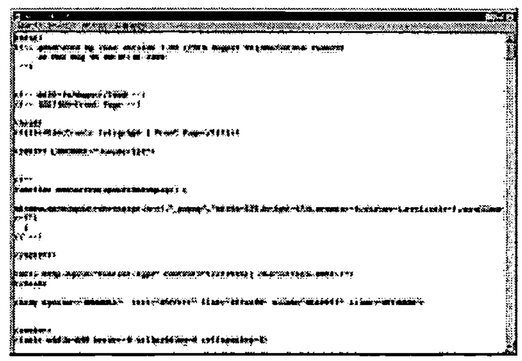

Figure 3. Source of homepage

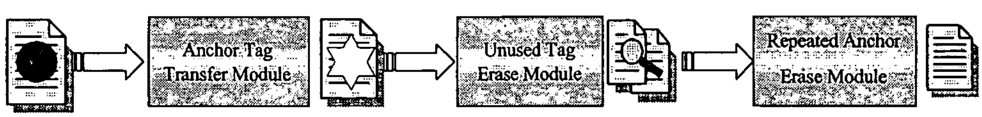

Figure 4. Steps of noise filtering

The example of educational newspaper site is shown figure 2. The tag information is not shown to user on the web-browser. While, the source of newspaper homepage is shown figure 3. The source is represented with a text and a complex tag information. Such tag information represents the arrangement of a document data and a multimedia information, a hyperlinked information.

The noise filtering is used to remove duplication data or an unnecessary data. For processing data called by HTTP, the noise filter processes work that removes a useless portion of the input data. The tags of HTML document have an irrelevant information to user, because tags only represent the formation of homepage and information of hypertext.

The noise filtering of the ENIG agent system removes an unnecessary tags in the document of an educational newspaper homepage except <A>...</A>tag, anchor tag of hyperlink and text data. The HTML sources are a difficult document to process noise filtering unconditionally, because the tag of document includes important information for the contents of document. Therefore, the noise filtering work must require a preprocessing module. Three steps of the noise filtering work is shown figure 4.

The preprocessing work for the noise filtering converts from basic <A>...</A> tag into suitable information and the works is listed below.

- Convert relative path for absolute path
- Change the URL of ASP form for the URL of HTML form
- Convert the path of CGI for general HTML form
- Change the path of script for absolute path
- Convert the hyperlink of image for absolute path

At the next step, the preprocessed documents are removed unnecessary tags by the noise filtering method except following items. <TABLE>,<TR>,<TD>,<LI>,<P>,
 tags are necessary the tags to keep the information of documents. The HTML document is composed one line of text or a record of table by such tags. Because most results of searching are represented with form of list or table, such tags is very an important information and may be not removed.

The final step of noise filtering is a work that gets rid of the duplicate from the URL of a document. The filtered document of educational newspaper homepage is show figure 5. We can know that the filtered document is ease for content analysis upon deletion of an unnecessary HTML tags. The advantage of noise filtering is that, it can process the same analysis about another newspaper homepages through removing tag.

```
Newspaper=Electronic Telegraph
URL=http://www.telegraph.co.uk:80/et?ac=003278937115627&rtmo=3mmquqwM&atmo=3mmquqwM&pg=/
title=updatednews
date=2000.8.14
<table>
<tr>
<td>
<a>
href="http://www.telegraph.co.uk:80/et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/
nhon14.html"
Honda to double British factory output
</a>
<a>
href="http://www.telegraph.co.uk:80/et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/
njake14.html"
Boy, 5, vanishes on trip to beach
</a>
<a>
href="http://www.telegraph.co.uk:80/et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/
wiraq14.html"
West's raids spark Iraq fury
</a>
<a>
href="http://www.telegraph.co.uk:80/et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/
npaed14.html"
Labour welcomes Hague's paedophile plans
</a>
<a>
href="http://www.telegraph.co.uk:80/et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/
wthai14.html"
Murder hostel was notorious for drugs
</a>
```

Figure 5 Result of a noise filtering

3.3 Pattern matching

The filtered document is translated from each information and data into regular expression. The pattern of regular documents is extracted with sequence of regular expression by the method of string matching. The hyperlink information of image may infer by using the pattern matching through regular expression, because the hyperlinked image do not contain the text information on hyperlink. The pattern matching is executed to extract text data and information of hyperlink in HTML documents. Specially, if image has been including hyperlink, the pattern matching is a very important work. The article information of the educational newspaper site has information of hyperlink as followed.

*< a href= ......> ...... text ...... *

Generally, the hyperlinked text information exists between <a> tag and tag. If an image exists between the anchor tags as " <img src=...> ", then text information can exist at front or back of the anchor tags. In this case, each tag and the text information is changed the defined tokens previously. In addition, each data is created a string of a regular expression by the pattern matching.

The portion of tokens for creation of regular expression is shown table 1.

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Table 1 Token for regular expression

<table>	</table>	<p>	</p>	<tr>	</tr>	<td>	</td>	<a>		href	text
T	T	P	p	R	r	D	d	A	a	H	M

If the filtered document is represented with regular expression by tokens of table 1, the content of figure 5 is converted a tag page into the sequence of the alphabet as "TRDAHMaAHMaAHMaAHMa...". And the string pattern of regular expression has the process of pattern matching. This study used the three types of pattern for pattern matching as followed.

- *"AHMa" : "< a href= ......> ...... text ...... "*
- *"MAHa" : "... text ... <img src=...> "*
- *"AHaM" :" <img src=...> ... text ..."*

The extracted string by pattern matching restores to the original tag and text information in HTML document. The extraction strings are reverted with source records. Figure 6 shows result that article is extracted through pattern matching of regular expression.

The translation of regular expression and the pattern matching have a many advantages. The advantage of pattern matching method is that the complex matching of string can extract only one time by matching of substring, and that agent can easily learn the rule of pattern.

Therefore ENIG system eases the addition of new educational newspaper site and pattern by the addition of URL and the type of pattern.

```
Electronic Telegraph|updatednews|2000.8.14|Honda to double British factory output|http://www.telegraph.co.uk:80/
et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/nhon14.html
Electronic Telegraph|updatednews|2000.8.14|Boy, 5, vanishes on trip to beach|http://http://www.telegraph.co.uk:80/
et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/njake14.html
Electronic Telegraph|updatednews|2000.8.14|West's raids spark Iraq fury|http://www.telegraph.co.uk:80/
et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/wiraq14.html
Electronic Telegraph|updatednews|2000.8.14|Labour welcomes Hague's paedophile plans|http://www.telegraph.co.uk:80/
et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/npaed14.html
Electronic Telegraph|updatednews|2000.8.14|Murder hostel was notorious for drugs|http://www.telegraph.co.uk:80/
et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/wthai14.html
```

Figure 6 Example of string exchanging for regular expression

3.4 Inference and learning method

The extracted newspaper information is not provided all good information to student. In case of an inserted advertisement site, such site can become an obstacle of learning by the useless content. Moreover, a negative content or a harmful page too must be not suitable site to student. Such sites can be provided about a lustful content and a crime, an slang, a violence and so on. The harmful data can be removed in advance learning by inference engine and knowledge base. Reasoning rule uses the rule-based production system. The representation of knowledge is shown below

IF A THEN B

The production system has a merit that it is simple and easy the representation of rule as well as the addition of knowledge. The learning method of the ENIG Agent system uses the supervised learning learned by human teacher. If new rule is occurred, teacher input new rule and knowledge in knowledge base. For example, if the extracted information contains harmful text as a sex and a narcotic, a knife, then teacher input new rule and knowledge as *"IF sex AND narcotic AND knife THEN delete"*.

The harmful site at gathering site reason a rule by the analysis of content and the rule are stored in knowledge base by teacher. The bad information of extracted document is removed by the vocabulary DB and the rule of knowledge base. For forbidding the access of the student, the addition and deletion of rule and fact in the knowledge base can be control only by a teacher.

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4 Implementation and Experiment

The implemented ENIG Agent can extract only the important information of newspaper site. In addition, it can be had with only a text and URL information at various homepage. For implementation of the ENIG Agent, we used Visual C++ and the CLIPS DLL. The CLIPS is rule-based a production system shell and it is used as an inference engine.

The execution screen of the ENIG agent system is shown figure 7. The ENIG system is composed of three parts. The left side of the screen is a part that the directory manager manages and edits educational newspaper sites, and the mid-screen is a part to view the result of the gathering information, and the button of right above is part to add a rule for inference and machine learning. If 'gathering' button is clicked, the ENIG agent gathers and extracts an article from an educational newspaper site. If 'learning' button is clicked, a rule and knowledge is added and edited by teacher in the ENIG agent.

This ENIG agent system can be applied directly at the homepage of different domain without change of system. If site is constructed standard HTML document, an agent can search and gather even the document of a foreign site.

The applying example of NIE learning using the ENIG system is shown figure 9. This example is used the ENIG system and the Web Browser and word processor. The screen is the NIE learning about music using the ENIG agent system and the Window application. The information of newspaper on the web can be applied directly at a web-based instruction (WBI).

One of the advantages of this system is that the extracted information uses a mobile environment directly. Because the extracted information is very small data and hyperlinked information, such data can be inserted the mobile communication as a cellular phone, a PDA, a notebook computer, a portal computer, and so on. Furthermore, the information of this system can transmit the WML by WAP.

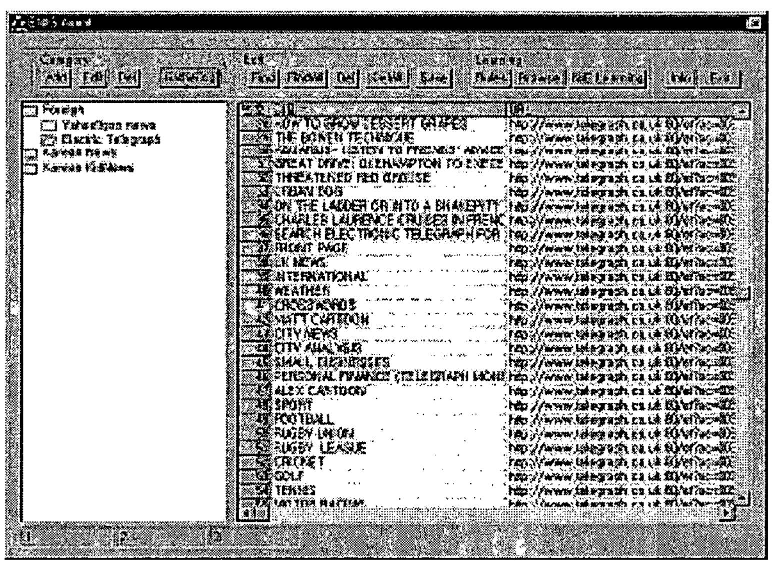

Figure 7 ENIG Agent system

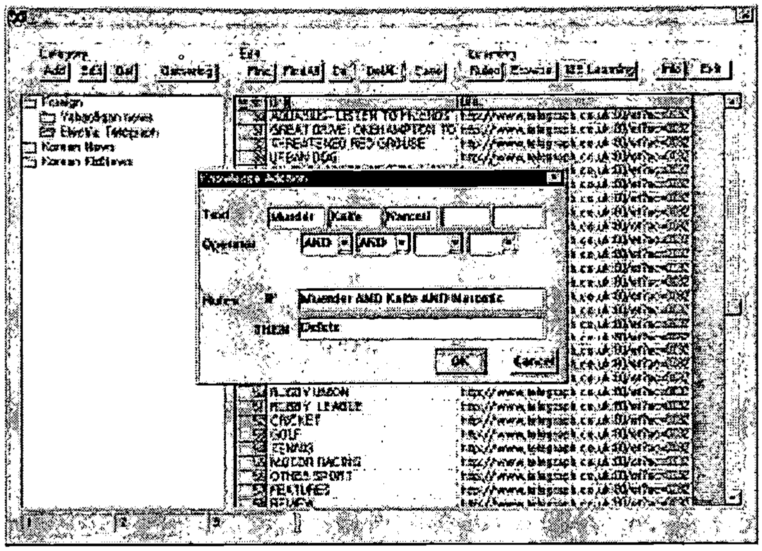

Figure 8 Addition of knowledge

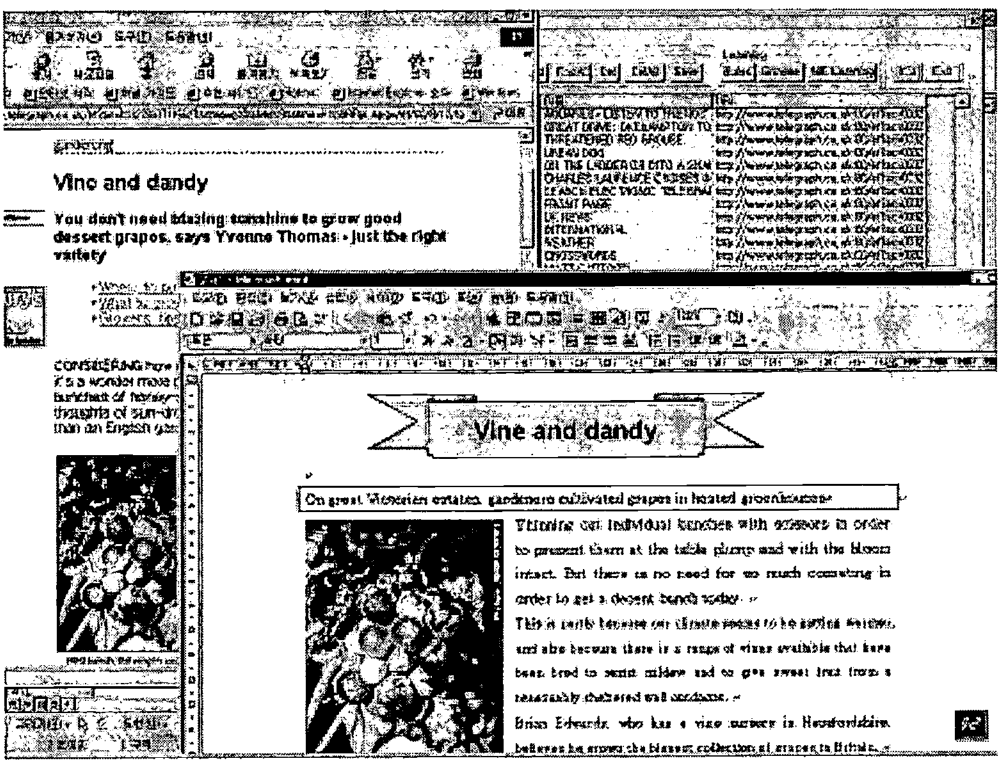

Figure 9 Example of NIE learning using ENIG agent

5 Conclusion and Future works

As mentioned above, we described about the ENIG agent system for the gathering information of educational newspaper homepage. In addition, we designed the method of noise filtering and pattern matching for suitable information. The method of noise filtering was used to remove unnecessary tags at source of HTML document and the method of pattern matching was used to extract necessary URL and text information. The learning of agent was used to provide with good information to student by supervised learning. Most a web-based instruction was mainly learning about information retrieval. As student spent a lot of time to find learning information and data, so these lead deficiency of time for the essential learning.

Consequently, the ENIG agent system can provide not only to student for the learning of information retrieval but also can help them capturing the genuine NIE learning. And this system can execute the role of information treasury for the whole education through scraps of information.

The future works are that we improve the faculty of agent for information gathering of all sites; moreover, we need research about unsupervised learning of agent and not supervised learning. In addition, we need research to remove gathering information of header and footer through addition of heuristics and pattern type that requires the study about the method of keyword searching it. Finally, for providing a location of information to the agent, we will research the extension method of URL.

References

[1] Barbara Hayes-Roth. "An Architecture for adaptive intelligent agent systems", Artificial Intelligent, Vol. 72, pp.329-365, 1995.

[2] David Pallmann, "Programming Bots, Spiders, and Intelligent Agents in Microsoft Visual C++", Microsoft Press,1999.

[3] Erik Selberg, Oren Etzioni, "Multi-Service Search and Comparison using the Metacrawler", Proceedings of the 4th World Wide Web Cinference, Boston, MA, USA, pp 195-208, 1995

[4] Filippo Menczer, Alvaro E. Monge, "Scalable Web Search by Adaptive Online Agents: An InfoSpiders Case Study", Intelligent Information agents, Springer, USA, pp 323-347, 1998.

[5] Frances Anderson, "Classroom Newspaper Activities: A Resource for Teachers, Grades 1-8", Charles C Thomas Pub, 1985

[6] Henry Lieberman, "Personal Assistants for the Web: An MIT Perspective", Springer, USA, pp 279-292, 1998.

[7] Josheph Giarratano, Gary Riley, "Expert System, Principles and Programming", PWS Publishing Company, 1994.

[8] Paul Sanderson, "Using Newspapers in the Classroom: Cambridge Handbooks for Language Teachers", Cambridge Univ. Press, 1999.

[9] Ricardo Baeza-Yates, Berthier Ribeiro-Neto, "Modern Information Retrieval", Addison-Wesley, 1999.

[10] Sandip Sen and Gerhard Weiss, "Learning in Multiagent systems", The MIT Press, USA pp 259-298, 1999.

[11] Wooldridge, M., Jennings, N. R., "Intelligent Agents", Springer-Verlag, 1995.

LEARNERS' STRUCTURAL KNOWLEDGE AND PERCEIVED DISORIENTATION IN A HYPERMEDIA ENVIRONMENT: THE EFFECTS OF INFORMATION CONVEYING APPROACHES AND COGNITIVE STYLES

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The flexible nature of hypermedia allows it to be tailored to an individual's needs. Despite the many degrees of navigational freedom, however, users of hypermedia often find difficulty locating information, feel disoriented, or even become "lost in hyperspace" within such large seas of data. Research findings suggest that the disorientation problem could be solved if users are able to hold a conceptual overview of the hypermedia structure. How a learner can acquire correct structural knowledge of the information becomes an important issue to affect their learning performance in a hypermedia environment. Variables such as the different ways of structuring or conveying information and cognitive styles may affect learners' cognitive abilities in knowledge structuring and should be taken into account together. The results of this study will show whether the interactions between information conveying approaches and learners' cognitive styles have significant effects on learners' performances in terms of structural knowledge and feeling of disorientation.

Keywords: **Structural knowledge, Cognitive style, Concept map, Disorientation, Hypermedia**

1 Introduction

One of the recent developments in computer technology now applied in many educational institutions is the technology of hypermedia (Liu & Reed, 1994; Paolucci, 1998), in which users can access specific information by various paths. The flexible nature of hypermedia allows it to be tailored to an individual's needs. Reading in hypermedia allows more random access and offers overt ways of accessing (Tierney, 1994). However, users of hypermedia often experience difficulty locating information, feel disoriented, or even become "lost in hyperspace" (Elm & Woods, 1985) within such large seas of data. Scholars (Beasley & Waugh, 1995) have suggested that the disorientation problem could be solved if users are able to hold a conceptual overview of the hypermedia structure. In other words, if users can substantially construct a structural knowledge (Jonassen, Beissner, & Yacci, 1993) of the information provided in the hypermedia system, their learning performance could be improved.

Ways to structure or convey information in the physical sense should not be the only concern when the instructortry to facilitate the formation of the learner's structural knowledge. Factors such as learners' characteristics that could affect their cognitive abilities in knowledge structuring should also be taken into account. Few studies have been conducted in this domain. The purpose of this study is to investigate learners' cognitive characteristics in the dimension of cognitive styles and their effects on the acquisition of structural knowledge through the application of different information conveying approaches: the Less Explicit approach and the More Explicit approach.

2 Background of The Study

Learning is a process of reorganization of knowledge structure. Based on the concept of meaningful learning (Ausubel, 1963), in one way, learners structure knowledge to serve as a framework that helps them to associate new information with previous knowledge. As this framework becomes more complex, learners may in turn rely on this conceptual structure to filter the important from the irrelevant points (Anderson, Reynold, Schallert, & Goetz, 1977). The acquisition of correct structural knowledge has become a critical issue in learning. Among other computer technologies, hypermedia is a potential tool to mediate the structural knowledge of the target domain to learners. One of the current theories about mind structure, the "mind as rhizome" (MAR) metaphor (Eco, U., 1984), hypothesizes that the human mind is organized like an underground rhizome. Hypermedia tangibly simulates the learning assumptions of this mind metaphor in that learners can filter, link and search for new or existing information. These features have made hypermedia an ideal environment where experts' knowledge structures are made visible and navigable for learners in a graphical or a textual form (Wilson & Jonassen, 1989). Compared with novice users of a subject domain, expert users in this domain are believed to possess a better knowledge structure that enables them to effectively solve problems. The learning strategy of externalizing experts' knowledge structures to provide "idiosyncratic" intellectual thinking (Schwen, Goodrum, & Dorsey, 1993) has been deemed a pragmatic way to empower learners.

In comparing hypermedia with linear text in book-bound printed material, Conklin (1987) noted that any piece of text that the user wishes to locate in a book can only be further forward or further back from where the user is currently located. Hypermedia, on the other hand, is often designed to store or to locate information in a non-linear manner. Instead of a long run of narrative text on sequentially numbered pages, hypermedia is typically organized into small segments of text and learners control the reading flow of the materials (Berk & Devlin, 1991). Regardless of claims about the benefits of using hypermedia, however, Charney (1987) and Dias & Sousa (1997) pointed out that the ordering of topics and points as well as various traditional orientating devices, such as overviews and summaries which are usually taken for granted in books and papers, are non-existent in hypermedia. Without such orientating devices or narrative cues, and lacking the knowledge of hypermedia structure, users can barely determine where they are, what they want, and how to get there (Beasley, 1994; Tripp & Roby, 1990). These issues raise a number of questions. Is knowledge of the material' s structure as important as scholars suggest? Can one attempt to represent the structure of a document cognitively, and if so, what form might it take?

3 Theoretical Framework

Learning in Hypermedia

Hypermedia is a developing concept that perhaps first originated with Bush (1945), who envisioned a text that was organized like the human mind. Unlike a traditional learning environment, hypermedia mainly relies on self-directed learning. With this system, the responsibility for identifying what is useful information and the selection of search strategies for locating that information are largely left to the user (Small & Grabowski, 1992). Instead of having an instructional-base, like conventional Computer-Based Instruction (CAI), the format of hypermedia is information-based. CAI materials normally include objectives, presentation of information, and drill-and-test activities (Gange, 1976). These materials lead users to engage in intentional learning, in which all learning activities are arranged to accomplish the pre-determined learning goal.

