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## Chapter 5

# **Open Technology, Open Standards and Open Knowledge in ICT-Enabled Learning**

## Preface

Open technology and open standards play key roles in today's growth of ICT-based education. Open technology and open standards are not just technical components but provide an open infrastructure to share open knowledge to evolve technology enhanced education. This workshop is the successor of the ICCE 2010 workshop with the same topics and will provide an opportunity to share information on the cutting edge activities such as R&D towards open technology and standards, open systems implementation based on the open standards, application and practice of open knowledge sharing on open technology-based platforms, open knowledge exchange between e-learning systems and neighboring fields such as e-Books, games, digital libraries, knowledge management, human resource development, and informal learning based on the open technology and standards. It is our great pleasure to be able to organize this workshop with the distinguished papers under the above mentioned scope. We hope this meaningful event will be an opportunity to deepen the understanding of this cutting edge field and encourage further research activity in the future.

Organizers

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# Usability Evaluation on an Affective Mobile Platform Based on Social Computing

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**Abstract:** In recent years, people's impression of web2.0 has been changed by many social networking rising abruptly, especially Facebook. It has become the most popular site for most of the Internet users. Facebook's CEO, Mark Zuckerberg, has also announced that there are over five-hundred million members visit Facebook for a day. It means many people use Facebook to socialize with their friends. With Facebook's graffiti wall, you can post news, photos, or favorite links. By pressing the "like" or replying message on your graffiti wall, you can easily know there are many of your friends concerned about you.

But only through the content which was published on the graffiti wall is difficult to find out users' emotions. So, if we can build an affective social computing platform on Facebook, analyzing and evaluating the contents what user posted on their graffiti wall, sending the relevant emotion result let user's friends know, it may help them understand what is user's emotion easily, and this may help your friends know what is your situation recently that they can have some corresponding to you, and this behavior is what we want to see. We hope to use this platform to help improving you and your friends' friendship. This study is focus on three major as following: (1) Using Internet to have Community and interaction. (2) How to build a platform combining affective computing on Facebook (identify symbols including text and voice), then let users decide whether update their emotion status on Facebook's graffiti wall or not. (3) Setting up our platform on mobile device. Such as: Android, iPhone...etc. We used Android smart phone in this project.

**Keywords:** Mobile Device, Social Network, Affective Computing, Facebook, Android

## Introduction

Due to the Internet boom, people who use computer are growing to a enormous number. Many people will use computer no matter how old they are; And using time is also being longer and longer. For those results, many different communities had been built on Internet. Those communities which were built on Internet have a new name, "Social Network". Facebook, which is the leader of social networks in recent years. According to checkFacebook.com (Facebook's official website) shows that, Facebook had already have

624,682,160 users, and is continuously growing. The data said that: Taiwan's Facebook users have more than ten million people. What a enormous number!

You might have a question for Facebook, how did Facebook get so many users? Here is the reason :Facebook has a function called "user's emotional state", this one is really attract teenagers; You can make friends on Facebook or comment a post by "like". If your friends change their emotional state from "In a relationship" into "single", there must have a lot of curious friends to ask "What's going on" or something else. But sometimes ,they are already heart-break, and don't want to be bothered cause they are in a blue. So, we think Facebook might need an affective computing platform which can let users talk about themselves then make analysis. When user's emotion state come out, sharing on the graffiti wall .This may help people understand each other more clearly.

## **1. Typographical Style and Layout**

### *1.1 Web2.0 and community computing*

Facebook can be regarded as the representation of Web2.0 and social computing .Web2.0 and social computing have many definitions; Macaskill and Owen had a definition : "To allow users to have access rights to get, provide, description, tags, comments and labels with a variety of Internet web media formats such as text, video, music, photos, graphics on the website platform".

### *1.2 Affective computing*

Affective Computing has four dimensions: (1) Perception: the system in terms of a mechanism for emotional input. (2) Modeling: to establish the classification of emotional relationship with the relevant variables. (3) Expression: emotional output mechanism. (4) Communication: to describe the emotion through language, to facilitate the transmission of emotions (Li Yan Tsai, 2004; Vesterinen, 2001; Hosts Red, 2007).

Picard (2000) mentioned on the Emotional Intelligence and noted that affective computing can be divided into four levels, they are: (1) Identification of emotions (2) The expression of emotions (3) With emotion (4) Emotional Intelligence.

### *1.3 Android*

Android is created by Google, many technology and mobile phone companies .They gathered a team called "Open Handset Alliance", and it's totally free and open source, this reduces the costs of research a new mobile device. Android mobile device is designed on the basis of Java programming language, and use Linux Kernel as core; It provide a lot of convenient API and works on Dalvik (the machine use to test Android system). In this framework, developers can minimize the coupling degree between programs and hardware that they can concentrate on developing Android program .