Conversely, the learning that occurs in hypermedia is a type of incidental learning: the instructional content is provided without a specific learning goal (Spiro & Jehng, 1990). Learners in a hypermedia environment are encouraged to interact with and explore the information by developing their own paths or knowledge structures.

Although hypermedia has had remarkable impacts (Jonassen & Grabinger, 1990; Mcaleese, 1991) on human

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learning modes, accessing immense amounts of information within a hypermedia system is often not an easy task, especially for novices. As Hammond and Allinson (1989) indicated, people may encounter a number of common problems when they use hypermedia. They may have difficulty using interface tools in order to gain an overview and to locate specific information; they are also likely to wander without a strategy or goal and finally get lost. It is necessary that we investigate what types of cognitive characteristics might affect learners' performances involved in hypermedia learning and how hypermedia can thus be customized to fulfill learners' cognitive needs.

Hypermedia and Cognitive Styles

Hypermedia appears to be an ill-structured and non-linear type of conceptual networking environment. It seems to avoid prescribing a particular path for navigating information. Such a structure could be questionable for a learner who is in need of guiding pathways. A learner's performance in hypermedia may be affected by his / her individual cognitive style. Many variables, such as age, motivation, cognitive style, and prior knowledge / experience with the system (Heller, 1990; Lai, 1994; McAleese, 1989; Paolucci, 1998; Rhee, 1993) have been proven to be influential factors in the user' s performance. Some of these studies were conducted in a conventional computer-based instruction environment. In those that were conducted in a hypermedia environment, cognitive style was found to be an essential factor in learning (Chang, 1995). Research findings support this notion that individual cognitive differences affect learning results among adults (Davidson, Savenye, & Orr, 1992; James & Blank, 1991). Understanding these differences can help instructors cope with the variations in performance exhibited by their students (Moore, 1994).

Cognitive style refers to a learner' s information processing habits, this being manifestly reflected in his / her perceptual ability and in personality as well (Greco & McClung, 1979; Witkin, et al., 1977). It is "a superordinate construct involved in many cognitive operations that accounts for individual differences in a variety of cognitive, perceptual, and personality variables" (Vernon, 1973, p.141). There are no good or bad cognitive styles. They could only to be described as effective or ineffective in terms of their influence on a specific task (Strother, 1982). Studies on cognitive styles initially stemmed from the field of individual differences. These issues were extensively studied during the 1960s and remained popular in the early 1970s, but have since tended to fade out. As Riding and Cheema (1991) stated, this decline left the whole field of exploration fragmented and incomplete. In spite of their attracting little interest in the last two decades, cognitive styles are now once again being considered more seriously by scholars due to the coming of hypermedia technology.

In this research proposal, cognitive style will be examined in the two dimension of Wholist / Analytic and Verbal / Imagery. After reviewing work on the cognitive style study, Riding and Banner (1986) found that there was an interaction effect between Field-dependence / independence style and verbal / imagery style on the learner' s performance. Riding and David (1991) concluded that the Group Embedded Figures Test (GEFT)(Witkin, 1962) that has frequently been used to identify Field-dependence / independence style has limitations. In order to overcome some weaknesses of the traditional method for assessing Field dependence / independence like GEFT (e.g. Witkin, 1962), the Cognitive Styles Analysis (Riding, 1991) was developed. This approach classifies learners' cognitive behaviors into four different categories: Wholist-Verbaliser, Wholist-Imager, Analytic-Verbaliser, and Analytic-Imager. In this classification, Riding felt that for educational and training purposes it is more meaningful to term Field-dependent as Wholist and Field-independent as Analytic. The Wholist trainee tends to view the information in whole and the Analytic trainee tends to separate out the individual parts of information. Riding method differs from GEFT in four significant ways. First, it positively measures the wholist tendency and does not simply assume that if a person does poorly on a disembedding task that they are Field-dependents. This overcomes a major objection to the notion of Field-independence being a learning style raised by those who have argued that since generally Field-independents are superior to Field-dependents, it is simply a correlate of intelligence or general ability. Secondly, it compares a person' s relative performance on the to halves of the continuum. Thirdly, by using computer presentation, it allows more sensitive timing of the task. And finally, Riding' s Cognitive Styles Analysis refines the GEFT method and incorporates the assessment of the second fundamental dimension: Verbal-Imagery cognitive style. The Wholist-Analytic (Field-dependence-independence) / Verbal-Imagery classification is considered to be particularly valuable when it is used to examine different learners' behaviors in a non-linear environment such as hypermedia (Roberston, 1982; Riding, 1997). These two dimensions of cognitive styles that reflect on learning involve the various cognitive restructuring skills and analyzing ability for incoming information that are especially demanded in an ill-structured environment such as hypermedia. It is likely that the best performance on learning task comes from combinations of these two style dimension that offer the greatest strengths, namely Wholist-

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Verbalist learners and Analytic-Imager learners, whereas Wholist-Imager learners and Analytic-Verbalist learners are less complementary and might result inferior performances.

Hypermedia and Structure Knowledge

According to Conklin (1987), disorientation is one of major problems for hypermedia systems. Elm and Woods view this "disorientation" in terms of degradation rather than as a subjective feeling of being "lost". One of the assumptions in their 1985 study about users' performance is that users might attempt to create a comprehensive cognitive map of the knowledge domain. The problematic issue of getting lost in a display network is caused by the user lacking a clear conception of the relationships within the system, or as Jonassen, Beissner, & Yacci (1993) call it, *Structural knowledge*. Structural knowledge is a memory / cognitive structure, a collection of bits of information and relationships among concepts. It could also be termed the internal structure (Korthauer, R. D & Koubek, R. J., 1994), which refers to the knowledge structure of users who are experienced in the domain, and to a type of mental model that users must create and bring to bear as they work in an electronic information space (diSessa, 1986; Gentner & Stevens, 1983; Russell, 1986). The acquisition of structural knowledge, according to Ausubel (1963), involves the linking of new information to existing information, which results in a dynamic framework of knowledge. That is, through the information processing procedure, learners experience new information and refine or reconstruct their knowledge frameworks as needed.

In hypermedia, there are two approaches to help learners construct their structural knowledge (Korthauer, R. D. & Koubek, R. J., 1994). The first is the use of *hyperlink approach*. Hyperlink approach is designed according to the intrinsic attributes of the information; the designer finds the best way to organize it so that the information structure is salient to the user (Gordon & Gill, 1993). This approach could commonly be seen as the underlying organization embedded in the hypermedia database, such as the hierarchical, associative, and networking structures. The second is the use of *navigational aid approach*, which is usually based on the hyperlink approach but graphically represents hyperlinks (such as the concept map) to make the information hierarchy more explicit for learners (Nelson, 1990). It is thought that instead of relying on hyperlink approach, as experienced users do, novice users may rely more upon the navigational aid approach, as they have no knowledge structure of their own (Korthauer, R. D. & Koubek, R. J., 1994). In addition to the external factor, like the hyperlink and navigational aid approaches, learners' cognitive styles are the internal factor suspected to particularly affect novice users, by affecting the degree to which they can draw out the embedded structure of the hypermedia document.

As Mandler (1983) indicated, "Meaning does not exist until some structure, or organization, is achieved" (p4). For designers and instructors, it would seem wise, then, to balance structural knowledge acquisition and the knowledge that users expect to learn in their consideration of learning results. Mental constructs could not be formed without structure. Learners might be able to remember each single object without structural knowledge, but they could not relate these isolated ideas to each other to form abstract knowledge, or even translate them into procedure knowledge (Jonassen, Be issner, & Yacci, 1993). It is important that the learner first develop an accurate structural knowledge of the knowledge domain being studied. Once the learner has a grasp of the bigger picture, he / she will be released from the burden of trying to organize the structure of the information while he / she is also required to study the content at the same time.

4 Methodology

Independent Variables

There are two independent variables in this study. First are the two types of information conveying approaches which mediate the hypermedia-based instruction. The second independent variable is the learner's cognitive style which is identified by a standard test. Figure 1 outlines a conceptual model for the variables of this study.

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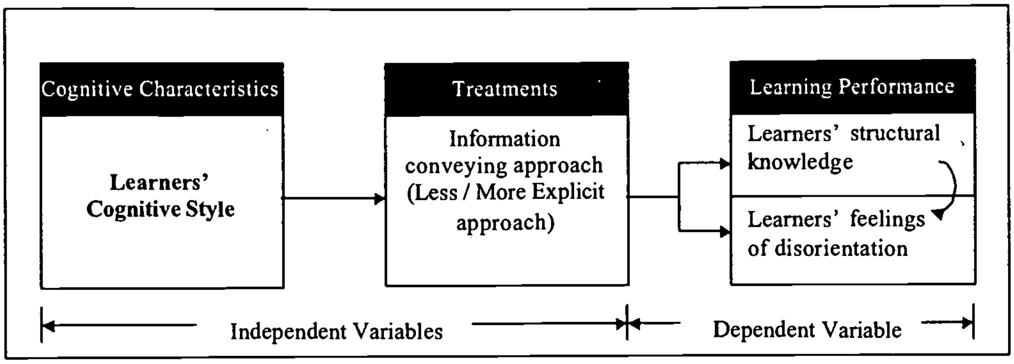
Figure 1. The conceptual model of variables for this study



Information Conveying Approach

In this study, there are two types of information conveying approaches:

1. The Less Explicit (LE) approach: the instructional material with the hierarchical-associative hyperlink

The More Explicit (ME) approach: the instructional material with an interactive concept map

Cognitive Style

The second independent variable is the learner' s cognitive style in the combination of the dimension of Wholist-Analytic and the dimension of Verbal-imagery.

1. Wholist-Verbaliser
2. Wholist-Imager
3. Analytic-Verbaliser
4. Analytic-Imager

A subject's particular style is determined by the subject's score on the Riding' s Cogntive Style Analysis (Riding, 1991).

Dependent variables

There are two types of dependent variables in this study: learners' structural knowledge and learners' feelings of disorientation.

Structural knowledge

Structural knowledge is defined here as the compilation stage of a knowledge development theory (Anderson, 1982, 1987, & 1990). It is a transition knowledge that helps learners to associate their declarative knowledge with their procedural knowledge (Jonassen, Beissner, Yacci, 1993). It represents the interrelationships between concepts that the learner forms in his or her memory.

Feeling of Disorientation

The second dependent variable in this study is a learner's feeling of disorientation which results from his / her use of different types of information conveying approaches.

Subjects

The researcher plans to collect a total of one hundred twenty subjects participating in this study. All of the subjects will be current students enrolled in Indiana University at Bloomington (IUB). Subjects' ages range from 19 to 45, and they have various majors in the School of Education in IUB. Before this experiment, a Human Subject Form shell be completed by each subject and has been approved by the University Committee for the Protection of Human Subjects.

A two-stage filtering procedure will be administered to identify the most appropriate subjects for this study.

In the first stage of the filtering procedure, subjects will be recruited by means of an Email flyer. Experienced subjects will be excluded according to their replies on the computer background questions sent together with the Email flyer. The remaining respondents will receive a confirmation message from the researcher to thank them for their participation and to set up a possible time with them to come for this study. The subject filtering procedure moves to the second stage.

In the second stage of the subject filtering procedure, Riding's Cognitive Styles Analysis (Riding, 1991) will be administered to all remaining students to determine their cognitive styles: Wholist- Imager, Analytic-Imager, Wholist-Verbaliser, or Analytic-Verbaliser. This computer-based test will give measure of a subject's position on both the Wholist / Analytic and Verbal / Imagery cognitive style dimensions.

Instructional Materials

Content

The topic of this web-based instruction – "Building a Homepage", was about building a personal homepage in the IUB domain. The categories of "Building a Homepage" were adopted from the "IU Webmaster" web site (http://www.indiana.edu/~wmhome/), which is maintained by the University Information Technology Service (UITS). This web site provides information for those who wish to build or maintain a web page by themselves.

Interface layout

Two different versions of hypermedia-based instructions were developed in this study: the instruction lesson using the Less Explicit approach (hierarchical-associative hyperlink) and the lesson using the More Explicit approach (concept map). Both versions contain the same instructional content but convey it through different interface layouts. The interfaces were functionally equivalent in terms of the amount of content available in each node, and both allowed access to top-level pages at all times. Therefore, one design was not viewed by the researcher as less functional than another. These two types of hypermedia-based instructions could be accessed through using Web browsers like Netscape Navigator or Internet Explorer. Additionally, in order to control the learning environment and also to remove unpredictable factors that might affect learning, the browser's (Internet Explorer) toolbar and address bar were removed and did not appear in either approach. This was viewed as necessary in order to attempt to isolate any learning effects that may have resulted from use of the "Back" function (Boling et al., 1996).

Experiment Procedure

Upon the completion of the two-stage filtering procedure, the selected subjects will be informed of the time and the place for this experiment by Email. Before the study, subjects are randomly assigned into two groups – the group using the Less Explicit approach and the group using More Explicit approach. Only one group is measured at each time. In this experiment, subjects will be required to study a hypermedia-based instruction lesson. The content of this lesson is designed to help subjects acquire the knowledge to build homepages in the IUB domain. In the beginning of this experiment, subjects will be given five minutes to practice and master the tutorial web page that had been loaded on their screens. After this five minute tutorial session, subjects are required to spend at least fifty minutes (or even longer time, depending on their wishes) to read through the "Building a Homepage" web site.

When subjects complete the self-directed study, they will be required to complete a three-part post-test and a disorientation questionnaire in order to measure their structural knowledge and perceived disorientation. Subjects have a total of twenty-five minutes to finish the post-test and the questionnaire and return them together with the signed consent form to the researcher.

5 Conclusions

This study attempts to make a contribution to our understanding of how learners' cognitive attributes affect their learning performances while using hypermedia. The study results should provide some useful design concepts for hypermedia development, especially when a hypermedia material is designed for novice learners.

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Learning functions play a central role in theories regarding the regulation of learning processes (Vermunt, 1989). However, the question of how students carry out these functions in a hypermedia context, or the way in which this execution is regulated by internal and external factors has largely gone unproved (Burton, Moore, & Holmes, 1995). It is worthwhile to explore whether the hyperlink or the concept map is better for different cognitive-styled learners in the acquisition of structural knowledge. As structural knowledge has been proven to be a crucial predictor of problem solving skills (Chi & Glaser, 1985; Gordon & Gill, 1989; Robertson, 1990), the information regarding whether supplied models are useful and for what kinds of users is also important for hypermedia developers.

In addition, it is hypothesized that users could overcome the disorientation problem if they could acquire a more correct structural knowledge of the knowledge domain. The findings of this study may result in insight and shed light on the importance of acquiring structural knowledge as a learning goal. Hypermedia developers may accordingly develop guidelines for designing interfaces that help users to access information and which will accommodate their needs while preserving the quality of independent learning. This should improve the effectiveness of their designs.

References

Anderson, R. C., Reynolds, R. E., Schallert, D. L. and Goetz, E. T. Frameworks for comprehending discourse. American Educational research Journal, 14(4), pp. 367-381, (1977).

Anderson, J. R. Acquisition of cognitive skill. Psychological Review, 89, pp. 369-406, (1982).

Anderson, J. R., Skill acquisition: Compilation of weak-method problem solutions. Psychological Review, 94, pp. 192-210, (1987).

Anderson, J. R., The adaptive character of thought. Hillsdale, NJ: Erlbaum, (1990).

Altun, A., Patterns in cognitive processes and strategies in hypertext reading: a case study of two experienced computer users. Journal of Educational Multimedia and Hypermedia, 8(4), pp. 423-443, (1999).

Ausubel, D. P., The psychology of meaningful verbal learning: An introduction to school learning. New York: Grune & Stratton, Inc., (1963).

Berk, E. and Devlin, J., A hypertext timeline. In E. Berk and J. Devlin (Eds.), Hypertext / Hypermedia Handbook, NY: McGraw-Hill, Inc. pp. 13-16, (1991).

Beasley, R. E., The effects of three browsing devices on learner structural knowledge, achievement, and perceived disorientation in a hierarchically organized hypermedia environment. Doctoral dissertation, University of Illinois at Urbana-Champaign, (1994).

Boling E., Kira K., Avers D., Hsu Y. C., Lee J., and Frick T., Naviagting backward: concrete vs. abstract representation in hypertext buttons. Canadian Journal of Educational Communication, 25(2), pp. 161-176, (1996).

Bruner, J. S., Toward a theory of instruction. Cambridge, MA: Belknap, (1966).

Bush, V., As we may think. The Atlantic Monthly, 176(1), pp. 101-108, (1945).

Burton, J. K., Moore, D. M., and Holmes, G. A., Hypermedia concepts and research: an overview. Computers in Human Behavior, 11(3-4), pp. 345-369, (1995).

Chang, C. T., A study of hypertext document structure and individual differences: effects on learning performance. Doctoral dissertation, University of Illinois at Urbana-Champaing, (1995).

Charney, D., Comprehending non-linear text: the role of discourse cues and reading strategies. Proceedings of Hypermedia' 87, Chapel Hill, North Carolina, November 13-15. pp. 109-120, (1987).

Chi, M. T. and Glaser, R., Problem solving ability, In R. S. Sternberg (Ed.), Human abilities: an information processing approach. NY; W. H. Freeman, (1985).

Conklin, J., Hypertext: An introduction and survey. IEEE Computer, 20(9), pp. 17-41, (1987).

Duffy, T. M., and Cunningham, D. J., Constructivism: Implications for the design and delivery of instruction. In Jonasson D. (Ed.) Handbook of Research in Educational Communication and Technology, pp. 170-198, (1997).

Elm, W. and Woods, D., Getting lost: a case study in interface design. In Proceedings of the Human Factors Society 29th Annual Meeting, pp. 927-931, (1985).

Eco, U., Semiotics and the philosophy of language. Bloomington, IN: Indiana University Press, (1984).

Gagne, R. M., Instruction & conditions of learning. In L. Siegel (Ed.), Instruction: Some contemporary viewpoints , pp. 291-313. San Francisco: Chandler Publishing Company, (1967).

Greco, A. A. and McClung, C., Interaction between attention directing and cognitive style. Educational Communication & Technology. 27(2). pp. 97-102, (1979).

Hammond, N. V. and Allinson, L., Extending hypertext for learning: an investigation of access and guidance toos. h A. Sutcliffe and L. Macaulay (Ed.), People and Computer V, Cambridge University Press, Cambridge, (1989).

Jonassen, D. H. and Grabinger, R. S., Problems and issues in designing hypertext/hypermedia for learning. In D. H. Jonassen and H. Mandl (Ed.), Designing Hypermedia for Learning. Springer Verlag. Berlin, NY. pp. 3-25, (1990).

H., Beissner, K., and Yacci, M., Structure Knowledge: Techniques for Representing, Conveying, and Acquiring Structural Knowledge. Lawrence Erlbaum Associateds, Publishers. Hillsdale, New Jersey, (1993).

Keefe, J. W., Learning Style: Theory and Practice. Reston, VA: national Association of Secondary School Principals, (1987).

Korthauer, R. D and Koubek, R. D., An empirical evaluation of knowledge, cognitive style, and structure upon the performance of a hypertext task. International Journal of Human-Computer Interaction, 6(4), pp. 373-390, (1994).

Landow, G., Hypertext: the convergence of contemporary critial theory and technology. Baltimore, MD: Johns Hopkins University Press, (1992).

Liu, M. and Reed, M. W., The relationship between the learning strategies and learning styles in a hypermedia environment. Computers in Human Behavior, 10, pp. 419-434, (1994).

McAleese, R., Navigation and browsing in hypertext. In R. McAleese (Ed.), Hypertext: theory into practice. Oxford, England, pp. 5-38, (1993).

Nielsen, J., The art of navigating through hypertext. Communications of the ACM, 33, pp. 297-310, (1990).

Paolucci, R., The effects of cognitive style and knowledge structure on performance using a hypermedia learning system. Journal of Educational Multimedia and Hypermedia, 7(2/3), pp. 123-150, (1998).

Riding, R. J. and Banner, G.E., Sex and personality differences in second language performance in secondary school pupils, British Journal of Educational Psychology, 56, pp. pp. 366-370, (1986).

Riding, R. J. and Cheema, I., Cognitive styles – an overview and integration. Educational Psychology, 72, pp. 59-64, (1991).

Riding, R. J., On the nature of cognitive style. Educational Psychology, 17(1/2), pp. 29-49, (1997).

Robertson, W. C., Detection of cognitive structure with protocol data: Predicting performance on physics transfer problems. Cognitive Science, 14, pp. 253-280, (1990).

Schwen, T. M., Goodrum, D. A., and Dorsey, L. T., On the design of an enriched learning and information environment (ELIE). Educational Technology, 33(11), pp. 5-9, (1993).

Spiro, R. J. and Jehng, J. C., Cognitive flexibility and hypermedia: Theory and technology for the nonlinear and multidimensional traversal of complex content domains. In D. Nix and R. J. Spiro (Ed.), Cognition, Education, and Multimedia: Exploring Ideas in High Education. Hillsdale, NJ: Lawrence Erlbaum Associates, (1990).

Tripp, S. D. and Roby, W., Orientation and disorientation in a hypertext lexicon. Journal of Computer-based Instruction, 17(4), pp. 120-124, (1990).

Wilson, B. G. and Jonassen, D. H., Hypertext and instructional design: some preliminary guidelines. Performance Improvement Quarterly, 2(3), pp. 34-49, (1989).

Witkin, H. A., Psychological Differentiation, Studies of Development. New York, Wiley, (1962).

Witkin, H. A., Moore, C. A., Goodenough, D. R., and Cox, P. W., Field-dependent and field-independent cognitive styles and their educational implications. Review of Educational Research, 47(1), pp. 1-64, (1977).

Learning Protocols for Knowledge Discovery: A Collaborative Data Mining Approach to Creative Science Education

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One of the creative capabilities of scientists is the ability to turn data (observations) into knowledge, that is, the capability for knowledge discovery. In this paper, we propose a collaborative data mining approach to designing learning tools in educational environments for creative science education. Specifically, students can experience knowledge discovery by engaging in collaborative data mining activities that enable students to cooperate both with the computer and the other students. Data mining process is typically made up of a set of activities such as selection and sampling, preprocessing and cleaning, transformation and reduction, forming knowledge rules, evaluation and revising knowledge rules. The learning process is modeled as a set of learning protocols that properly distribute the data-mining work among students and computers. Based on these protocols, we design and implement a set of learning tools in a web-based learning environment for global climate exploration.

Keywords: **Learning protocol, knowledge discovery, data mining, learning environment, collaborative learning, science education.**

1 Introduction

Among the creative capabilities of scientists, the most important one is the ability to turn data (observations) into knowledge, that is, the capability for knowledge discovery. In this paper, we propose a collaborative data-mining approach to creative science education in learning environments. In this data-mining supported environment, students could observe real world data in different perspectives, derive their own classification rules and test the rules collaboratively, such that they can experience knowledge discovery by engaging in collaborative data-mining activities.

In this paper, we adopt learning protocols [9] to describe the learning processes. Learning protocols are a set of constraints, rules, or processes for structuring learning processes, and are externalized as executable methods, with roles, events, and actions made explicit. Learning protocols can be used to coordinate goal-directed, effective interaction in a group of learners. In this paper, we will devise a set of learning protocols that properly distribute the data-mining work among students and computers.

Based on the collaborative data-mining protocols, we design and implement a set of learning tools in the CILSE-GCE learning environment [7, 8]. CILSE-GCE is a web-based collaborative learning environment for global climate exploration. The task domain, global climate exploration, is inherently a scientific classification problem. Students are expected to induce classification rules by making observations under a couple of climatic features. These tools are designed with the intention not only to teach students the target knowledge, but also the scientific ways of study skills. We believe the students will achieve higher learning goals through the collaborative process of creating knowledge by themselves.

2 The CILSE-GCE Learning Environment

The target domain draws sources from the instructional material in the geographic climate course of senior high schools in Taiwan. One of the domain knowledge is the classification of each climate pattern, which is recognized as a specific set of the climatic attributes. In this paper, we focus on the construction of the climatic classification knowledge. Three components of the CILSE-GCE learning environment were built. They are the Virtual Classroom, Visualized Data Viewer, and Intelligent Tutor, respectively, which are outlined below.

The Virtual Classroom serves as the origin where teachers and students coordinate and collaborate. Through the Virtual Classroom, students could access the multimedia coursebase, the climatic GIS database (via the Visualized Data Viewer) and the historical literature database. These rich data sources allow students to observe, search and collect related information in different aspects regarding to the problems at hand. The CILSE-GCE environment also provides an intelligent tutor to help students induce the classification rules. During the rule induction process, a student has to identify what the settings of the relevant attributes are by exploring resources of all kinds. When he/she determines a specific set of attribute values, the intelligent tutor would evaluate the student's answer, and give suggestions to guide the student's further exploration.

A set of rich data sources are needed to allow students to observe, search and collect related information in different aspects regarding to the problems at hand. In the Visualized Data Viewer, rich climate information could be displayed in different layers of maps covering the globe. Students could select, resize and combine different information layers for display to investigate the climate attributes in different perspectives. Hotlinks to climatic data and statistical graphs associated with the typical cities are also provided to allow students to do some measurements and inferences. Up to now, we have collected more than 1700 city records of various kind of climatic information, such as latitude, temperature, precipitation, height above sea level, etc. This database is the main data source that students can collect related data and perform data-mining process to discover the classification knowledge. Figure 1 shows a snapshot of the Visualized Data Viewer.

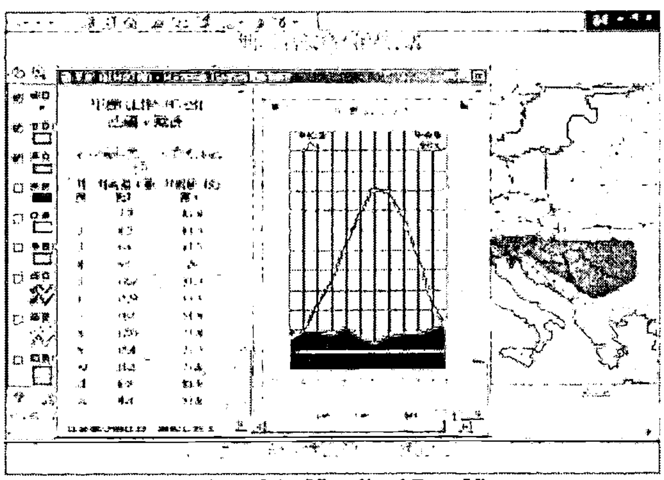


Figure1 A snapshot of the Visualized Data Viewer system.

3 Collaborative Data Mining as Knowledge Discovery

For creative science education, students are asked to acquire the learning skills of knowledge discovery, such as making observations and data collections, performing data analysis, generating hypotheses, testing hypotheses, and making conclusions. Standing from the viewpoint of knowledge discovery [2], we model the learning process as a data-mining process. Figure2 shows the set of data-mining activities, such as selection and sampling, preprocessing and cleaning, transformation and reduction, forming knowledge rules, evaluation and revising knowledge rules. Some steps of the data-mining process can be handled well with computer supports, especially those involving tedious computations and comparisons. Other steps are more suitable to be learning tasks for human students. In this section, we propose the framework of collaborative data mining within which each student member first applies the data-mining process to generate his/her private knowledge base, and then all students collaboratively integrate their private knowledge bases to a more general knowledge base, a result of social consensus process.

The first step in the data-mining process is to select a target data of interest from database, and to possibly sample the target data. The learning skills required of the students are the capability of observation and data collection. Based on the aspects they observe data, students can select all relevant attributes they think might be important to the classification problems at hand. Besides, there are so many samples in the database that students have to learn the sampling skill by selecting as typical samples as they can.

Secondly, the preprocessing and data cleaning step handles noises and unknown values, as well as accounting missing data fields. This step can be dealt with quite well with computer software. Thirdly, the data reduction and transformation step involves checking relevant features depending on the goal of the learning task and certain transformations on the data such as converting one type of data to another (e.g., discretizing continuous values), and/or defining new attributes. It is this step that testifies the hypothesis of attributes that students generated at the previous data observation step.

In the knowledge formulation step, students may apply one or more knowledge discovery techniques and tools on the transformed data set to extract valuable patterns. In this step, students can learn domain-dependent skills as well as the ability to work with computers, as is practiced by most scientists nowadays. Finally, the knowledge evaluation step involves interpreting the result with respect to the goal/task at hand. And as is often the case, students may get back to previous steps based on the evaluation results. Well-designed OLAP (OnLine Analysis Processing) tools are required for students to practice such kind of data analysis tasks. Note that the data-mining process is not a linear one. It might involve a variety of feedback loops, because any one step can result in changes in preceding or succeeding steps.

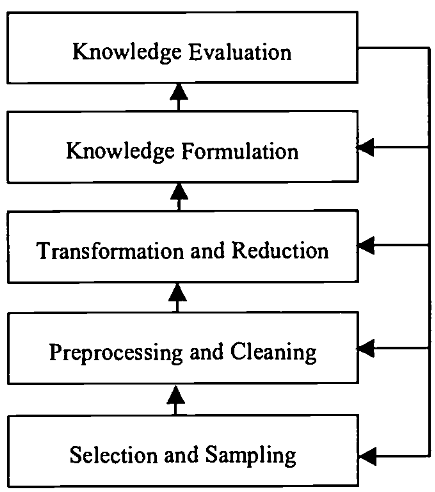


Figure2 The data-mining process.

4 Learning Protocols for Collaborative Data Mining

Learning protocols can be used to coordinate goal-directed, effective interaction in a group of learners. A learning protocol consists of a set of components. First, a protocol has a name signifying the situation type to which the protocol can be applied. Secondly, a protocol consists a set of states and transitions. In each state the users can perform actions such as communicate or manipulate artifacts. A transition to another state is triggered by an action or a specific condition. Actually, a learning protocol can be represented as an event-driven state-transition graph. Thirdly, a protocol includes different roles pertaining to the persons involved in the enactment of the protocol. Finally, a protocol may contain various types of artifacts, such as text documents, graphical objects, test forms, etc. In the following, we design a set of learning protocols for the collaborative data mining process.

4.1 The protocol to construct member knowledge

The protocol shown in Figure 3 outlines the actions of personal data-mining process and coordinates the interactions between a student and the computer. There are totally ten states in the protocol. Each state and transition is described as follows. In the Observing Data state, the student observes the data in all aspects he/she consider important to classify the climatic patterns. The main data source is the Visualized Data Viewer. The student then defines a set of attributes (in the Defining Attribute state) that will be used to classify the climatic patterns. In the Sampling state, the student starts to collect data (cities) and fill in all the details of the climatic attributes that he/she had defined. Since some of the attributes are numeric values, the student has to transform them into symbolic ones (like temperature is high or low) in the Discretizing Attributes state for more data understandability.

In the Mining Rule state, students have to extract and write down the classification rules hidden in the collected data. For this purpose, we design a set of data analysis tool that depicts the distribution graph or dependency graph of the climatic data based on the attributes specified by the students, such as the ones shown in Figure 4.

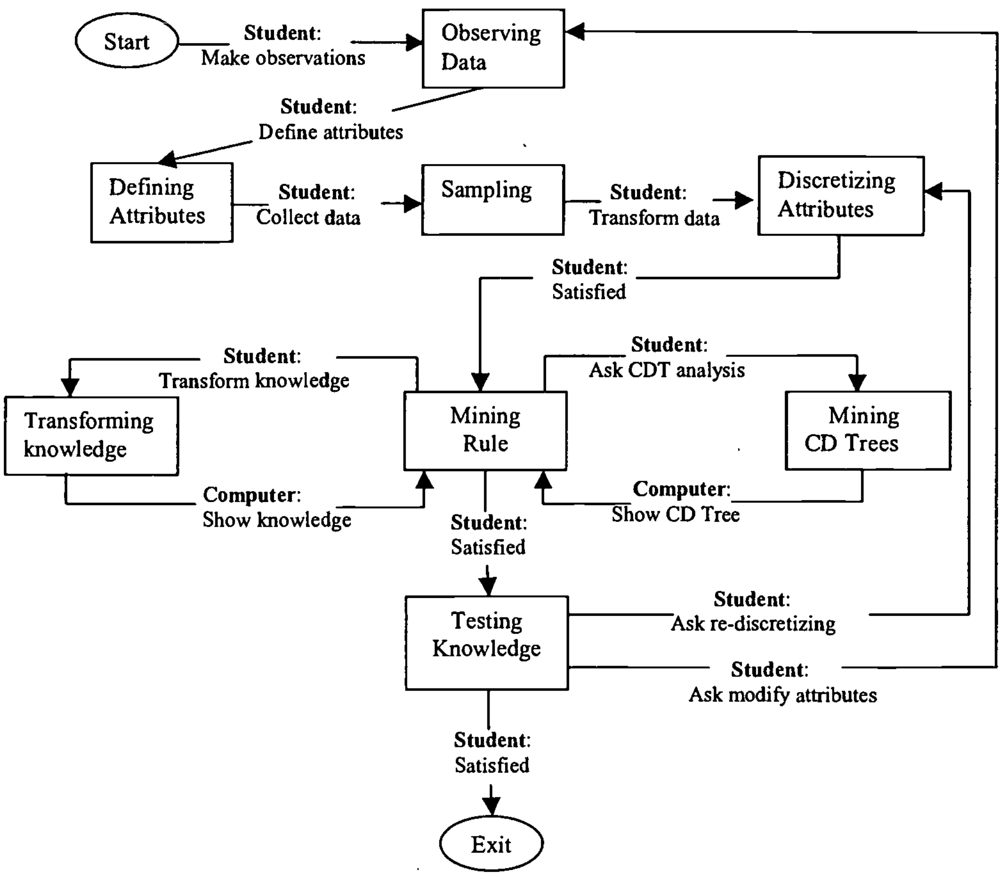
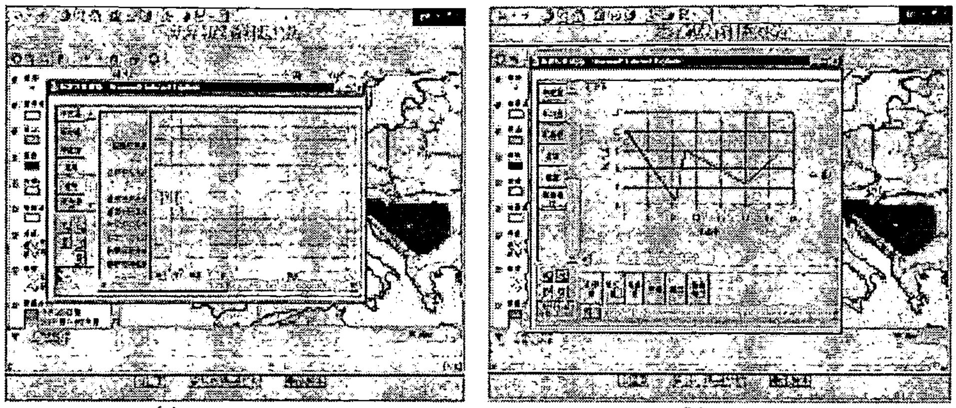


Figure3 The personal data-mining learning protocol.



(a) (b)

Figure4 (a) A data-mining support tool for comparing frequency distributions. (b) A data-mining support tool for depicting data dependency graphs.

Nevertheless, it would be still difficult for some students to discover the hidden knowledge (rules) without further computer supports. Hence, we design and implement another tool to facilitate the data-mining process in the Mining Decision Tree state. This tool uses a variation version of ID3 algorithm [4] to devise a Composite Decision Tree (CD Tree) out of the collected data. A As shown in Figure 5, students can use the CD tree to select and compose classification rules that are of more accuracy, stability and understandability. While rules provide a good local view of each knowledge unit, CD Trees provide another view that facilitates the comparison of different rule structures. . In the Transforming Knowledge state, the student can exchange the knowledge format from CD Trees to Rules, and vice versa. At last, the student can test his/her classification knowledge against the city cases in the Testing Knowledge state, and decide whether to further revise the knowledge.

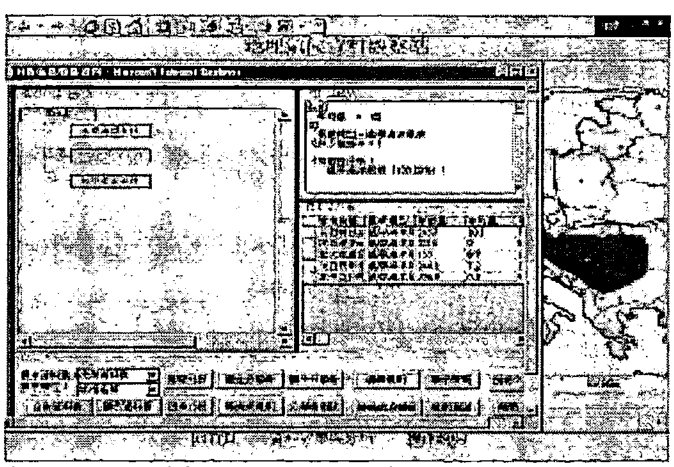


Figure5 A data-mining support tool to help students extract hidden knowledge (classification rules) from data.

4.2 The protocol to integrate group knowledge

After each student member establishes his/her own knowledge, the student group starts to perform the knowledge integration task collaboratively. The students achieve the knowledge integration goal by solving the classification problem collaboratively, trying to reach a consensus, which is the group knowledge. The corresponding learning protocol is shown in Figure 6. In the Presenting Cases state, a Coordinator (a software agent) selects a city case from the database for the student group to identify its climatic pattern. In the Classifying Case state, each student member applies his/her knowledge to solve the problem, and shows the applied rule and related information (such as the symbolic terms for each numeric attribute) in a shared working space. With the information shown in the shared working space, each student member starts revising his/her own knowledge by references to the correct answers and the colleagues' knowledge. Detail of the Revising Knowledge state is described in next protocol. Each time the member knowledge is revised, a new applied rule is sent once again to the shared working space. This process will loop until a temporary consensus is reached. At last, the Coordinator store the final rule set into the integrated knowledge base (i.e., the group knowledge). We adopt the Blackboard Architecture [3] to implement this learning protocol.

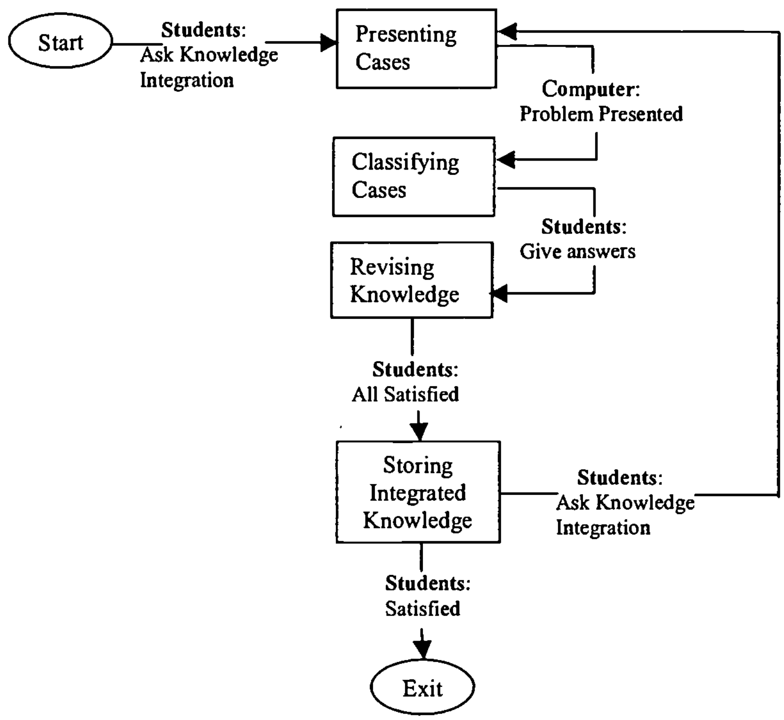


Figure6 The collaborative knowledge integration learning protocol.

4.3 The protocol to revise member knowledge

When students ask to revise his/her private knowledge, the knowledge revising learning protocol, as shown in Figure 7, is entered. In this protocol, two kinds of knowledge operations, the knowledge generalization and knowledge specialization operations, are supported. Each student member can revise his/her private knowledge by applying the two knowledge operations and/or exchange knowledge through the Group Chatting state that involves chatting-support tools. Each kind of knowledge operation can be applied to the various artifacts such as rule structures, numeric attribute intervals, and attributes. Specifically, in Knowledge Generalization state, students can delete conditions from rules, reduce numeric attribute intervals or delete some attributes from the attribute set, while in Knowledge Specialization state, the students can add conditions into rules, extend some numeric attribute intervals or add new attributes into the attribute set. To facilitate both kinds of knowledge revision, an automated rule testing and warning subsystem is implemented to list the rules that are potential for further generalization or specialization based on the test result against any data set.

5 Conclusions

In this paper, we have proposed and implemented a collaborative data-mining support tools for knowledge discovery in creative science education. These functional extensions are being integrated to our previous Web-based learning environment, CILSE-GCE. This collaborative process fosters all the constructive design principles mentioned in [1, 5], such as observation, interpretation construction, contextualization, cognitive apprenticeship, collaboration, multiple interpretations, ownership of knowledge, self-awareness of construction process. In this collaborative learning model, students would experience the process of looking for patterns collaboratively. Besides, we find that learning protocols are very effective ways to the description and implementation of learning processes. Finally, it is indicated that during free exploration of a problem space, greater learning occurred if students adopted more systematic strategies for rule induction [6]. Further evaluation tests will be conducted to provide beneficial evidences of such kinds of discovery learning.

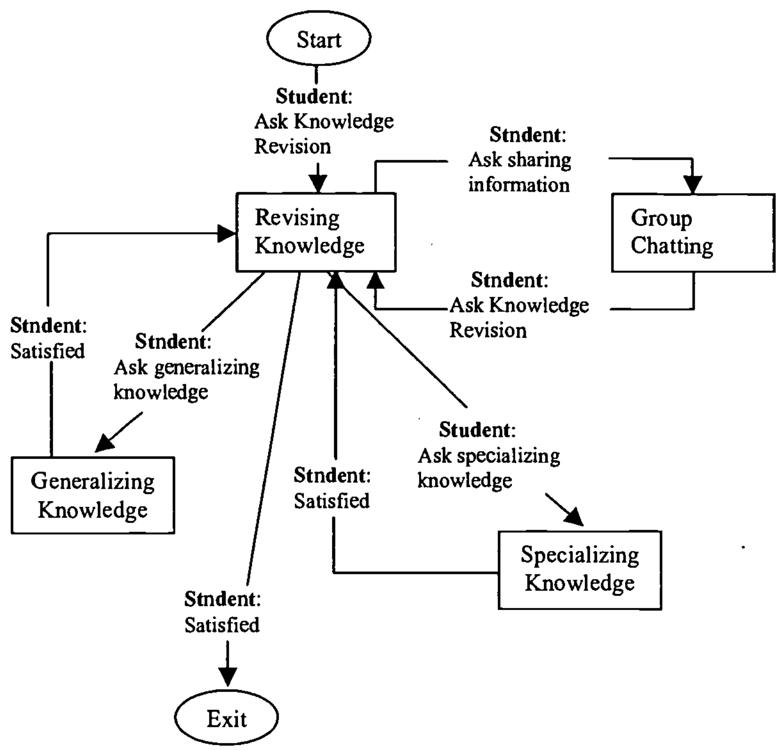


Figure7 The knowledge revising protocol.