## 2. Research Methods

This research used affective computing algorithm, PHP, MySQL, Android mobile device and Flash AS3 , to build a platform that can recognize emotion with user's text or vocal level. We built a platform by Flash AS3, turning it into an Android App to catch information from user's inputs. After our database get user's information, it'll return the recognize results for users. The database used Facebook API to communicate with Facebook.

Word recognition, using the method as follows: (1) Ontology and natural language processing technology base on the Symbolic AI mode.(2) Computational Intelligence model which is Combined with SVM, KNN and other classifiers, emotional dictionary, language structure. Vocal level recognition part are: (1) Using sensors to capture emotional speech signal, then use the endpoint detection method to cut out the useful passages to exclude unnecessary data.(2) Calculating sound pitch and energy from the data to define different emotional features. Finally, to determine the emotion state with hybrid model of decision-making through voting algorithm to send the recognition results.

### 2.1 Emotion recognition database

User's Android phone or Facebook will be linked to the emotional identification database to define. The function of this emotion recognition database are as follows:

- (1) Connecting and setting with user's Android phone.
- (2) Capturing user's text from the platform and use text to do emotional recognition.
- (3) Capturing user's voice then transmitted from Android phone to the database and doing voice emotion recognition
- (4) The emotion recognition results will automatically publish on user's graffiti wall.

### 2.2 Facebook API

Facebook provide some API and related development kit for developers ;That can be used in Facebook's website, mobile application and so on. In this research we used Graph API and PHP for development, JSON for Graph API to pass user's data, PHP SDK will assist in communication between PHP and Graph API (such as login, pass the user ID, etc).

The main functions of this API are as follows:

- (1) To obtain the permission to post the recognition on user's graffiti wall.
- (2) Automatically obtain the user's information from Facebook.
- (3) Automatically post user's results on the graffiti wall.

### 2.3 Symbolic AI mode: Ontology and natural language processing technology as the foundation

In the relationship between the intensity of the two concept ;If one concept is set to emotions of joy, anger, sorrow, hate, surprise or other emotions, then it can get a concept node relative to the distance between different emotions, then it can be regarded as a concept for associated intensity with different emotion. Therefore, we can define every keyword (concept) by the emotional intensity.

If we only discuss the keywords of a sentence, make inferences, then calculate, it can be regarded as the emotional content of this sentence.

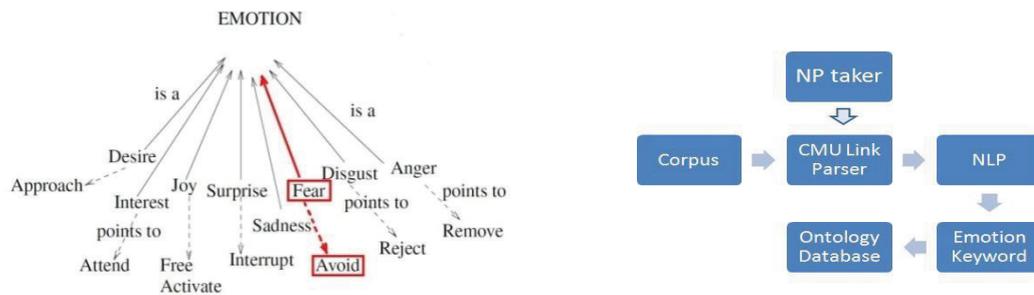


Figure I: Ontology-based & NLP system architecture      Figure II: Emotion Ontology

#### 2.4 KNN

KNN (K-th Nearest Neighbor) is based on Statistical Learning Theory. It developed a kind of unsupervised machine learning system. After analyzing text ,the information with those characteristic values will help KNN training and improving recognition accuracy.

#### 2.5 Hybrid voting algorithm for decision-making model

We use Nguyen’s study to decide the emotion, it contains three types (Nguyen, 2005): (1) Minimum Misclassification Method (2) Maximum Accuracy Method (3) Dominant Class Method.

#### 2.6 System usability scale(SUS)

SUS was created by Digital Equipments Co Ltd. in 1986; It’s purpose is to help companies to know their product’s usability and it’s easy to get the information which you need. We used SUS to figure out how people think about our platform. We analyzed the question and solve the problem which base on these questionnaire.

Table 1 shows our SUS questionnaire. In this research, we got 59 subjects .

Table1 SUS questionnaire

	Very disagree	Disagree	Non	Agree	Very agree
I think it’s really easy to use this					

prototype of the Simulation tests ,and I love to use this way to share my emotion					
I think this prototype of the Simulation tests is too difficult, there are some Redundant design.					
I think this prototype of the Simulation tests is easy to use					
I think I might need a guide to tell me how use this prototype of the Simulation tests					
I think this prototype of the Simulation tests have a good design of interface, it can help me to share emotion easily.					
I think this prototype of the Simulation tests have so many confused place.					
I think most of the people can easily learn how to use this prototype of the Simulation tests					
I think it's hard to use the prototype of the Simulation tests					
About this prototype of the Simulation tests ,I have confidence to use the correct way to share my emotion.					
I think I should use more time to figure out how to use the prototype of the Simulation tests					

Table2 is the calculation base on Table 1. The average is 62.14; Minimum is 45, maximum is 87.5, and mean is 60.