References

[1] Black, J. B. & McClintock, R. O., "An interpretation construction approach to constructivist design". In B. G. Wilson & D. N. Perkins (Eds.), "Constructivist Learning Environments: case studies in instructional design" (pp. 25-32), Englewood Cliffs, NJ: Educational Technology Publications, (1996).
[2] Fayyad, U. M., "Data mining and knowledge discovery: Making sense out of data", IEEE Expert, Vol.10, pp. 20-25, (1996).
[3] Nii, H. P., "Balckboard systems: Blackboard application systems from a knowledge based perspective", AI Magazine, Vol. 7, No. 3, (1986).
[4] Quinlan, J. R., "Induction of decision trees", Machine Learning, Vol. 1, No. 1, pp. 81-106, (1986).
[5] Honebein, P.C., "Seven goals for the design of constructivist learning environments", In B. G. Wilson & D. N. Perkins (Eds.), "Constructivist Learning Environments: case studies in instructional design", (pp. 11-24). Englewood Cliffs, NJ: Educational Technology Publications, (1996).
[6] Vollmeyer, R., Burns, B. D. & Holyoak, K. J., "The impact of goal specificity on strategy use and the acquisition of problem structure", Cognitive Science, Vol. 20, pp.75-100, (1996).
[7] Wang, F. H. & Chen, C. H., "CILSE-GCE: A collaborative intelligent learning support environment on world wide web", Annual Meeting of ED-MEDIA, Seattle, WA, USA., June, pp. 264-269, (1999).

[8] Wang, F.H., "On the design of an intelligent exploratory environment for geographic climates on WWW", Computer Networks and ISDN Systems, Vol. 30, pp. 699-700, (1998).
[9] Wessner, M., Pfister, H. R. & Miao, Y., "Using Learning Protocols to Structure Computer-Supported Cooperative Learning", Annual Meeting of ED-MEDIA, Seattle, WA, USA., June, pp. 471-476, (1999).

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Navigation Script for the World Wide Web

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In the World Wide Web, there is rich material for education. We propose a language to navigate students through the educational material on WWW. Navigation script makers can describe a tour with sequential, parallel and selective controls. It supports multiple Threads where video and audio accompany a browsing window. The language is described with XML and implemented in Java. So, the system can be used as an applet and as an application.

Keywords: **Hypermedia navigation ; Web graph ; XML ; JAVA**

1 Introduction

In the World Wide Web, there is rich material for education. For example, many university teachers give the contents of their lectures as their homepages. This paper describes a system which utilizes internet resources as educational material and makes them into an organized tour. The tour is described in a script language and an interpreter program navigates students through the material on WWW. Students are navigated automatically and interactively while they browse html-files and listen to and watch continuous multimedia.

We need to collect necessary pages from web resources containing a lot of garbage in order to make lists of URLs for our educational purpose. It is important to have students understand the relation between the collected pages and grasp the whole view of the field. When they do not understand the relation, or when they forget how they arrived the page, they feel that they got ``lost in webspace". There is a proposal of using web graphs as imaginary map of WWW[3]. A web graph is a directed graph whose nodes are URLs and whose edges are links between URLs. The web graph is more intuitive than just a list of URLs. But a web graph is nothing but a static representation of WWW. There is no mechanism how to lead students with material on the graph. There is no dynamic process to navigate them. We propose a script language that describes the navigation of WWW.

Maps are useful for navigation of real world and for navigation of WWW. For example, the page of Mapion http://mapion.co.jp/ shows geographic maps of towns. Besides, ``car navigation systems" based on GPS are becoming popular. RWML[5] and NVML[6] are proposal to combine the geographic map and the information on WWW. NVML describes the driving course, distance, time and supplies messages and images for specified points. When the car passes the point, a message and a image will appear according to a signal from GPS. The main concern of these researches is in geographic maps and navigation in real world. The maps we consider are imaginary maps of internet resources. Our goal is to design a language to describe a tour of WWW and to implement an interpreter of the language.

Ariadne[4] is a system of WWW navigation. It has a browser window and a separate window of tour. A user views the map of the tour and can proceed forward, backward and can choose if there are branches on the tour. But user needs to control every step of navigation. Our system supports both interactive and automated navigation. Another feature of our system which lacks in Ariadne is the parallel navigation. In our system, while a user is watching a browser window, another navigation thread can play audio data.

WebOFDAV[1] is a visualization system of web graph. When a user is traversing a series of URLs, the system draws the local graph of visited pages. The graph changes dynamically following the user. WebOFDAV is useful to tell where we are on WWW and powerful to get rid of the problem of lost in webspace. But the graph is used only for an aid for browsing and no navigation route is provided.

The rest of paper is organized as follows. The section 2 analyses the basic feature of navigation of WWW. The section 3 describes the navigation script using XML and explains the visualization of the scripts. The section 4 introduces a virtual machine with two stacks, which enables forward and backward navigation. The section 5 summarizes the paper.

2 Navigation Script

The most important feature of the navigation system is to guide the user around web pages in specified order. Therefore, we adapt sequentiality into navigation language. And to make the contents of html-files easier to understand, we need to combine audio, video, and images together with the usual browsing window. We introduce parallelism. To increase the variation of the navigation depending on each visitor, we add selection mechanism in the language. We design the language as a structured programming language with sequential, parallel and selective controls. The basic navigation units are multimedia data specified as URLs.

We chose XML as the description language of the navigation for simplicity and extendability. As implementation language we chose Java. We use "XML Parser for Java"[2] for XML parser,and "JMF"[7] for multimedia data. We describe the language as the following DTD (Document Type Definition).

```
<!ELEMENT statement (simple|sequential|parallel|select)>
<!ELEMENT simple (message)>
<!ATTLIST simple kind CDATA #REQUIRED
  target_name CDATA #REQUIRED
  play_time CDATA #REQUIRED
  delay_time CDATA #REQUIRED>
<!ELEMENT message (#PCDATA)>
<!ELEMENT sequential (simple|sequential|parallel|select)*>
<!ELEMENT parallel (simple|sequential|parallel|select)*>
<!ELEMENT select (selector)+>
<!ELEMENT selector (simple|sequential|parallel|select)>
<!ATTLIST selector selectname CDATA #REQUIRED>
```

Each tag and parameters have the following meaning.

- <statement>: This tag represents the root of navigation tour. It may contain subtours as children. There are four kinds of tours,<simple>,<sequential>,<parallel> and <select>.
- <simple>: This is the basic unit of the navigation. It contains a few lines of messages to describe the contents of the web page. It has the attributes of kind, target name, play time and delay time. Target name specifies the URL of the data. The kind describes the kind of multimedia data. Play time is the duration time and delay time is the time to wait before play.
- <sequential>: It may contain subtours of the kind <simple>, <sequential >, <parallel> and <select>. Subtours are followed consecutively.
- <parallel>: It may contain subtours of the kind <simple>, <sequential>, <parallel> and <select>. Subtours are activated in parallel.
- <select>: This tag causes a pause of the system. User can choose the navigation selectively from the given subtours. Those subtours are provided as children with the tag <selector>.
- <selector>: It may contain a subtour of the kind <simple>, <sequential>, <parallel> and <select>. It has the selectname as an attribute, which is used in the select menu.

3 Navigation Window, Control Panel and Browsing Window

Fig 1 is a screenshot of the system, which has a browser window, a quicktime movie screen, the controller screen and the window of navigation script.

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We chose the representation with nested boxes for the visualization of navigation script instead conventional DOM-tree of XML nodes for several reasons. The most important feature of the navigation is the flow of time. To visualize this, we draw the subtours of a sequential tour from left to right. In Fig 1, time goes horizontally from left to right. Parallel tours and visualization of selection are placed vertically. The difference is that each subtour of the selection has its name, specified with its selectname, and the order in the choice. For example, if a selection has three choices, the second subtour is displayed as ``2/3 selectname".

Visualization of navigation script is not only for static view. It has a control panel and user can go forward and backward along the navigation. When a node is displayed on the browser window, the node in the navigation window is highlighted. So, the user has always global view of the navigation.

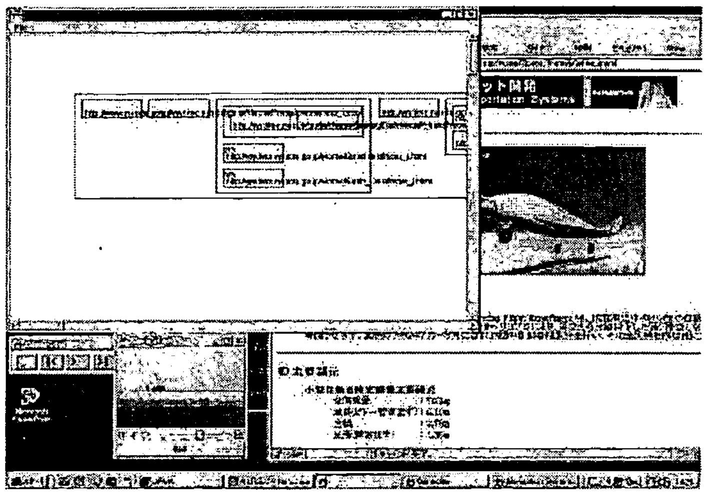

Figure 1: Screenshot

4 Interpreter of Navigation Script

Navigation is performed according to the kind of statement. Parallel statement opens a new browser window and a different thread performs the navigation in parallel.

The interpreter has two modes, the fully automatic mode and the interactive mode. Basically, the interpreter displays the specified html-files on the browser window. It displays the html-file on the screen for "play time" and changes to the next screen. When the user wants to see in detail, he can make a pause. He can go backward as well. The controller interacts with the user. The functions of the controller are "pause", "play", "forward", "backward", "rewind" and "stop". The "play" and "pause" toggles the mode. The "forward" and "backward" are for interactive mode. The browser screen moves one step in the sequential statement. This control is different to the controllers of multimedia players for the continuous media.

To realize forward/backward control in the navigation, we use two stacks of statements in the interpreter. The first stack "do"contains the list of statements to follow. The second stack "done" contains the list of statements already performed. The interpreter is realized by a transition of states depending on the top of the two stacks.

4.1 Forward Transition

Due to the limit of space, we only explain the forward transition concerning to parallel statement. If a parallel statement contains substatements, the interpreter creates n-1 threads which begin execution with ``done" stack empty and whose "do" stack contains the substatements. For example, a parallel statement "<parallel>a b c</parallel>" creates two new threads(Fig 2).

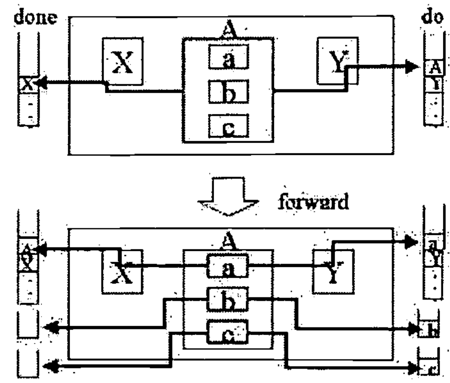

Figure 2: Forward Transition for Parallel Statement

4.2 Backward Transition

In the backward transition, the interpreter pops the statement at the top of ``done" stack and pushes it on "do" stack. If it is a sequential statement, then all the substatements are poped out of the "do" stack. A situation, where the "done" stack is empty, occurs only after a forward transition of a parallel statement. To go backward from such a situation, we need to delete such threads activated by the parallel statement.

5 Conclusions

We proposed a language for the navigation of WWW and described its implementation. The material of a navigation tour is web pages and multimedia data on WWW. The navigation script is defined as DTD of XML. Anyone can create a dynamic navigation from a static list of URLs. The language supports multimedia data and provides sequential, parallel and selective constructs of the tour.

References

[1] M. L. Huang, P. Eades, R. F. Cohen, ``WebOFDAV -navigating and visualizing the Web on-line with animated context swapping", Proceedings of 7th international WWW conference, Computer Networks and ISDN Systems, Vol. 30, no. 1-7, 638-642, (1998).

[2] IBM, ``XML Parser for Java", http://www.alphaWorks.ibm.com/tech/xml4j/(accessed on August 9,2000).

[3] D. Ikeda, T. Taguchi, S. Hirokawa, ``Developing a Knowledge Network of URLs", Proceedings of Discovery Science '99', Springer Lecture Notes in Artificial Intelligence Vol. 1721, 328-329, (1999).

[4] J. John, A.T. Jensen, K. Geronbak, ``Ariadne:a Java-based guided tour sys-tem for the World Wide Web", Proceedings of 7th international WWW conference, Computer Networks and ISDN Systems, Vol. 30, no. 1-7, 131-139, (1998).

[5] RWML Working Group, ``Road Web Markup Language (RWML) Draft Ver.0.71a (in Japanese)", http://www2.ceri.go.jp/its-win/RWML/RWML-071.html (accessed on August 9,2000), (1999).

[6] M. Sekiguchi, K. Takayama, H. Naito, Y. Maeda, H. Horai, M. Toriumi, "NaVigation Markup Language (NVML)", submission to the World WideWeb Consortium, http://www.w3.org/TR/NVML(accessed on August 9,2000), (1999).

[7] Sun Microsystems, ``Java Media Framework", http://java.sun.com/products/java-media/jmf/2.0/index.html (accessed on August 9,2000).

Proposal of an XML-based Knowledge Sharing and Management System Supporting Research Activities

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The proposed system is primarily focused on research activities which create various kinds of knowledge through trial and error. The knowledge is classified into formalized knowledge, such as papers or reports, and un-formalized knowledge, such as suggestions or advices. The former is easily utilized for research activities, because they are accumulated as visible data. However, the latter is not utilized in many cases even if they are informative and useful. Therefore, a web-based management system giving attention to un-formalized knowledge as well as formalized information would be a possible solution. This paper describes the features of the system based on the XML, and shows an example of usage through a trial system. Functions of the system include: (1) collecting un-formalized information related to formalized knowledge, (2) connecting un-formalized knowledge with formalized knowledge, and (3) creating feedback information while using the system. The system creates a repository in a lab, a collaborative space for research activities, and a set of new document and knowledge.

Keywords: **Research Activities, Knowledge Sharing and Management System, Formalized/Un-formalized Knowledge, XML**

1 Introduction

Researches on system environments that share knowledge on the Web have increased because of the needs for accumulating and utilizing knowledge [3][8]. Specially aiming learning activities, the Covis [1], for example, visualizes processes of collaboration between users, and memorizes the processes through the Covis Collaboratory Notebook. Another example is the CSILE [4][9] with networked computer environment particularly designed to support progressive discourse. In CSILE, students write text or graphic notes to convey their explanations. Similarly, the KIE [6] have collaborative environments that make network discussion possible by using the interface called Netbook. Users of the Shrlok [2] also have shared knowledge environments. They can discuss their opinions in an opened condition and make hypertext links between relevant knowledge. Thus, users of these four systems can exchange their own opinions and argue their individual ways of thinking, based on ideas and questions stored in the Database (DB) system [7]. Therefore, in these four systems, students can be subjective while having clear objectives. Teachers can also help students solve problems, and students can collectively work on problems.

The process of advanced researches, on the other hand, is not the same as that of education because researches might not always have definite objectives. In many cases, new things can be discovered from one trivial thought, and researchers enlighten and encourage each other. Individual studies can be more important in a condition where there is no instructive person who clearly knows and ultimate goals. Although research activities have a different characteristic from education activities that have clear goals, few studies aiming research activities have been discussed.

This paper proposes an XML-based knowledge sharing and management system. It focuses on an accumulative style of knowledge management for supporting research activities, rather than for learning.

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The activities in a laboratory produce various kinds of knowledge by repeating trial and error. That knowledge is classified into formalized knowledge, such as papers or reports, and un-formalized knowledge, such as suggestions or advices. The former is accumu lated as visible data in the form of paper material or digital data. On the other hand, the latter is only spoken and is not represented in the real material. Therefore most of that information is not recorded. However, it is important to accumulate and share the un-formalized knowledge because live suggestions or advices are often very useful to promoting research activity. Their accumulation is useful for participants to remember knowledge and also for peer that cannot attend the discussion process.

Thus, we focus on this un-formalized knowledge. By making the un-formalized knowledge active as memorandums and by connecting them with meta-data of formalized knowledge, the proposing system creates a new set of knowledge documents, Knowledge DB. Proposing system allows users to produce feedback information while using it. The system by using the XML could effectively help research activities. Finally we provide some considerations on the prototype system.

2 The outline and features of knowledge sharing and management system

Chapter 2 summarizes the features of the proposal.
The system consists of the following three steps.
(1). It attaches un-formalized knowledge with formalized knowledge, for example paper and reports, as memorandums.
(2). It connects the above information with meta-data of formalized knowledge.
(3). It utilizes connected knowledge and feedback the information.

If more than two documents share the same information, they are connected through a memorandums. That is to say, the memorandum connects clearly the original documents existing independently in DB. Such connections are useful for the documents retrieval and research analysis. Further, continuous cycles of connection, searches and analyses can be occurred, which assemble a lot of knowledge and information.

At this time, the trial of this system is focuses on Research DB. However, it is reasonable that fundamental policy is not changed even if the DB is changed, because XML is used for exchanging between applications and our system process only the meta-data.

Three advantages of the system are:
- It provides auxiliary information for user's document retrieval by attaching a memorandum to original documents.
- The original documents are related with each other by the connection with the memorandums, and it creates a new document set.
- It supports continuous research activities for users to analyze sets of information and knowledge.

3 Adoption of XML technology

Chapter 3 discusses advantages of the XML, which is one important characteristic in the system.

We adopted the XML, a standard language for information exchange, for two reasons. The first was the need to do knowledge management on the Web because the sharing space accumulated knowledge can be accessed anytime and anywhere. The second was the need to consider the connection with another advanced DB, such as CG and 3D data. Thus, the system would be more flexible because of the XML.

Effectively, the XML is used in two aspects. One is as a way for exchange between DB and systems. The other is for the preservation of information, including the XLink function [10]. Considering that memo randum and data items can change in near future, XML has several advantages: It can set flexible data lists, and express arbitrary number of elements in a tree structure [5].

4 The system configuration

Chapter 4 shows the configuration of the system.

The system consists of three main parts: (1) Sets of Knowledge-Memos, (2) Knowledge processing system, and (3) Interface for knowledge sharing on the Web. (Fig.1). The role of the part (1) is collection and accumulation of knowledge. Part (2) connects two kinds of knowledge. Part (3) relates to the interface for users. The followings sections present their details, respectively.

4.1 Set of Knowledge-Memos: Collection, accumulation of the memorandums

The system needs to collect un-formalized knowledge, such as advices or suggestions from teachers and researchers, even though they are not in any form. Thus, the style of memo randums to formalized knowledge, like papers, are adapted. This chapter presents the concept of "Knowledge-Memo".

4.1.1 The proposition of the Knowledge-Memo concept

The system adopts concept of memorandum called "Knowledge-Memo", in order to collect un-formalized information. We classify Knowledge-Memos into two types to be attached to the original documents in accordance with their natures. In this way, layers of un-formalized knowledge can be created.

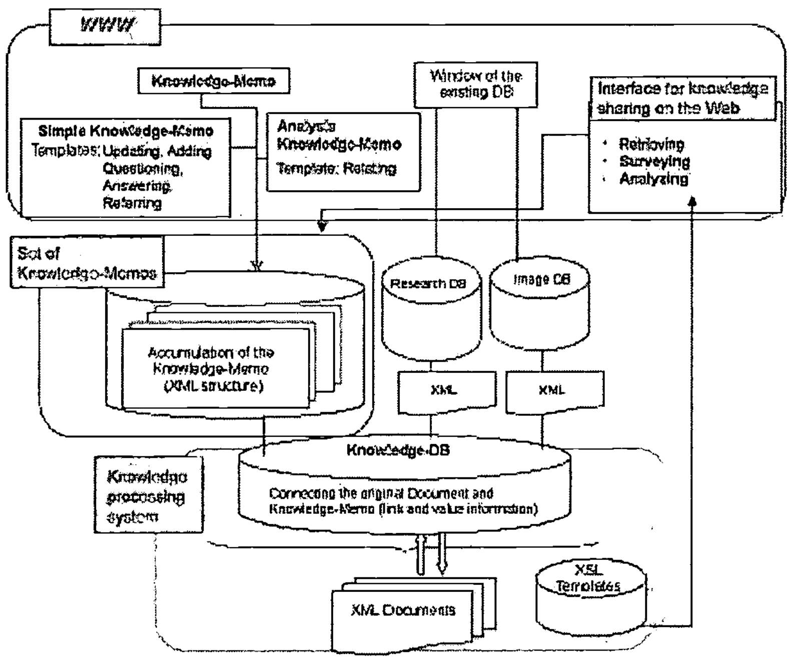

Fig.1. System overview

Simple Knowledge-Memo: specific information which users want to attach. For example, "This paper is an updated version of named B paper." This type of memo randum can be registered at the same time original paper is entered in the DB.

Analysis Knowledge-Memo: constructed and connected information that is based on researchers' analyses. This type of memo randum can be a Simple Knowledge-Memo because it can be re-analyzed. Users would register Analysis Knowledge-Memo as research results of documents and memorandums.

According to making of the Knowledge-Memo, new sets of documents are created. One objective of proposed system is to change from fragmentary and separated information to collected new knowledge, due to the analyses of researchers in a common created space.

4.1.2 Collection and accumulation of Knowledge-Memo

The following templates make inputting memo randums simple.
Information inputted in prepared templates is stored on the Web as Knowledge-Memos through XML structure. Types of the Simple Knowledge-Memo are updating, adding, questioning, answering and referring. Analysis Knowledge-Memo includes relating memo randums.

Usage of these templates is as follows.
Updating templates: describing information and explaining reasons for renewal, which create relationships between before and after renewal.
Adding templates: adding information, such as advices and references to original documents.
Questioning templates: asking questions to documents. When inputting Questioning templates, e-mails would be simultaneously sent to a person who created the original documents.
Answering templates: answering to questions. Automatically sent to the person who wrote questions.
Referring templates: referring to external documents and create new relationships with sites on the Web.
Relating template: describing relationships between documents which are based on analysis of documents and Knowledge-Memos. More than two documents and memos can have relationships.

Several tags of the XML are also used:• • <key> for keywords, • <hi> for highlights, •
 for starting new lines. In an experimental usage of the system, users were free to use these tags without any restriction and enforcement. If tags were used, words would be shown in only emphasized style on the screen. (Fig.2). However, the system would better more reflect users' intentions if the use of new tags were available and inventive Extensible Stylesheet Language (XSL) was developed.
As previous discussion shows, the system has an advantage of creating sets of documents, which reflects users' intentions.

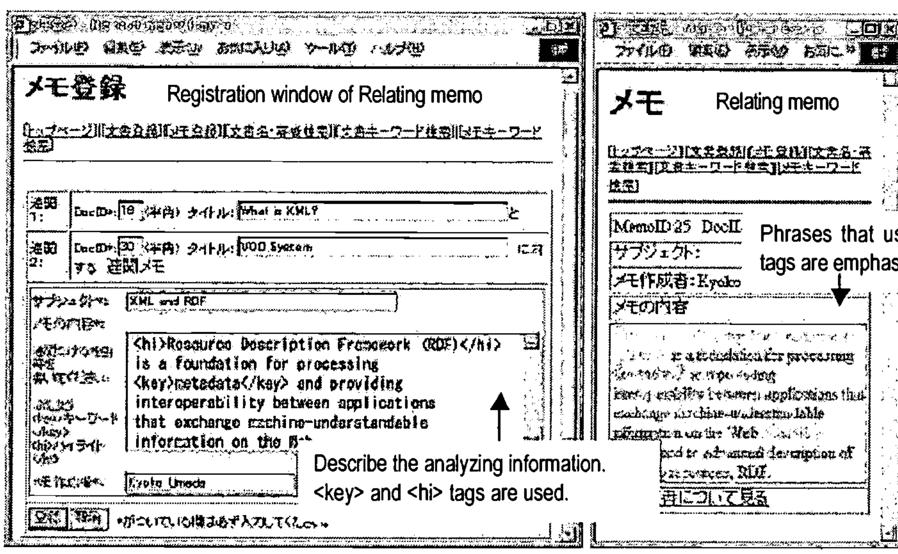

Fig.2 Input screen of "Relating memo" used to input XML tags. (Left)
The "Relating memo" including enhanced expressions created through XSL (Right)

4.2 Knowledge processing system: Connecting the original document and Knowledge-Memo

After collecting un-formalized information, the system connects it with formalized information. Such connection creates a Knowledge repository.

The process of connection is as follows. First of all, this system picks up necessary meta-data from Research DB and stores it in a XML structure. Such information is connected to the Knowledge-Memo which is also in a XML structure. Thus, a Knowledge repository is created. The system employs XLink function to connect un-formalized information with documents. Because of XLink potential, it is possible to make multidirectional links among original documents from a remote resource, that is, from a Knowledge-Memo related to original documents. Moreover, the system also creates lists of linkage information about existing Knowledge-Memos related to one original document. That is, from one individual document all its existing connections are easily obtained (Fig.3). Unfortunately, the experimental utilization of the system in this paper uses Internet Explorer5 which still does not support all these XLink functions. That is why the system utilizes link functions of HTML, reflecting the structure of the XLink. If the XLink was supported, it would be easily possible to make relationships between documents through the above simple structure. The fact that these connections are automatically created by users' simple operation constitutes an advantage of the system.

The Knowledge DB pulls out necessary information, and displays on a Web interface. The system uses XSL templates to arrange and display requested information.

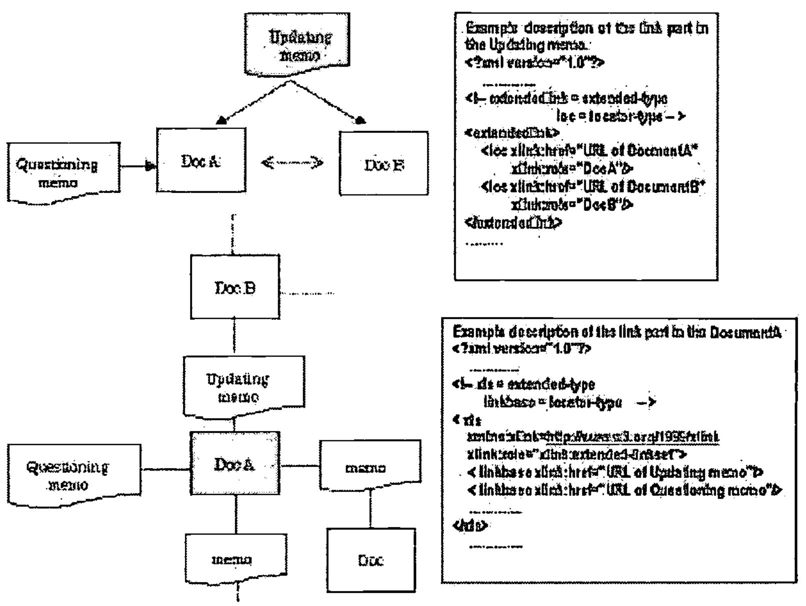

Fig.3 Description examples of relation between documents and Knowledge-Memo based on XLink. The memorandum associates remote documents through extended link (above). The external linkset centralizes the link information (below).

4.3 Interface for knowledge sharing on the Web

Peers use a trial system on the Web as a part of research activities. In order to make a user-friendly interface, we studied the flow of research activities. As the result, three processes, such as retrieving, surveying and analyzing information, are prepared for their research activities.

First, two retrievals are available, which include searching documents and Knowledge-Memos. Document search is a method which is often used, and it searches a document from a title or keyword. If an Updating memo is shown as a result, and there are some corrections on the documents including updated document. In another word, Updating memo provides help of the retrieval. Moreover, a renewal reason has the possibility to become a reference when a peer writes a paper. Retrieving from Knowledge-Memos may be useful for getting information toward vague ideas. I can be more efficient than previous ways, because researched results are sets of documents and memorandums. Further, due to the XSL, it is possible to sort by dates and to filter by types of memorandums.

In a Surveying process, connection between documents and memorandums is visualized, when traversing search results. For example, even if users think that there is no relationship between documents, there might have some kind of relationship after following links. Such new researches can help proceeding researches.

With respect to analyzing information, a new finding, resulted from surveying information, can be used for making analyzing memo in a combination with related and added memo randums. These processes can be continued by adding new information and findings that stimulate utilization. On the Web, a common space, such utilization can increases effective research activities. .

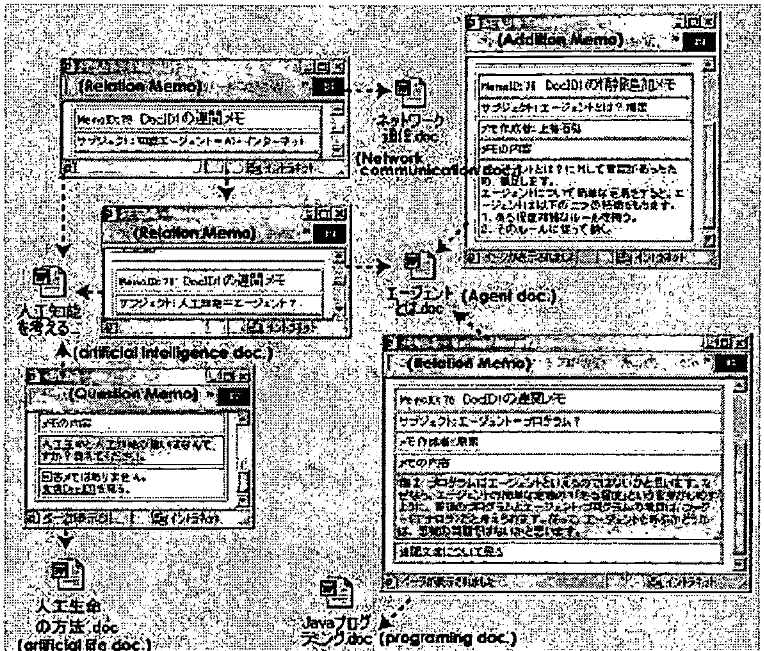

Fig.4 Set of knowledge by Analyzing; Knowledge-Memo and documents related to it.
Documents and Memos are gathered around the "Agent document".

5 Prototype evaluation

Usage of the system and evaluation of the prototype are discussed and reviewed in this section.

5.1 Usage of the system

In order to study further, followings show a way of system utilization, based on discussions and reports in a research group which studies agent technologies in a laboratory. Suppose that there are three members, named A, B and C, in the group.

(1) "A" makes and reads a report, "About Agent" in a seminar. After the seminar he registers the report in Research DB. At the same time, conclusion of discussion, advice, etc. are also registered as Knowledge-Memos.

(2) "B" who was absent for discussion reads the report. Then "B" asks, "What does autonomy mean?" in a Questioning memo. Such question is registered in memo randums of questions related to reports, and at the same time, "A" will get the e-mail.

(3) "A" answers the question from "B" in Answering memos, which is registered in Answering memos, and e-mail is sent to "B".

(4) "C" tries to do a programming of an agent by using Java. He finds a report of "About Agent" written by "A" through a keyword search, "agent". "C" completes his report, referring A' s report. . He makes a Relating memo, for example, describing which part of the agent report is quoted and how it is useful for him.

After repeating these memorandums registrations, it is possible to analyze information as shown Fig.4. Members of agent seminar could gain the following effects at this time.

5.2 Test results

Seven students in a lab used a practical sample test of the system, and answered questionnaires. Table.1 shows the results.

	Yes	No
(1). Helpfulness of the Knowledge-Memo.	93%	7%
(2). Easiness of inputting the Knowledge-Memo.	58%	42%
(3). Acceptance of sharing ideas written in the memo with other users.	93%	7%
(4). Satisfaction of inserting XML tags for emphasizing and changing colors.	67%	33%
(5). Usefulness of the system. (i.e. connecting the Knowledge-Memo with documents, resulting in a set of new documents.)	71%	29%

Table1. Results of questionnaires.

The overall evaluation of the system was positive. In terms of the question (1), students used the Knowledge-Memo for connecting to related documents and getting information of their documents. There were several responses in question (2), which demanded for the improvement of the interface when inputting the memorandums. Some students suggested a possibility of creating more successful system if incorporating with other laboratory members. In the question (3), most students were positive for informing and sharing ideas through memorandum with other users, since they can identify their ideas and get some comments. As for question (4), some students complained the new tag system that requires additional input. However, other students recognize the advantages of the system that can emphasize the keyword and change colors as far as the tags were not so complicated. Finally, most students recognize the structure of relationships centered on the document is useful for research activities.

5.3 Discussion

Test results lead to three fundamental findings.
(1). The system is useful for using and searching documents because it is possible to use information of Knowledge-Memo as well as abstracts.
(2). The system is convenient, since it enables users to make relationships with other preserved documents, to create new sets of documents, and to traverse from memorandums.
(3). The system is effective for informing and sharing opinions with peers because it enables to identify their ideas, to get some comments, and to record the process of studies.

From these results, it is possible to conclude that this management system effectively supports research activities, which collects and accumulates peer's knowledge and promotes collaborative and shared utilization.

Furthermore, we need to evaluate more effects for future research, such as;
- Is there any possibility in this system to give linkage of documents that seem to have no relation with each other?
- Is there any possibility that the results of using this system, such as creation of new document sets and analysis of memorandums, can give deeper understanding and new definition to users?

Additionally, this system should be improved in terms of the following three points.
(1). Revision of interfaces, including the interface for inputting the memo and the interface for classifying documents by theme.
(2). Addition of the level of importance to Knowledge-Memos for arrangement and classification, in order to promote re-use of knowledge.
(3). Exploration and employment of XLink potential. (Current browsers, such as IE or Netscape communicator, do not support XLink functions.)

6 Conclusions

The proposed web-based management system is primarily designed for research activities. Previously, databased and written information, such as papers and reports, were only available for research activities, even though other information, such as ideas and opinions, are also important knowledge. The new management system enables to utilize un-formalized knowledge as well as formalized information.

Positive responses from lab members who used a trial system show that because separated and fragmentary information are collected through Knowledge-Memos, effective and efficient research activities would be feasible. A lot of information and ideas toward papers are collected by members as databases, which creates sets of documents. Researchers can collaborate with other researchers through the system.

From the technical standpoint, the system utilizes the XML in two parts of exchange and preservation. Users' intentions on the WWW can be more reflected by the XML.

For the future usage, since only meta-data is managed in a XML, the utilization of documents as well as digital data is feasible. Further, the system can connect knowledge more easily, since XLink functions will be realized soon. Important advantages of the system include creation of relationships, and searches of information and knowledge. Improvement of the interface and the classification memorandums will be necessary for the long term.

References

[1] D.K. O' Neill, L.M. Gomez, "The Collaboratory Notebook: a Networked Knowledge-Building Environment for Project Learning", Proc. of Ed-Media 94, pp.416-423 (1994)

[2] H. Ogata, K. Imai, K. Matsuura and Y. Yano, "Knowledge Awareness Map fro Open-ended and Collaborative Learning on World Wide Web", Proc. of ICCE99, pp319-326 (1999)

[3] I. Nonaka, "The Knowledge-Creating Company", Harvard Business Review, November-December1991, pp96-104 (1991)

[4] J. Oshima, "Students' Construction of Scientific Explanations in a Collaborative Hyper-Media Learning Environment", Proc. of CSCL97, pp187-197 (1997)

[5] N. Pitts-Moults, C. Kirk, "XML Black Book", The Coriolis Group. Inc. (1999)

[6] P. Bell, E.A. Davis, M.C. Linn, "The Knowledge Integration Environment: Theory and Design", Proc. of CSCL95 (1995)

[7] S. Puntambekar, "An integrated approach to individual and collaborative learning in a web-based learning environment", Proc. of CSCL 99, pp458-465 (1999)

[8] T.H. Davenport, "Integrating Knowledge Management into the Organization", Diamond Harvard Business, August-September 1999 pp26-36 (1999)

[9] Knowledge Forum 2.0, http://www.motion.com/lim/kf/KF1.html (accessed on August 1, 2000)

[10] XML Linking Language (XLink) Version 1.0, http://www.w3.org/TR/2000/CR-xlink-20000703/ (accessed on August 1, 2000)

Scientific revolutions and conceptual change in students: Results of a microgenetic process study

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A microgenetic process study of dyad learning was conducted with the objective of further understanding conceptual change as students learn. This paper describes the knowledge negotiation, co-construction, and problem-solving efforts between two student volunteers, both aged 15, in a computer-mediated-communication (CMC) environment. We illustrate protocols of the students' problem-solving processes, showing how the students manifested, expressed, defended, abandoned, conjectured, and eventually transformed their (mis)conceptions on various aspects of velocities and distances. In doing so, we address important questions raised about students, their concepts and (lack of) theories, and the types of conceptual change that take place as students learn. This paper provides empirical evidence to show that as long as students do not think in theoretical terms, conceptual change in students will be very different from scientific revolutions. It not only agrees with the theoretical shift to viewing *learning* as *conceptual change*; it also lends empirical evidence in support of this view.

Keywords: **Cognition and Conceptual Change, Collaborative Learning, and Knowledge Construction and Navigation**

1 Introduction

The study and understanding of conceptual change is a field that is significant to the research community [10]. An example of macro-level conceptual change is the paradigm shift [8] from the phlogiston theory to the oxygen theory (commonly dubbed the chemical revolution). There have been numerous attempts to compare and contrast between such scientific revolutions and conceptual change in children and students. For example, Carey [2] contends that the development of the concept *living thing* in a child is analogous to scientific revolution because her study shows that between the ages of 4 to 10, children undergo a cognitive restructuring of their *living thing* concept; this restructuring is tantamount to theory change (from an animist theory to a set of biological theories). On the other hand, Harris [5] argues that "children do not think in theoretical terms, but on the basis of working models or concrete paradigms that serve as a basis for predictions and explanation" (p.303). Given these two opposing viewpoints, it is natural for Thagard [21] to state:

> The questions remain: do children have theories, does conceptual change occur by replacement, and is theory replacement the result of considerations of explanatory coherence? An affirmative answer to each question is a precondition of an affirmative answer to the succeeding one. (p.256)

Before discussing whether conceptual change in students is as revolutionary as scientific revolution, we should be reminded that scientific revolution involves a paradigm shift from one theory (or theories) to another competing theory (or theories). At the risk of oversimplification, we define a theory to be a set of *explicit* and *well-coordinated* principles that yield *predictions* based on their *explanatory mechanisms*. Since all "conceptual structures provide some fodder for explanation", "the distinction between theory-like structures and other types of cognitive structures is one of degree" [2, p.201]; theories embody deep explanatory notions.

Given the above, if students do not possess theories, not only is conceptual change in students fundamentally different from scientific revolution, but we must also offer negative answers to Thagard's questions.

2 Context of Study

This study describes how two student volunteers, Tim and Ming (both aged 15), engaged in meaningful knowledge negotiation and co-construction in a manner that allowed their conceptions and thought processes to be made overt for our analysis. Tim and Ming are schoolmates (but not classmates) in an academically average neighborhood secondary school. Both students have learnt physics in school for one year prior to this study and hence, are familiar with the terms velocity, acceleration, time, and distance. Prior to this, both students have not worked academically with each other.

Tim and Ming were placed in a large room that was partitioned in the middle. Each student occupied onepartition, and conversed with the other exclusively via a computer-mediated-communication (CMC) environment. The CMC environment consisted of a chatbox and whiteboard facility. The chatbox facility allowed the two students to converse via typed text, while the shared whiteboard allowed pictorial drawings and ideas to be depicted and discussed. Figure 1 shows a snapshot of this CMC environment, implemented via Microsoft NetMeeting™. Besides the standard furniture such as tables, chairs, and a computer, each partition housed two unmanned video cameras. The main data collection method comprised the video recordings of the students' interactions through the CMC environment. In each partition, a video camera was directed at the screen, capturing every interaction sequence performed on the computer, while the other video camera was directed at the student, capturing the student's physical gestures and reactions. To further aid the transcription process, both the shared chatbox and whiteboard were regularly "saved."

The questions that we posed to the students to solve were adaptations of the "Context Rich Problems" formulated by the Department of Physics, University of Minnesota (for more information, see http://www.physics.umn.edu/groups/physed/Research/CRP/crintro.html).

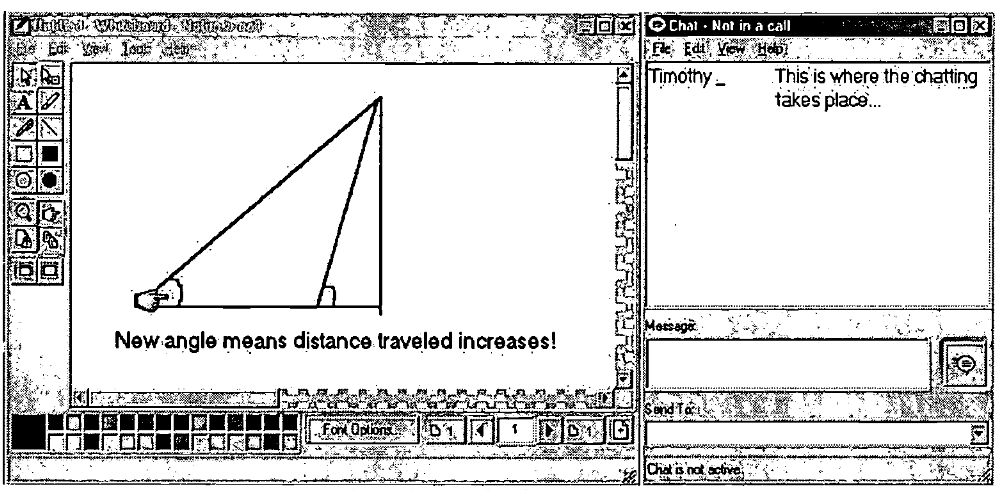


Figure 1: The CMC environment

3 Research Methodology

If we simply engage in endpoints analysis, we would not be able to understand conceptual change [10]. As such, we need to take into account the actual developmental process of conceptual change. A research methodology that focuses on microgenetic (developmental) processes is that of Ethnomethodology [4]. In short, ethnomethodology is interested in interaction sequences and requires that we focus on "participant categories" rather than "third person observer" perspectives [7]. It forces us to ask, "what questions can the data answer" rather than "what data do I need to answer these questions."

Since conversation analysis is the most productive and prolific form of analysis that has been developed with ethnomethodological concerns in mind [1], the protocol data obtained were transcribed into a log format, and then analyzed and annotated in accordance with the practices of conversation analysis (see also [6, 9, 12, 13, 17]). This was a time-consuming process as each tape had to be viewed and reviewed until the gaps in the data were resolved to the fullest extent possible.

4 Study Findings

In the following section, we illustrate portions of Tim and Ming's problem-solving processes through protocols collected in our study. Because this paper only presents portions of the protocols collected, see Soong [19] for full details. The question below details one of the problems attempted by Tim and Ming.

The cycling problem:

You and your physics teacher are cheering your cyclist friends Alex and Bon who are taking part in a straight but uphill bicycle-racing contest. You and your teacher are watching the race from the side-lane just beside the racetrack, 132 meters away from the finish line. It so happened that both cyclists passed by in front of you at exactly the same point in time. Your teacher estimated Alex's velocity to be 12m/s and Bon's velocity to be 11m/s. Given your training sessions with Alex and Bon, you know that from this position, Alex will accelerate at the rate of $0.25m/s^2$, while Bon will accelerate at the rate of $0.4m/s^2$, for the next 10 seconds.

- What is the final velocity of both cyclists at the end of that 10 seconds?
- Who will reach the finish line first?

Comments in square brackets "[ ]" are remarks made by the author regarding the protocol statements. These comments aid understanding of the protocols by relaying contextual information not available to the reader. No attempts were made to correct the students' grammatical and spelling errors. Tim, Ming, and the author are represented by "T", "M", and "A" respectively.

```
4.    M: part a looks tha same as what we did in the last session
```
[The first part of this question looks the same as what they previously attempted]
```
5.    T: yes....
6.    M: can we use that method?
```
T: lets try

Both students drew structural similarity between Part A of this question and a question that they previously attempted. In that previous problem-solving session, T and M had agreed that "(acc. x acc. time) + initial velocity = final velocity". However, the reason they agreed on this formula was because "it's the only method where we could get the ans. so far". It is clear that the students lacked a conceptual understanding of the solution, but nonetheless that did not hinder them from solving the problem.

It is noteworthy that M referred to the problem-solving process as "that method", rather than "that theory" or even "that logic". It is clear that in this instance, the students did not think in theoretical terms. In fact, it was a mechanical application of the "method" that the students "did in the last session".

With this, the students worked collaboratively, using the formula *final velocity = (acceleration x acceleration time) + initial velocity*. They then obtained the (correct) solution that Alex's final velocity was 14.5 m/s while Bon's final velocity was 15 m/s.

```
11.   M: 12+2.5=14.5
12.   T: yes
13.   T: and bon = 11 + 4 = 15
17.   M: agree?
18.   T: yup
```

It was clear to both students that Bon was faster than Alex after the acceleration. However, both the students had the conception that an object with a higher final velocity travels further than one with a lower final velocity. This conception is true in some, but not all cases. This is a well-known misconception, and it has been documented extensively by Piaget [11], among others. In the context of our study, we will refer to this

ERIC

as the "higher final velocity = winner" concept.

```
38.   T: bon is faster after the acc.
39.   M: yes
40.   T: therefore if the speed be constant after the acc., bon would
   complete the race first
41.   T: agreed?
44.   M: agree.
```

Confident that their answer was correct, T checked their answer with the author, only to be informed that their answer was incorrect, since Alex will actually complete the race first. When T related this to M, he was surprised.

```
47.   T: nope.....
48.   T: wrong ans....
49.   M: huh?
```
[M is surprised that their answer was incorrect]

When the author informed the students that their answer was wrong, the students tried again. T stuck to the concept that an object with a higher final velocity will travel further than one with a lower final velocity. Since T was basing his problem-solving attempts on this concept, he thought the only possible reason why Bon did not win the race was that his final velocity was lower than that of Alex's. To allow for this, he hypothesized that both bicycles returned to their initial velocities after the acceleration.

```
53.   T: they will only acc. for that 10 s
54.   T: after that their speeds will return to the same as b4
```

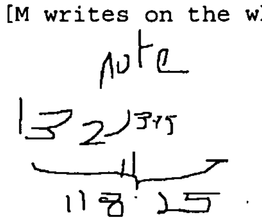
At this point in time, the author informed the students that the bicycles did not decelerate after that 10 seconds. Upon hearing this, both students felt that Bon should win. Their expression was totally consistent with their conception.

```
62.   A to T: They did not decelerate after the 10 seconds.
65.   T: the 2 didn't decelerate
66.   M: then b should win
67.   T: yah........
```

In the episode above, T was trying to reconcile their findings via qualitative analysis of the situation. However, because their source of reasons came from their "higher final velocity = winner" (mis)conception, this yielded no alternative results.

The episode below shows M's attempt to obtain an alternative answer via mathematical formulations. In so doing, M unwittingly put aside the "higher final velocity = winner" concept.

```
84.   [M writes on the whiteboard]
```




```
86.   M: a travelled 118.25 to the checkpt
```
[M was referring to his workings on the whiteboard. See L88, L89 and L92 for an explanation of M's workings]

```
87.   T: y is that so?
```
[T looks at M's drawing on the whiteboard]

```
88.   M: 0.25+(2x0.25)......+(2.5)=13.75
89.   M: the distance travelled during acceleration
```
[13.75m is the (additional) distance covered due to the acceleration]

ERIC

The protocol above manifests another of M's misconception. M's workings imply that the bicycles gain speed instantaneously rather than incrementally. In short, M's workings imply that Alex's bicycle covered an additional 13.75 meters due to its acceleration of $0.25 m/s^2$ for 10 seconds. We observe that this exact same working was also exhibited by M in one of his earlier problem-solving sessions.

```
90.   T: ok.....
91.   T: but i still dun get it....
```
[T does not understand M's workings]
```
92.   M: 132(distance from check pt)-13.75=118.25
      [132m - 13.75m = 118.25m]
```
[M is saying that the initial portion of Alex's velocity covered 118.25m]
```
93.   M: there/s no decceleration,then bon should reach first!
```

It is likely that, to M, the distance traveled by Bon due to Bon's higher acceleration was greater than Alex. Based on this method, Bon would have traveled 22 meters due to his higher acceleration. Hence, M drew the conclusion that Bon should reach the finish line first, since Bon was "faster". Clearly M's reasoning was flawed.

```
94.   T: how u get 13.75?
95.   M: 0.25+(0.25x2)+(0.25x3)+(0.25x4)...... +(0.25x10)=13.75
```
Upon further probing by T, M provided a fuller explanation of his conceptualization. M's formulation is as follows:

The velocity of Alex due to acceleration during the 1st second is = $0.25 m/s^2$ x 1s
= 0.25m/s

Hence Alex, moving at 0.25m/s, travels 0.25m/s x 1s = 0.25 meters during the 1st second.

Likewise, Alex's velocity due to acceleration during the 2nd second is = $0.25 m/s^2$ x 2s
= 0.5m/s.

Hence Alex, moving at 0.5m/s, travels 0.5m/s x 1s = 0.5 meters during the 2nd second. The same process was extended until the 10th second. As such, M conceptualizes that the summation of the distances from the 1st to the 10th second indicates the total distance traveled during the 10 seconds. Figure 2 and 3 pictorially illustrate M's conception and the actual acceleration process respectively.

Figure 2: M's Conception

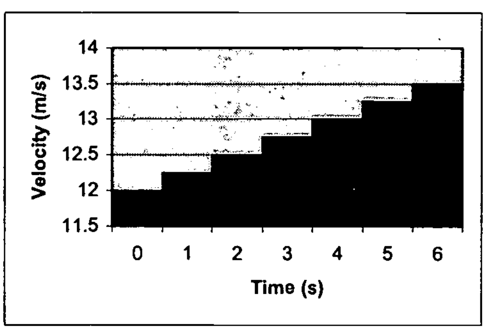
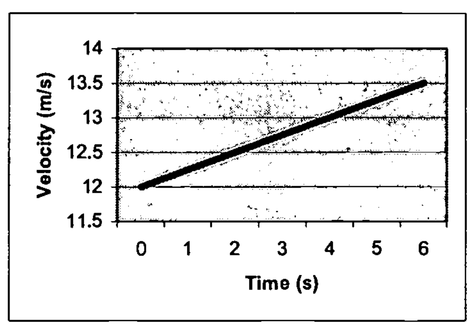


Figure 3: Actual acceleration process



T thought long and hard about M's formulation. After doing the math, he understood and agreed with M's conceptualization. This provides us with evidence that T had this misconception as well.

```
96.   T: [long pause (thinking)]
97.   T does the maths
98.   T: oic
```
[This is a short form for "Oh, I see"]

Discussing the problem-solving process by qualitative analysis failed to provide new insights. As such, M started using mathematics as an alternative source of potential explanation. M's workings reveal that he had a misconception that the bicycles gain speed instantaneously rather than incrementally. We also see evidence that T suffered from the same misconception. Despite the use of both approaches, both students were unable to find any reason why Alex should win. Hence, they concluded that Bon would win. With this conclusion, they checked again with the author, only to be told that they were incorrect.

110. M: no............................
111. T: huh?
[T is surprised that the answer was incorrect]
113. M: that's no the ans..
114. T: i don't get it....
115. M: smae here.....

Faced with this bleak situation, both students, perhaps unwittingly, put aside their "higher final velocity = winner" conception. Evidence of this is shown when, without first thinking it through, M suggested that perhaps both bicycles arrived at the same time.

117. M: maybe they arrive at the same time?
118. M: assume
119. T: it may be possible but wat is the reasoning...?
120. M: thinking.......

Perhaps unknown even to M, he was putting aside the "higher final velocity = winner" concept by suggesting that "maybe they arrive at the same time". This suggestion was made without even an initial reason, and hence this suggests that the students did not think in theoretical terms.

Because the students had put aside the "higher final velocity = winner" conception, they were able to make progress in solving the question.

124. T: acc. = total dist travelled / total time taken
[T makes overt his thought process to M]
125. M: that's speed
[M corrects T]
126. T: aye.... yah hor.....
[Local expression for "Oh yes, you are right"]
127. M: acc=what formULA?
128. T: the gradient of the distance time graph....
[This is actually incorrect; acceleration is the gradient of the velocity-time graph]
129. M: huh?
[M was not expecting this]
130. T: the acc. is the gradient of the distance-time graph
134. M: could u find the time ?
135. A to M: Do you agree that "acc. is the gradient of the distance-time graph"?
136. M: acc.=changes in velocity/time taken
[After pondering over the author's question, M gives an accurate definition for acceleration]

As T searched broadly for answers, he drew upon the formula of acceleration. However, his definition was incorrect. This set M thinking about the actual formula of acceleration and "the time" (L134). M then started to use the formula *time = distance traveled / (velocity+acceletion)* in order to find the time taken for each bicycle to complete the final 132 meters. While M's actual workings were incorrect (there is no such formula), it nonetheless provided the students with an alternative answer suggesting the conclusion that Alex won the race. More importantly, it allowed the students to derive the relation between the time of race completion and the winner of the race.

151. M: a move faster than b.....reach first.......z???????
[M draws the relation between *time of completion of race* and *winner of race*]
156. M: 132/(12+0.25)=132/12.25=10.76
[132 is the distance traveled, 12 is the initial velocity, 0.25 is the acceleration]
157. M: A
158. M: 132/11.4=11.58
[132 is the distance traveled, 11 is the initial velocity, 0.4 is the acceleration]
159. M: B
160. M: i getting a little bit confused
[Perhaps M noticed that the formula he used made no sense]
161. T: oic/......these ans are the time taken for the cylist,....

```
162.  T: therefore, A takes less time and b takes longer..
164.  T: so A will reach first
```

M's workings were incorrect. He had used a formula that had no basis, but nonetheless, T was able to make sense of it and concluded from M's answer that since Alex took less time than Bon, Alex will reach the finish line first. This provided the students with an alternative answer, and they were excited. M immediately asked the author if they were correct.

```
165.  M to A: Correct?
166.  A to M: The answer is correct, but the working is wrong
167.  M: working XXXXXXXXX
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Upon hearing that the answer was correct, M deduced correctly that because Alex traveled faster initially, Alex was at a point ahead of Bon such that Bon could not overtake him despite Bon's higher acceleration. This provided the students with a reason why, despite his higher acceleration and final velocity, Bon lost to Alex.

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172.  M: a travelled faster aT FIRST SO HE'S AT A POINT FURTHER THAN
   WHERE B COULD OVER TAKE EVEN THOUGH B ACCELERATE FASTR.
```

The above problem-solving endeavor took about 50 minutes. From here onwards, the students continued their problem-solving efforts. After considerable struggle, they eventually "corrected" their second manifested misconception (the "stepwise velocity increment" conception). They were also able to obtain a correct mathematical process to show Alex completing the race before Bon. The total time taken to solve this question was 130 minutes.

5 Results

The results of our study show that our student volunteers did not think in theoretical terms when attempting to solve the physics (kinematics) problems. Instead, they used a variety of methods such as simulations, conceptions, and even baseless conjectures. While these students certainly have concepts and based their reasons on these concepts, they were loose, unsystematic and highly fragmented. We may be tempted to call these students "naive learners", but further research by the authors reveal that the vast majority of elementary physics students who were studied worked in this fashion.

The students' "higher final velocity = winner" conception stemmed from their prior knowledge, and because their source of reasons came from this conception, they were unable to understand how it could be that Bon, who had the higher final velocity, did not reach the finish line first. Only upon putting aside this concept were they able to appreciate how it could be possible for an object with a higher final velocity to reach the finish line later than an object with a lower final velocity; it was because the slower object was at a point further than where the faster object could overtake. The protocols strongly support constructivist learning theory, which posits, among other things, that new knowledge is built (or constructed) from prior knowledge [15, 16]. Our study not only agrees with the theoretical shift to viewing *learning* as *conceptual change* [21]; it also lends empirical evidence in support of this. It also shows the conceptual change process (and hence learning process) to be continuous, but non-cumulative. This particular *feature* is strikingly similar in structure to scientific revolutions.

With respect to Thagard's request to "pin down the kinds of conceptual change that occur as children learn" [21, p.260], the kind of conceptual change that occurred here is that of "adding a new strong rule that plays a frequent role in problem solving and explanation" [21, p.35]. Initially, the students had the conception that an object with a higher final velocity (B) implied that it would travel further than one with a lower final velocity (A). Their problem-solving efforts added a new rule to this concept: B would travel further than A *only if* A is not at a point ahead of B such that B could not overtake A despite B's higher acceleration and higher final velocity.

6 Conclusions

Here in Asia (and in many parts of the world), the current method of teaching and assessing primary, secondary, and pre-tertiary students (aged 7-18), is still very much based on the over a century-old Western pedagogy of teaching boys and girls nothing but *facts* [3]. Such a methodology is efficient for dissemination of information, but this decontextualised-content focus causes students to suffer from a lack of deep conceptual understanding of the domain being taught, and immensely decreases their exposure to expert problem-solving processes and strategies. As such, they do not look at problem solving through a "theoretical lens." Since "advancement in science is a continual dance between the partners of theory and experiment, first one leading, then the other" [14, p. 796], as long as students do not think in theoretical terms, negative answers should be offered to Thagard's opening quote.

Learning environments, computer-based or otherwise, should be designed to play a more *strategic* role with the *objectives* of the educational system as their core focus. Since the objectives of educational systems are rarely to produce unadaptable and inflexible graduates concerned only with egotistical benefits, then the learning environment, as well as the evaluation methodology, should be designed to reflect their intended objectives (also see [18]).

References

[1] Benson, D. & Hughes, J., "The Perspective of Ethnomethodology", Hong Kong: Longman, (1983).
[2] Carey, S., "Conceptual Change in Childhood", Cambridge, MA: Bradford/MIT Press, (1985).
[3] Dickens, C., "Hard Times", London: Collins, (1954), (original work published in 1854).
[4] Garfinkel, H., "Studies in Ethnomethodology", Englewood Cliffs, NJ: Prentice-Hall, (1967).
[5] Harris, P., "Thinking by Children and Scientist", In Hirschfeld, L. & Gelman, S. (Eds), Mapping the Mind
(pp. 294-315), NY: Cambridge University Press, (1994).
[6] Have, P., "Doing Conversation Analysis: A Practical Guide", London: Sage Publications, (1999).
[7] Hung, D., "Epistemological change through peer apprenticeship learning: From rule-based to idea-based social constructivism", International Journal of Computers for Mathematics Learning, Vol 3, No. 1, pp. 45-
80, (1998).
[8] Kuhn, T., "The Structure of Scientific Revolutions", Chicago: University of Chicago Press, (1970).
[9] Mehan, H. & Wood, H., "The Reality of Ethnomethodology", NY: John Wiley & Sons, (1975).
[10] Nersessian, N., "Conceptual Change", In Bechtel, W., & Graham, G. (Eds), A Companion to Cognitive Science (pp 157-166). Oxford, UK: Blackwell Publishers, (1998).
[11] Piaget, J., "The Child's Conception of Movement and Speed", London: Routledge & Kegan Paul, (1970),
(original work published in 1946).
[12] Potter, J., "Representing Reality: Discourse, Rhetoric and Social Construction", London: Sage Publications,
(1996).
[13] Psathas, G., "Conversation Analysis: The Study of Talk-in-Interaction", Thousand Oaks, CA: Sage Publications, (1995).
[14] Redish, E., "The Implications of Cognitive Science for Teaching Physics", American Journal of Physics, Vol 62, No. 6, pp. 796-803, (1994).
[15] Resnick, L. "Introduction", In Resnick, L. (Ed.), Knowing, learning and instruction. Essays in honor of Robert Glaser (pp 1-24), Hillsdale, NJ: Lawrence Erlbaum Associates, (1989).
[16] Roschelle, J., http://netra.exploratorium.edu/IFI/resources/museumeducation/priorknowledge.html (accessed
on Nov 1, 1999).
[17] Sacks, H., "Lectures on Conversation", Vols. I & II, (Ed.) Jefferson, G., Oxford: Basil Blackwell, (1992).
[18] Salomon, G., http://construct.haifa.ac.il/%7Egsalomon/edMedia2000.html (accessed on Jul 18, 2000).
[19] Soong, B., "A Novel CMC-assisted Constructivist Environment for Learning Physics", MSc. dissertation,
National University of Singapore, (in preparation).
[20] Strike, K. & Posner, G., "A conceptual change view of learning and understanding", In L.H.T. West and A.L. Pines (Eds.), Cognitive Structure and Conceptual Change (pp. 211-229), NY: Academic Press, (1985).
[21] Thagard, P., "Conceptual Revolutions", Princeton, NJ: Princeton University Press, (1992).

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The "Half-Life" of Knowledge in the University of the 21st Century

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In this paper, the role of the post-secondary institution in promoting half-life, and short half-life knowledge skills is examined. We provide an overview of the role that the university traditionally played in transmitting knowledge and lead into a discussion regarding the need for change in order to adapt to the knowledge society of the present and future. Four different models of online technologies in North American virtual universities is presented, followed by a comparison of the approaches that academia and private sector have taken towards educational technology. In conclusion, we argue that there are not competing ideologies for online learning. Rather, we are all addressing different parts of the same problem.

Keywords: **Knowledge Construction and Navigation, Methodologies, and Teaching and Learning Processes**

1 Introduction

As we move away from the industrial society to a knowledge-based society, how we view teaching and learning in the 21st century is changing as well. Duderstadt [3] argued that information technology contributed to this shift by "dramatically changing the way we collect, manipulate, and transmit knowledge". He suggested that four themes were converging in the last decade: (a) the role knowledge would play in determining security, prosperity, and quality of life for the individual, (b) movement towards globalization, (c) the ease and speed that information technology allows us to obtain information, (d) formal social structures were being replaced through informal networks and collaborations among individuals and institutions.

Currently our university system is geared toward an undergraduate student who attends the university after their high school completion. Many institutions also offer graduate courses and courses for the distance learner. Beyond that, most institutions do not have course offerings geared towards the mid-career learner. Denning [1] suggested that these professional programs would play a role in the business design of a successful university in the next century. This corresponds to a rising number of requests from industry requesting professional development for their employees to be provided by post secondary institutions [1]. This has resulted in a significant trend that the traditional divisions between post-secondary institutions, the workplace and government are becoming less visible [5].

2 Theory of the "half-life" of Knowledge

Knight [4] discussed the concept of the "half-life" of knowledge. He discussed two broad categories: (a) core knowledge or skills, and (b) economically relevant knowledge. These core skills have a longer half-life, and include things like critical thinking and reasoning skills, communication skills, and social skills. These types of skills are the on-going skills that are part of lifelong learning. The economically relevant knowledge has an even shorter half-life. These skills or knowledge relates to what makes you marketable (e.g., job skills, knowledge of an industry or profession or trade). The concept of the half-life suggests that over a period of time this knowledge is worth less economically, therefore, in orderto retain your economic value and marketability you have to learn more.

This half-life knowledge is making us feel more pressure as we attempt to keep up with the pace of learning new skills. Twenty-five years ago, you would be able to use the knowledge you learned for approximately twenty-five years. A person could learn a skill at age twenty and build their entire career around it. Ten years ago, the average half-life for economically relevant skills was only seven years. Three years ago, it was four years. Today it is eighteen months in the knowledge society. This half-life is even less in technology related fields. Individuals in the workforce will need to constantly upgrade their skills, as their current knowledge base needs to continually evolve to keep up with how rapidly technology is changing [6].

The "early adopters", the ones in high tech and engineering, re-invent themselves by jumping from job to job to stay on the newest wave of invention. This has created the "skills shortage crisis" found in larger organizations. These people constantly migrate to newer companies and even other countries in order to stay on the cutting edge and to market themselves while their skills are still relevant. That accounts for in Canada what is coined the "brain drain" that the government assures us does not exist.

3 Need for A Change

In a 1995 study, Dolence and Norris [2] suggested that this upgrade of skills might need to take place on average every five to seven years. They predict that by the year 2010, the full-time equivalent of one-seventh of the American workforce will be enrolled in higher education or retraining. This would mean that everybody in the workforce in Canada alone needs to do some new learning every three years that would put approximately five million new learners into the system every year. This would be over and above the entry level people that are currently in the workforce. You can imagine the size of the market in The United States, or India, or Asia. (see Dolence & Norris chart).

Country	Labour Force 2000	FTE Leaners	Campuses (30,000 students)	Cost to Build Campuses (Canadian $)
United States	141.1M	20.2M	672.00	$352.8B
Japan	64.3M	9.2M	306.00	$160.8B
Germany	37.2M	5.3M	177.00	$93.0B
United Kingdom	29.1M	4.2M	139.00	$72.7B
France	25.8M	3.7M	123.00	$64.5B
Italy	24.2M	3.5M	115.00	$60.4B
Spain	15.7M	2.2M	75.00	$39.3B
Canada	14.6M	2.1M	70.00	$36.5B
Australia	8.9M	1.3M	42.00	$22.2B
Sweden	4.6M	.7M	22.00	$11.5B
			TOTAL $	$913.7Billion
The World	2,752.5M	100.0M+	3,300.00	??????

To accommodate this demand would require a re-invention of our education and training systems to cope with these new demands. For now, competition is not the issue. We have not yet refined a product or an approach that promises to satisfy the enormous demand that is already emerging, and that will reach a crescendo over the next decade. To add to this increasing demand, the first wave of the so-called "echo-boomers" is set to hit our post-secondary system this year. This increase will pressure an already overburdened system, if we keep it the way it is today.

4 Application of Online Technology in Academia

The following are four different models of online technology usage in four North American virtual Universities.

Athabasca:

Pioneers in electronic distance education, they focused on the time and place needs of their students. They offer self- paced learning with mentors and instructors available online, instead of by snail mail. Their program is built on Lotus notes. They are now moving into some more collaborative models, particularly with their MBA program, this is cohort based. They are reporting phenomenal demand, but still report a high rate of in-completion.

Western Governors University:

This university can be viewed as more of an accreditation collective. They offer a widely diverse collection of program offerings using diverse delivery technologies from diverse university departments. It has been slow to get off the ground, but the cross-accreditation concept is good, but still needs to evolve.

Royal Roads University:

A hybrid model. Students attend the campus at the beginning, middle, and end of their degree program for a very intensive "boot-camp" like experience designed to bond them as a community. In between, they work online in-group oriented and collaborative exercises. They go through the program in "Cohorts" all at the same time, with the same start and finish dates, but with flexibility built into each course to allow for "learner-centred" approaches. In this way, the University can put 1800 students through a former military college with only 300 classroom seats. Most students are fully employed while taking the programs, and are able to apply immediately what they learn.

Tech-BC:

Here's an interesting model. Perhaps the one with the most implications for Universities as we know them. Imagine if you were to divide the learning objectives into the ones that must be learned on campus and the ones that can be accomplished online. Have the students attend University a couple of days per week and do the rest of the work online. Leverage the facility, and potentially offer partnered learning with industry while the student remains employed. We think this model offers a blueprint for how we can leverage overtaxed facilities. This model is dependent of course on having a market within commuting distance.

If we revisit the concept of long half-life learning, and short half-life learning, we envision a future where we use Universities to teach that "long half-life" stuff that is best learned on campus, or face to face with other students. In this model, academics drive the "long-half life" stuff, but we use the technology to cover the "short half-life" material that is constantly changing, and is driven by economics and industry. There will be some crossover of course, but it is interesting to note that there are already some noticeable leanings in the two camps of academia and industry.

Academia and the Private Sector

The following is a comparison in general trends between the Academic and Private sectors:

Academic online programs tend to favour:

- Asynchronous
- Community based
- One to many
- Semester based
- Everyone covers everything

These things lend themselves to those "long half-life" skills.

Private sector training has tended to favour:

- Synchronous
- Learner-Centred
- Many to one
- Just in time
- Just enough
- Performance support

These, you could argue, are better suited to the "short half-life" skills.

So should we be marrying all these techniques together? Or on the other hand, should each sector start to focus on the niche to which they are best suited? Of course for the last 40 years, the lines between academic training and job-skill training have become increasingly blurred. Employers tell us they value critical thinking, reasoning skills, pattern recognition, organizational skills, and communication abilities. Many tell us they find these skills are well developed in individuals who have studied for example, anthropology, music, and history. They like these people to have a University education; however, they don't want to spend a year or six months grooming them after University, because today' s graduates don't stay that long. They need to have the necessary job skills from day one.

These are those "short half-life" skills. Obviously, we cannot take two, three, or even four years to teach skills with a half-life of eighteen months. Would the answer be a model like the one at Tech-BC or at Royal Roads? On the other hand, will the new educational institution be a combination of new kinds of university offerings, perhaps with a robust new private industry creating big budget online units that can be used as adjuncts to University courses?

5 Concluding Thoughts

The point we are trying to lead to is that there are not really competing ideologies for online learning. We all are actually all addressing different parts of the same problem. We are like the six blind men in the parable of the elephant.

The Blind Men and the Elephant
by John Godfrey Saxe

It was six men of Indostan
To learning much inclined,
Who went to see the Elephant
Though all of them were blind,
That each by observation
Might satisfy his mind.

In the next six verses, each of the blind scholars grasps a different part of the elephant. One thinks that the elephant is like a snake, and another thinks they are like a tree, another like a fan, and in the last verse, it says,

And so these men of Indostan
Disputed loud and long,
Each in his own opinion
Exceeding stiff and strong.
Though each was partly in the right,
They all were in the wrong!

We think this describes quite well our present confusion about technology and where it will fit into our need to learn. We are all working on different bits of the elephant. The question we need to address as a community at this and other academic conferences, are where do we go from here?

References

[1] Denning, P.J. (1996). Business designs for the new university. Educom Review, 31(6), 20-30.
[2] Dolence, M.G., & Norris, D.M. (1995). Transforming higher education: A vision for learning in the 21st Century. Ann Arbor, MI: Society for College and University Planning.
[3] Duderstadt, J.J. (1997). The future of the university in an age of knowledge. Journal for Asynchronous Learning Networks, 1(2). Available: http:www/aln.org/alnweb/journal/issue2/duderstadt.htm
[4] Knight, P.T. (1997). The half-life of knowledge reform of the education sector for the global knowledge-based economy. Paper prepared for the Forum on Education in the Information Age, Cartagena, Colombia, 9-11 July 1997.

[5] Lewis, B., Smith, R., & Massey, C. (1999). Mirroring the networked society: Government policy, higher education, and telelearning technology in Canada. Canadian Journal of Communication, 24, 319-336.
[6] Muzio, J. (1999). The development of a prototype learner-centred electronic distributed learning course for Royal Roads University. Doctoral Dissertation Nova Southeastern University.

The Artistic Interface - A Transition from Perception to Screen

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1 Introduction

At present a dichotomy of computer art instruction exists, where the computer as an art medium, presents the learner with almost limitless possibilities of image manipulation; yet instructional methodology and current art curriculum provide no coherent framework through which the learner can effectively access this information.

2 Research

Throughout the last five years the researcher has taught numerous art concepts and involved students in art tasks using the computer. The reality of the researcher's teaching situation is that the use of the computer within an art context is not debated, but accepted as a part of the everyday teaching process. After several years and testing different ways of approaching the teaching of computer programs several issues emerged which warranted further consideration:
1. Frustration exists due to the limited time that students had available to use the computer and the amount of information students were expected to utilize.
2. Many computer graphic programs are structured in similar ways (display a similar interface) and use similar symbols (icons) to represent functions within the program
3. Students seem unaware of these similarities and unable to transfer an understanding of one programs GUI (Graphic User Interface) to another computer graphic program.
4. Students appeared to have no mental map or problem solving strategies with regard to searching for answers to problems within a computer art environment.
These thoughts led to the intention within this research study which is to document the qualitatively different ways that students interact with the graphic user interface of computer graphic software in an art education context in order to create art.

It is hypothesized that students need to build some form of mental model regarding the software program they are interacting with in order to understand its application domain. That by examining the influence of different types of interface cues regarding navigation within a computer art context a greater understanding of students' conceptions regarding utilizing the computer as an artistic medium could be facilitated. Interface cues in this regard pertaining to the icons, layout and menus presented to the user. This is defined by the researcher as the Artistic Interface. This Artistic Interface is the interaction that occurs between the student's artistic intent and the graphic user interface of the computer.

The underlying art educational assumption here is that the clearer the mental model the student has, the more capable the student will be at understanding the program, at locating a specific function and achieving the desired artistic result. Within the context of this study it is postulated that students with a clearer mental model of the graphic user interface (GUI) will have a more effective art educational experience (a more effective Artistic Interface) when utilizing the computer as an artistic medium.

In order to develop this 'mental model' a phenomenographical mode of inquiry will be used. Roth and Anderson (1988) stated that they consider learning to be a change in one's view of some phenomenon. Also Marton (1992) suggested that: "In order to develop teaching methods that help students arrive at new understandings of a given phenomenon, we must first discover the finite ways individuals may understand that phenomenon. Then, through experimentation, we may discover the most effective ways to bring

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students from a given conception to another, more advanced one, that is, from 'misunderstanding' to understanding." (p.253) Thus if students' conceptions of how they interact with the computer in an art educational context can be documented, then a learning framework could be developed which could enhance their understanding of the GUI of a particular program, and maybe other computer graphic programs.

3 Educational Considerations

Within a consideration of the influences of the GUI this study situates itself into the line of those devoted to the analysis of a possible correlation between the user's cognitive skills and his / her navigation abilities in an interactive, iconic, multimedia environment. This has been supported and further documented by Castelli, Colazzo, and Molinari, 1994; Elm and Woods, 1985; Osborne, 1990; Thuring, Hannemann, and Haake, 1995.

An effective analysis of students utilizing the computer in art education must begin with 'what is the student trying to do? Previous studies (Elm and Woods, 1985; Osborne, 1990) have demonstrated that getting lost is a consequence of the lack of a clear conception of the relationships within the system. In relation to this study this statement seems to imply that an effective use of the computer as an artistic medium depends upon the ability of the user to abstract from the system display discrete understandings relevant to the desired artistic result and that this may involve building a conceptual representation of a particular software programs GUI. It is further postulated within this study that if a learner can construct an effective mental map, or conceptual representation of a particular software programs GUI then this mental map maybe facilitate an easier and more effective understanding of another program due to the similarities in their GUI.

4 Conclusions

There is ongoing educational debate about the nature of the information society and the range of 'literacy's' needed to handle, understand, and communicate information in a variety of forms (Baker, Clay and Fox, 1996). The researcher has suggested that literacy in the information age requires not only the skills to operate the technology, but also the ability to identify and structure a line of inquiry in order to solve a particular problem. In this instance what is being analyzed is the range of 'literacy's' needed to form a line of inquiry into a computer art domain.

This research into the Artistic Interface is an attempt to document students' understanding of differing computer graphic arbitrary symbols (a software programs vocabulary) placed according to a systematic formula (a software programs grammar) to produce an understanding of various icons (pictograms used to represent a function of the computer). The researcher will seek to examine the qualitatively different ways that students understand the GUI in a particular computer graphic program and within a particular art educational context. This will involve a phenomenographical study that will lead to further understandings regarding students' perceptions of the Artistic Interface.

References

[1]. Baker, D.A., Clay, J., and Fox, C. (1996). "Challenging ways of knowing in English, maths and science". London: Falmer Press

[2]. Castelli, C., Colazzo, L., and Molinari, A. (1994). "Ht-Dedalus: Analysis of some models of hypertext performance". EC Newsletter, 6(1), 15 - 27.

[3]. Elm, W.C., and Woods, D.D. (1985). "Getting lost: A case study in interface design". Human Factor Society, 927 - 931.

[4]. Marton, F. (1992). "Phenomenography and "the art of teaching all things to all men"" Qualitative Studies in Education, 5(3), 253-267.

[5]. Osborne, D.J. (1990). "Browsing and navigation through hypertext documents: A review of the human-computer interface issues". Interactive Multimedia, 1, 3-32.

[6]. Roth, J.J., and Anderson C.W. (1988). "Promoting conceptual change and learning from science textbooks". In P.Ramsden (ed.) Improving learning: new perspectives. London: Kogan Page.

[7]. Thüring, M., Hannemann, J., and Haake, J. (1995). "Hypermedia and cognition: Designing for comprehension". Communications of the ACM, 38(8), 57-66.

The Discussion on the Dynamic Knowledge Generationand the Learning Potential Ability

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After we discussed with teachers to understand their instructional politics, we integrate the teachers' instructional politics, the process of knowledge generation, memorizing to construct the concept graph. Furthermore, we used the dynamic web pages to track the learner's learning and used the tracking data to reconstruct the learner how to construct his knowledge to understand the learner's thinking logic. In this paper we proposed the dynamic knowledge generation model and learning ability potential model. These were according to link the concepts to generate the knowledge. As following above idea we integrated the constructing materials and the dynamic knowledge generation to consist the expert system. The system would analyze his learning data to rebuild he how to build his knowledge, to understand his learning ability and he already built the whole knowledge or not. Rely on these results the system could supply the suitable materials to him for study. And the learning cycle would continue until the learner completely constructs the new knowledge into his ground knowledge. Finally, we could from proto type system to collect the experimental data and rebuilt the learner's learning steps, then followed the expert system to understand his learning ability potential. The system could supply a suitable material to him and help him to cross over the learning obstacle. These results also proofed that our model could really understand the learner's thinking logic and learning potential.

Keywords: **dynamic knowledge generation, learning potential ability, concept graph, expert system**

1 dynamic knowledge construct process of learners

A meaningful learning must accord with three main conditions: Accepting the learning material, having the knowledge of dealing with learning material, and firing this knowledge at the learning time, (Mayer, 1975,1984). Accordingly, learning behavior has originality, creation and activity. It's easy to make learners to find the meaning of learning. If we want learners to have meaningful learning, we must do: "if you want to teach active knowledge for learners, you have to understand how to get the knowledge first. It's the same as you want to teach learners to think, you have to understand how learners think first." Therefore, if want to know the learner how to learn the knowledge, it can use the information process theory to discuss the human how to process his information like Fig.1. we design a structural material like a story, attaching pictures, and animations that attract learners. At the last section we give an additional problem among the units, which give learners integrating the prior knowledge. Then, the blind spot in every learner is obtained by using the model of a learning barrier analysis. The reason of inspiring learning barrier is obtained by using learners' browse web pages order and frequency. (Note: 3D learning barrier analysis) Meanwhile, learners will dynamically update their constructional knowledge network by learning number, browsing process, and test frequency. (Note: all of attributions of cognition nodes are dynamical.) Because learners are not static learning, we developed a dynamical model as Fig.1..

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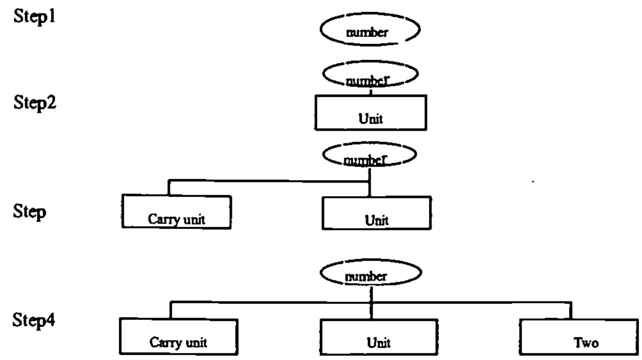

Fig.1 dynamic knowledge construct process of learners

2 the dynamical knowledge generation and learning ability analysis

In our model (**the model of dynamical knowledge generation and learning ability analysis**), using the teachers teaching experience, the system partition a judge learners' ability to achieve learning and the label of understanding course. And the Table1 is appropriate inference rule, what are the schools' teachers to classify the learners' learning ability.

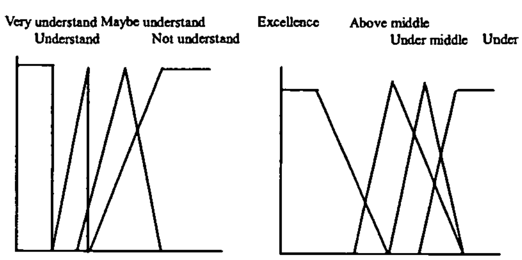

Fig.2 The relation of achieve a learning and the label of understanding course

Table 1. Inferring rule

TIMES / RESULT	UNDER	UNDER MIDDLE	ABOVE MIDDLE	EXCELLENCE
Cannot Understand	-2	-1	-1	0
Maybe Understand	-1	-1	0	+1
Understand	-1	0	+1	+2
Very Understand	0	+1	+1	+2

After the student had to go to the chapter's test. The testing results would according the learning obstacle analysis model to find his incompletely building knowledge and compared with the expert system to understand his learning ability. Finally, the system searched the suitable materials for him to study. The graph of learning cycle is shown in Fig. 3.

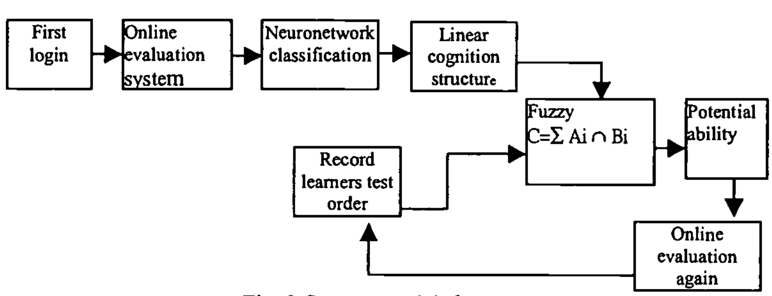

Fig. 3 System model chart

3 Conclusion

Although teacher can control his class ambiance and teaching trends, but he has many different individual learners in the classroom. If teacher cannot understand the learners how to learn and how to integrate their knowledge on his teaching, the teaching does not only let learner have a stuff learning, but also increase his teaching load. Therefore, in our paper we proposed "dynamical knowledge-generation model and learning ability analysis", to integrate the conceptual knowledge generation into structuring material and connect with the dynamical estimating expert's system. This system can collect what material learner had learned and the result of online testing was transmitted to the system. These real data used our analyzing model to decide his learning ability and supplied a suitable material to him for study. Thus, we believe our system do not only can help the teacher to understand learner how to build his new knowledge, but also can reduce the learner's learning barrier.

Reference

[1] Chao-Fu Hong、Yueh-Mei Chen*、Yi-Chung Liu、Tsai-Hsia Wu :Discuss 3D cognitive graph and meaningful learning,ICCE99

[2] Chao-Fu Hong、Yi-Chung Liu、Yueh-Mei Chen*、En-Yi Jen :Apply OO and T cell Cognitive Structurein Discovery Teaching,ICCE99

A Distance Ecological Model to Support Self/Collaborative-Learning via Internet

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With the rapid development of information technology, computer and information communication literacy has become the main new ability required from teachers everywhere. For enhancing teaching skills and Internet and multimedia information literacy, a new teachers' education framework is required. Here we propose a Distance Educational Model, as a School-Based Curriculum Development and Training-System (SCOUTS), where a teacher can learn subject contents, teaching knowledge, and evaluation methods of the students' learning activities (subject: "Information") via an Internet based self-training system. We describe the structure, function and mechanism of the model, and then show the educational meaning of this model in consideration of the new learning ecology, which is based on multi-modality and new learning situations and forms.

Keywords: **Distance Education, Teacher Training System, Learning Ecology, School Based Curriculum Development**

1 Introduction

Recently, with the development of information and communication technologies, various teaching methods using Internet, multimedia appeared. Most of them emphasize, in particular, the aspect of collaborative communication between students and teacher during interactive teaching/learning activities. Therefore, now-a-days it is extremely important for a teacher to acquire computer communication literacy [1]. So far, there were many studies concerning system development, which aim at fostering and expanding teachers' practical abilities and comprehensive teaching skills, by using new technologies, such as computers, Internet, multimedia. In Japan, systems using communication satellites such as SCS (Space Collaboration System) are developed and used as distance education systems between Japanese national universities. In the near future, a teacher's role will change from text based teaching, to facilitating, advising, consulting, and his/her role will be more that of a designer of the learning environment. Therefore, a teacher has to constantly acquire/learn new knowledge and methodologies. We have to build a free and flexible self-teaching environment for them under the concept of "continuous education". At the same time, we build a collaborative communication environment to support mutual deep and effective understanding among teachers. In this paper, we propose a Distance Educational Model, which is based on the concept of School Based Curriculum Development and Training System, advocated by UNESCO and OECD/CERI (Center for Educational Research and Innovation), and describe the structure, function, mechanism and finally the educational meaning of this model. Based on such a background, it is necessary to construct an individual, as well as a collaborative learning environment, that supports teachers' self-learning/training, by using Internet distributed environments and multimedia technologies. A teacher can choose the most convenient learning media (learning form) to learn the contents (subject units) that s/he desires.

2 Distance Educational Model based on SCOUTS

Until now, when a teacher wanted to take a class on "IT-education", s/he had to leave the office or school. Now it is possible to learn various kinds of subject contents by building a virtual school on the Internet environment.

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2.1 Distance Educational Model

Our Distance Educational Model is built on 3 dimensions. The first one is the subject-contents, which represents what the teachers want to learn. The second one represents the teaching knowledge and skills as well as the evaluation methods of the students' learning activities. From the third axis, the favorite learning media (form) can be chosen, e.g., VOD, CBR, etc. By selecting a position on each of the 3 axes, a certain cell is determined. A cell stands for a "script", which describes the instruction guidelines of the learning contents, the self-learning procedure, and so on (Fig. 1). In the following, I will explain the meaning of each axis in more details.

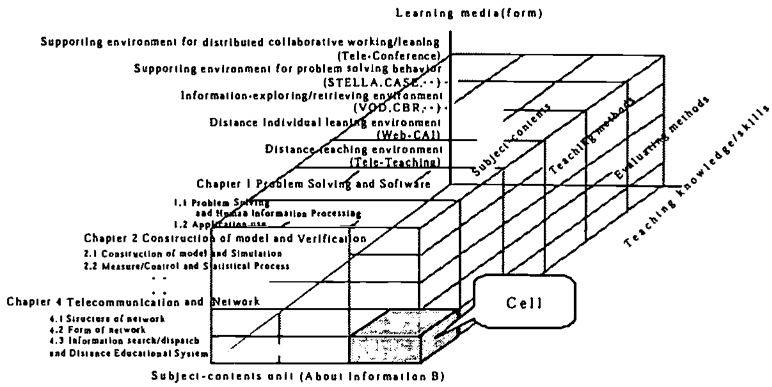

Fig.1 Structure of the Distance Educational Model

2.1.1 Subject –contents unit

In this study, we focus on the subject called "Information", which is due to be established as a new obligatory subject in the regular courses of the academic high school system in Japan. The subject "Information" is composed of three sub-subjects, "Information A", "Information B" and "Information C". The contents of each sub-subject are as follows.

Information A: raising the fundamental skills and abilities to collect, process and transmit "information" using computers, the Internet and multimedia.
Information B: understanding the fundamental scientific aspects and the practical usage methods of "information".
Information C: fostering desirable and sound behavior of participation, involvement and contribution in an information society; understanding peoples roles, and the influence and impact of technology, in the new information society.

2.1.2 Teaching knowledge/skills

On this dimension, we have represented sub-subject contents, teaching methods and evaluating methods for "information" classroom teaching. 'teaching methods' stands for how to use and apply IT, to enhance a student's problem solving ability, involving comprehensive learning activities, like problem recognition, investigation and analysis, planning and design, implementation and executing, evaluation, report and presentation. We aim at teachers acquiring the proper students' achievements evaluating skills, according to each of the above activities.

2.1.3 Learning media (form)

This dimension represents five different learning environments, as follows: 1) "Distance teaching environment (Tele-Teaching)" based on the one-to-multi-sites telecommunications 2) "Distance individual learning environment (Web-CAI)" based on CAI (Computer Assisted Instruction) using WWW facilities 3) "Information-exploring and retrieving environment" using VOD, CBR (Case Based Reasoning) 4) "Supporting environment for problem solving", by providing various effective learning tools 5) " Supporting environment for distributed collaborative working/learning" based on the multi-multi-sites telecommunications. Brief explanations for each environment are given in the following.

(1) Distance teaching environment (Tele-Teaching): This environment delivers the instructor's lecture image and voice information through the Internet, by using the real-time information dispatching function via VOD (Video On Demand).
(2) Distance individual learning environment (Web-CAI): This environment provides CAI (Computer Assisted Instruction) courseware with WWW facilities on the Internet.
(3) Information-exploring and retrieving environment: This environment delivers, according to the teacher's demand, the instructor's lecture image and voice information, which was previously stored on the VOD server. For delivery, the function of dispatching information accumulated on the VOD server is used. In addition to it, this environment provides a CBR system with short movies about classroom teaching practices.

(4) Supporting environment for problem solving: This environment provides a tool library for performance support, based on CAD, Modeling tools, Spreadsheets, Authoring tools, and so on.
(5) Supporting environment for distributed collaborative working and learning: This environment provides a groupware with a shared memory window, using text, voice and image information for the trainees.

2.2 • Cell" definition

The concept of a "cell" in the Distance Educational Model is quite important because it generates the training scenario, including the information to satisfy the teacher's needs, the subject materials learning-flow and the guidelines for self-learning navigation. The frame representation of the "cell" is shown in Table 1. These slots are used when the system guides the process of the teacher's self-learning.

Table 1 The frame representation of the "cell"

	Frame name	Slot-value
Slot-name	Learning objectives for a student	Subjects which should be understood Subjects which should be mastered
	Subject-contents	The unit topic
	Teaching method	The students' supervision method and instructional strategies
	Evaluating method	The students' evaluation method
	Useful tools	The software used for the training activity
	Operational manual of tools	The software operation method used for the training activity
	Prepared media	The learning media which can be selected
	Guide script	The file which specifies the dialog between the trainee and the system

3 Outline of the teacher training system

The system configuration of the teacher's training environment is composed of two subsystems based on the Distance Educational Model. One of the subsystems is the training system, where a trainee can select and learn the subject adequate for him/her guided by the script in the "cell". The other subsystem is an authoring system with creating and editing functions for "cell" description. The users of the second environment are, e.g., IT-coordinators or IT-consultants, who can design lecture-plans in this environment.

3.1 Training system

The training system aims to support teachers' self-training. The configuration of this system is shown in Fig.2. The role of this system is first to identify a "cell" in the model, according to the teachers' needs. Then, the system tries to set up an effective learning environment, by retrieving the proper materials for the teacher, along with the "guide script" defined in the corresponding "cell". Therefore, the system offers programs for both Retrieving and Interpreting. The training system works as shown in the following.

STEP 1: Record the teacher's needs.
STEP 2: Select a "cell" in the Distance Education Model according to the teacher's needs.
STEP 3: Interpret the "cell" in the guide WM (Working Memory).
STEP 4: Develop the interactive training with the teacher according to the "guide script" in the guide WM.
STEP 5: Store the log-data of the dialog (collect information on the learning histories and teachers' needs and behaviors).
STEP 6: Provide the needed applications for the user's learning activities and set up an effective training environment.
STEP 7: Give guidance-information, according to "cell" script guidelines, decide on the proper next learning step "cell".

The interpreter controls and develops the dialog process between user and machine according to the information defined in our "guide script" description language. This "guide script" description language (GSDL) consists of some tags and a simple grammar for interpreting a document, similar to the HTML (Hypertext Markup Language) on the WWW. The interpreter understands the meanings of the tags, and interprets the contents. An example of GSDL is shown below.

(1)<free>	*Definition: description of the text (instruction)*
(2)<slot (num.)>	*Definition: a link to a slot value in the "cell"*
(3)<question>	*Definition: questions to a trainee*
(4)<choice>	*Definition: branching control according to a trainee's response*
(5)<exe>	*Call: to relevant "cells"*
(6)<app>	*Definition: applications used for training activities (e.g., Tele-Teaching, etc.)*

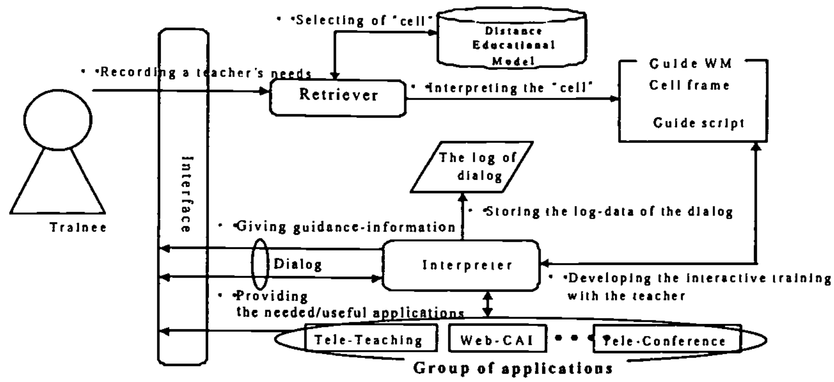

Fig.2 Configuration of Training system

3.2 Authoring system for creating and editing a "cell" description

The system provides an authoring module to create and edit the information in the "cell". This module also offers the function of adding new "cells", in order to allow supervisors (experienced teachers) to design the teachers' training program. The configuration of this system is shown in Fig.3. The tasks that can be performed by this system are: adding new "cells", editing the existing "cells", receiving calls for Tele-Teaching lectures, and managing the lectures schedule. This system is composed of the "cell" frame creating module, and the "guide script" creating module. A cell design can be performed as shown in the following.

STEP 1: Get the slot-values of "student's learning objectives", "subject-contents/teaching method/evaluating method", and "useful tools" from the "cell".
STEP 2: Substitute the return value of the slot of the prepared media with the training-contents corresponding to the user's needs.
STEP 3: Substitute the slot-value in the "cell" for the corresponding tag in the "guide script" template.
STEP 4: If "Tele-Teaching" as learning media is selected, then get some information about the lecture, by referring the lecture-DB and the VOD short movie-DB.
STEP 5: Add the new "cell" to the Distance Educational Model.

The lecture-database consists of "lesson managing files" containing user-profile data, lecture schedules, trainees learning records, lecture abstracts, and so on. The "guide script" template file contains tag-information, written in the "guide script" description language (GSDL), for all subject-contents items in the Distance Educational Model.

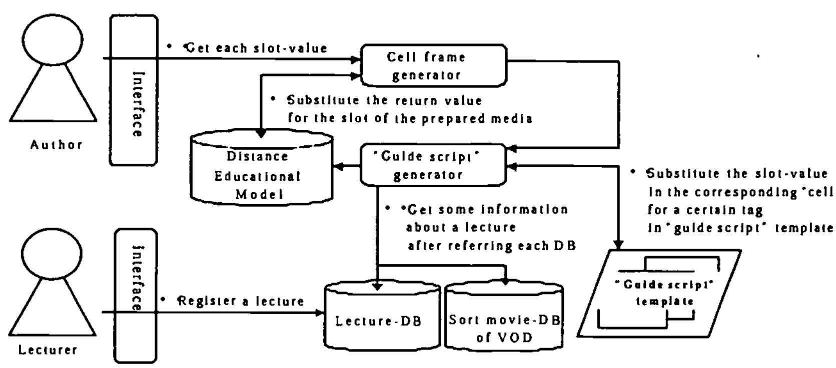

Fig.3 The procedure of "cell" description for creating/editing of the authoring system

4 Conclusions

This paper proposed the Distance Educational Model called the School Based Curriculum Development and Training System (SCOUTS). This model stands for the networked virtual leaning environment based on a three dimensional representation, which has on the axes 1) subject-contents, e.g., "information" for the training, 2) teaching knowledge, skills and evaluation methods and 3) learning and teaching media (forms). This represents a new framework for teachers' education in the coming networked age. We have mentioned the rationale of our system and explained the architecture of the training system via a 3D-representation model. Furthermore, we have described a "guide script" language. This system is superior to a simple rule-based instructional plan, as it allows a better and more natural overview of the global structure, as well as a quick identification of missing parts. The aim of our system is to support teachers' self-learning, provided as in-service training. At the same time, we need to build rich databases by accumulating various kinds of teaching expertise. In such a way, the concept of " knowledge-sharing" and "knowledge-reusing" will be implemented. As a result, we trust that a new learning ecology scheme will emerge from our environment.With this system, we can construct various kinds of learning forms and design interactive and collaborative activities among learners. Such an interactive learning environment can provide a modality of externalized knowledge-acquisition and knowledge-sharing, via the communication process, and support learning methods such as "Learning by asking", "Learning by showing","Learning by Observing, "Learning by Exploring" and "Learning by Teaching/Explaining"'. Among the learning effects expected from this system, we also aim at meta-cognition and distributed cognition, such as reflective thinking, self-monitoring, and so on. Therefore, we expect to build a new learning ecology, as mentioned above, through this system. Finally, we will apply this system to the real world and try to evaluate its effectiveness and usability from experimental and practical point of view.

References

[1]. Nishinosono, H.: A Teacher Education System for Information Education Teachers at High School Level in the Information Society. Proc. of the conference JET, pp.523-524 (1998)

[2] Collis, B.: Design, Development and Implementation of a WWW-Based Course-Support System. ICCE99, pp.11-18, IOS Press (1999)

[3] Seki, K., Takaoka, R., Matsui, T., Okamoto, T.: A Teaching Model in Distance Education based on Teacher's Needs. IEICE Technical Report, ET98-12, pp.49-56(1998)

[4] UNESCO Report: World Declaration on Higher Education for the 21 Century Vision and Action, Paris (1998)

[5] Salvador, L. G.: Continuing Education Through Distance Training. ICCE99, pp.512-515, IOS Press (1999)

The Internet-based Educational Resources of the U.S. Federal Government

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The Internet is an international computer network composed of thousands of smaller networks. Recently, through United States federal, state, and regional education networks and commercial providers, the vast resources of the Internet are increasingly available to administrators, school library media specialists, and classroom teachers. The web puts learning within the reach of anyone with Internet access. One of the most popular uses of this new medium, among teachers, is searching for ways to help students learn. But finding the right information on a particular topic for their students takes time. Current initiatives, such as FREE, GEM, ERIC, and Parents Guide to the Internet, meet this goal of improving online learning resources. This paper aims to introduce some of the United States' successful programs.

1 Introduction

One of the main priorities of the Clinton administration is to make sure that all Americans have the best education in the world. One of the goals of this "Call to Action for American Education" is to bring the power of the Information Age into all schools in the United States. This initiative requires connecting every classroom and library to the Internet, making sure that every child has access to multimedia computers, giving teachers the training they need to be as comfortable with the computer as they are with the chalkboard, and increasing the availability of high-quality educational content. When America meets the challenge of making every child technologically literate, children in rural towns, suburbs, and inner city schools will have equal access to the same knowledge base.

United States Federal agencies have made significant contributions to expanding this knowledge base. For example, "White House for Kids," is a home page with information on the history of the White House. NASA has a K-12 initiative, allowing students to interact with astronauts and to share in the excitement of scientific pursuits such as the exploration of Mars and Jupiter, and the experiments conducted on the Space Shuttle. Students participating in the GLOBE project (Global Learning and Observation for a Better Environment) collect actual atmospheric, aquatic, and biological data and use the Internet to share, analyze, and discuss the data with scientists and students all over the world. With support from the National Science Foundation, the Department of Energy, and the Department of Defense's CAETI program (Computer-Aided Education and Training Initiative), the Lawrence Berkeley Laboratory has developed a program that allows high school students to request and down-load their own observations of the universe from professional telescopes.

Of these government programs, four of these are as follows:

2 FREE (Federal Resources for Educational Excellence)

On April 18, 1997, President Clinton asked Federal agencies to determine what "resources you can make available that would enrich the Internet as a tool for teaching and learning." In response, more than 40

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Federal agencies formed a working group to make hundreds of federally supported education resources available on the FREE website.

Some of the subjects of the FREE include arts, educational technology, foreign languages, health and safety, and mathematics. Agencies involved include Centers for Disease Control and Prevention, National Gallery of Art, National Science Foundation, Peace Corps, Consumer Product Safety Commission, and the Smithsonian Institution.

3 GEM (Gateway to Educational Materials)

GEM began in 1996 after the National Library of Education (NLE) Advisory Task Force sought to find ways to apply library and information science skills to help educators find lesson plans and teacher guides on the Internet. GEM provides links to free Internet materials, partially free materials, and to resources that require a fee or registration to be used. There are two ways to access the education resources on GEM —Browsing and Searching. Browsing GEM is sampling from lists of predetermined categories (e.g. mathematics, language, education by grade level). Searching GEM is looking for any information containing the keywords of the query (e.g. algebra lesson plan). This website provides access to educational materials found on various federal, state, university, non-profit, and commercial Internet sites.

4 ERIC (Educational Resources Information Center)

The Ask ERIC service (Education Resources Information Center), supported by the Department of Education, has a virtual library of more than 900 lesson plans for K-12 teachers, and provides answers to questions from educators within 48 hours -- using a nationwide network of experts and databases of the latest research. Abstracts of some 1,300 (Educational Research Information Center) ERIC Digests are available online and text-searchable. A menu of services offered on the Internet not only introduces the user to ERIC documents, but also leads to other databases in education. It began in 1992 as a project of the ERIC Clearinghouse on Information and Technology and is now, with the ERIC Clearinghouse, a component of the Information Institute of Syracuse at Syracuse University. Today, Ask ERIC encompasses the resources of the entire ERIC system and beyond. Got an education question? Ask ERIC! The main components of Ask ERIC are:

1. Ask ERIC Question & Answer (Q&A) Service
   Need to know the latest information on special education, curriculum development or other education topics? Just Ask ERIC! When you submit your education question to Ask ERIC Q&A, you' ll receive a personal e-mail response from one of our network information specialists within two business days! We will send you a list of ERIC database citations that deal with your topic and will also refer you to other Internet resources for additional information. It' s that easy!

2. Ask ERIC Virtual Library
   The Ask ERIC Virtual Library contains selected educational resources, including 1000+ Ask ERIC Lesson Plans, 250+ Ask ERIC Info Guides, searchable archives of education-related listservs, links to Television Series Companion Guides, and much more!

3. Search the ERIC Database
   The ERIC database, the world' s largest source of education information, contains more than one million abstracts of documents and journal articles on education research and practice. By searching Ask ERIC' s web-based version of the ERIC Database, you can access the ERIC abstracts, which are also found in the printed medium, Resources in Education and Current Index to Journals in Education. The database is updated monthly, ensuring that the information you receive is timely and accurate.

5 Parents Guide to the Internet (16 page informational booklet)

This new, 16-page booklet, produced by the U.S. Department of Education, gives parents an introduction to the Internet and is "intended to help parents --regardless of their level of technological know-how--make use of the on-line world as an important educational tool. The guide cuts through the overwhelming amount of

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consumer information to give parents an introduction to the Internet and how to navigate it. Most importantly the guide suggests how parents can allow their children to tap into the wonders of the Internet while safeguarding them from its potential hazards.

This guide was produced with the sort of collaborative effort that American schools need in order to succeed. U.S. Department of Education staff worked with leaders from parent and education organizations, the private sector, nonprofit groups and others in order to give parents a clear and comprehensive overview of the Internet and its vast educational potential. In the same way, schools need support from every corner of the community in order to provide students with a high-quality education.

6 Conclusion

More than ever before, a high-quality education offers Americans the best path to a rewarding career and a fulfilling quality of life. As citizens of the Information Age, Americans must include access to technology among the elements of an education that is based on high standards of achievement and discipline. But incorporating technology into the Nation's schools is too big a job for the schools to tackle on their own. Teachers need support and involvement from parents, grandparents, businesses, cultural institutions and others in order to make effective in-class use of the wonders of technology.

The Internet is an international computer network composed of thousands of smaller networks. Recently, through United States federal, state, and regional education networks and commercial providers, the vast resources of the Internet are increasingly available to administrators, school library media specialists, and classroom teachers. The web puts learning within the reach of anyone with Internet access. One of the most popular uses of this new medium, among teachers, is searching for ways to help students learn. But finding the right resource on a particular topic for their students takes time. And time is in short supply for our teachers. Current initiatives, such as those outlined, FREE, GEM, ERIC, and Parents Guide to the Internet, meet this goal of improving online learning.

References

1. Becker, Henry J. Information Technology in Teacher Education: Survey of Current Status. Washington, D.C.: National Technical Information Service, U.S. Department of Commerce, March 1994.
2. Bernie Poole's EdIndex, Web Resources for Teachers and Students, http://www.pitt.edu/~poole/edmenum.html
3. Consortium for Policy Research in Education. CPRE Policy Briefs, June 16, 1995.
4. Cotton, E. G. (1998). "The Online classroom: Teaching with the Internet, third edition." Bloomington, IN: EDINFO Press. (ISBN-1-883790-29-8). (ED 413 606)
5. Educational Resources Information Center (ERIC) web site, http://www.askeric.org/
6. Federal Resources for Educational Excellence (FREE) web site, http://www.ed.gov/free/.
7. Gateway to Educational Materials (GEM) web site, http://www.thegateway.org
8. Junion-Metz, G. (1996). "K-12 resources on the Internet: An instructional guide." Internet workshop series, number 5. San Carlos, CA: Library Solutions Press. (ISBN-1-882208-14-5). (ED 389 316)
9. K-12 computer networking. (1995). "The ERIC Review," 4(1). (ED 392 413)
10. Lankes, R. D. (1996). "Bread and butter of the Internet." ERIC Digest. Syracuse, NY: ERIC Clearinghouse on Information & Technology. (ED 402 925)
11. Maeroff, Gene I. Changing Teaching: The Next Frontier. The National Foundation for the Improvement of Education, 1994.
12. McKinnon, P. Alistair, and Clesson S. Bush. "Technology for Education: What is the Federal Role?" Educational Technology 4 (1993): 37-41. Michalski, Jerry. Release 1.0: Esther Dyson's Monthly Report. New York: EDVenture Holdings, Inc., May 1995.
13. Milken Family Foundation. Expanding Classroom, Shrinking World: Resource Guide. Los Angeles, May 4, 1995.
14. National Center for Education Statistics, U.S. Department of Education. Advanced Telecommunications in U.S. Public Schools, K-12. Washington, D.C.: U.S. Government Printing Office, 1995.
15. National Center for Education Statistics, U.S. Department of Education. Annual Revenues and Expenditures: Public K-12 Schools. Washington, D.C.: U.S. Government Printing Office, 1991 and 1994.

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16. Parents Guide to the Internet web site, http://www.ed.gov/pubs/parents/internet/
17. Serim, F. & Koch, M. (1996). "NetLearning: Why teachers use the Internet." Sebastopol, CA: Songline Studios, Inc. and O'Reilly & Associates, Inc. (ED 396 700)
18. Tennant, R. (1996). Internet basics: Update 1996. ERIC Digest. Syracuse, NY: ERIC Clearinghouse on Information & Technology. (ED 392 466)
19. U.S. Congress, Office of Technology Assessment. Teachers and Technology: Making the Connection. Washington, D.C.: U.S. Government Printing Office, April 1995.
20. U.S. General Accounting Office. School Facilities: America's Schools Not Designed or Equipped for 21st Century. Washington, D.C.: U.S. Government Printing Office, 1995.

The network learning supported by constructivism

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1 Introduce

Network learning gives a chance to educators to rethink and investigate the learning modules and styles. Therefore the educators can rearrange learning strategies and develop new learning environment to validate the learning strategies and ideas. Although network learning cannot affect the learning completely and fully, at least network learning offer the environment to fulfill the ideas of constructivism.

2 Setting up the network learning environment

2.1.To provide multiple and abundant materials:

The network learning resources provide the objective and existed knowledge, the multi-angle and multi-level experiences to give learners various stimulations. In other words give the learners a chance to create multiple constructions, the same learner create different level construction at distinct time.

2.2.Give learners the authentic problems:

The important mission when teachers proceed with the instruction of constructivism is to arrange and provide the abundant and fitted learning environment, to offer and assist learners to construct knowledge actively and successfully.

2.3.Encourage learners raise various solving methods for the problems:

Promote learners to think of the problems by multi-angle ways. In order to encourage learners to discuss, think, argue and learn cooperatly, thus the learning have to be proceeded with dialog and communication.

2.4.Clear learning goals and concepts:

In internet world no place is too far away to be reached. If let learners grope or learn alone, it's usually happen that learners disorientate in the internet world. Thus if there is no clear goal, learning activity will be one pattern of browse and the emphasis will be neglect. Let learning activities concentrate at the learning goals or concepts, learners will get more complete knowledge, understand the key points, thus increase learning effects.

2.5.Learners can present viewpoints fully:

The internet world is a multi-person and pluralistic environment . In addition to self-learning, learners can see the learning portfolios of others. The learners review the cognition of others by self-viewpoint, furthermore to imitate and learn the others, and self-viewpoint can also be referred by others. Learners develop one kind of self-thinking in the environment of arguing with others again and again. Thus learners are no more silencers, but the learners are encouraged to present their viewpoints or opinions.

2.6.Adaptive courses:

There are individual differences between learners, learning processes or learning strategies of learners are different from others. Thus the design of courses should be considered about the individual

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difference,adapted to learning situation of learners. Arrange different course to match the learning situation and abilities of learners, thus learners got the individual learning.

3 Conclusion

It's convenient to search information and data in World Wide Web. The convenience is important factor to encourage learners to construct the self-knowledge. In the process of learners participating and learning actively, learners will feel that they have got self-learning goal.

In constructivism it's important factor that learners participate actively in learning process. Thus learners must participate self-learning activity positively. Learners should search and find knowledge what they want actively.In network learning environment the learning activities are emphasized the" internal control" directed by learners, and requesting learners to learn by their strategies in the process of learning activities.

4 References

[1] Chih-Yu Chan(1996),"Cognition and Knowledge: Constructivism VS. Acceptance", Journal of Education Research, 49,25-38.

[2] Chi-Hsien Lin(1999),'The design and application of network leaning environment", Journal of Information and Education,67,34-48.

[3] Kuei-Fa Chiu,(1996). "Situation learning concept and computer aided learning: The study of learning community " Taipei: Shih Ta Press.

[4] Kuei-Fa Chiu,(1996). "The study of network learning: The another space of education research", The 12th Science Education Seminar, Roc. December.

[5] Kuei-Fa Chiu,(1997), " The development of network learning environment supported by education", Environment education and information network seminar, May.

[6] Shih-Ju Chang(1997),'The meaning of internet hypertext and hypermedia applied in instruction with constructivism", Journal of Information and Education, 58 ,39-48.

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