Table 2 The result of SUS

Average	Median	Minimum	Maximum	Standard deviation
62.14	60	45	87.5	10.15

The initial simulation questionnaire's scores are not look pretty well. So we redesign the system and platform. At next round, we picked 30 people to do the questionnaire again. And we got Table 3.

We find that the score has raise. It means most of the subjects think our system is worth to develop and they would like to use our platform.

Table 3 (For 30 surveys)

Average	Median	Minimum	Maximum	Standard deviation

69	65	60	87.5	8.77
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Why are these surveys have different score?

- (1) Most of the subjects are students; They don't have much experience on using smart phone whether Android or iPhone, so they answered the question as "non". After using our system they find that it's not difficult to use smart phone and it's pretty easy to use our platform on it.
- (2) At the first time we have this questionnaire is only on paper, so some of the subjects maybe can not fully understand what we are doing and accept our system. After we turn it into video and put it on Youtube ,we put our questionnaire on the internet and we got positive affirmation more than we expected.

### 3. Experimental Results

Users can use our platform on Facebook or their Android phone. When users is using their Facebook on the PC, they can use microphone to input the vocal level, then upload to emotional recognize database or type text with their keyboard; Or, using Android smart phone to give the information which our system need to our database. After system recognized, the database will transfer user's emotional state to their platform and the platform will automatically upload the result to Facebook's graffiti wall.

### 4. Conclusion and Future Works

In this research, we met a numerous problem ;Some user don't have a smart phone and it's not easy for everyone to accept what affective computing is (Some of the subjects said that it's dangerous to give emotion to computer). This research did a great job to help people understand what is the new trend of 22 century technology, Smart phone ,Android, and affecting computing. We proof that computer have emotion it's really humanity and it's only dangerous in movies.

There are more and more people start using smart phone. Android, Apple and windows, they are getting better and cheaper. This is a chance to have a revolution on technology, letting everybody have a smart phone it's not just a dream; It have happened , and it's still happening. People will get closer due to our platform. It's really easy to share your feeling, after recognized you can upload your emotion to the Facebook. It is so easy to let people know each others.

We hope to add facial detection in our platform. Besides, we want to put our platform not just on Facebook or Android but even iPhone or Windows phone. This might help our system to get more recognition and more accuracy. Hoping user who use our platform will:(1)Getting more and more people to use Facebook, and let the social network getting better and better.(2) Let user know what is their feeling and help them to recovery or share with user's happiness (3) Let people know each other not just what they looked outside but their heart inside.

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# A Designing of a Storage Sharing System for LMS using Cloud Storage: A Case Study of eDLTV

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**Abstract:** The use of e-learning has always been encouraged in Thailand; however, in medium and small schools, the effort has not yet been achieved due to the inability to produce quality content, which resulted in a knowledge gap between larger schools and the medium and small sized schools. This paper proposed the design of an e-learning system that can easily be distributed to schools throughout the country. The system is a combination of an existing LMS system called eDLTV and a cloud storage technology; thus creating an e-learning system that is available to all instructors and students through the use of the Internet, with the flexibility to choose whether to use an existing learning material or to create their own custom content.

**Keywords:** Learning Management System, LMS, Cloud Storage, Content Sharing, Distributed Data storage, Gluster File System

## Introduction

The effort to encourage the use of e-learning in Thai educational system is increasing over the years, especially in secondary schools. Many of these schools accompany regular teaching with an e-learning system to improve the student performance. The teachers are trained to be able to manage a simple e-learning system, as well as to create the content. From this perspective, the growth of e-learning in Thailand is to be expected; however, the result is not so. Two major problems faced by most schools are in the creation of digital content and the readiness of the infrastructure. These problems are even more severe in rural schools because of the limited number of teachers and other financial resource; to have an e-learning system of their own is almost impossible to accomplished. With this in mind, we proposed a new model of an e-learning system so that schools will not have to create the content or own their own server. The content is created by experts in each subject and stored on cloud storage, ready for school access. The servers will be supported by organizations with available infrastructure such as government agencies or universities. In this paper, the design of digital content sharing based on cloud storage technology for eDLTV, a further development of LearnSquare e-learning system, is presented.

## 1. Background

The proposed system consists of two components: eDLTV system and Cloud Storage technology.

1.1 eDLTV: an e-learning system based on LearnSquare - an open source e-learning system developed by NECTEC, Thailand [1]. The eDLTV was established under the collaboration of Her Royal Highness Princess Maha Chakri Sirindhorn: Royal IT project and the Distance Learning Foundation for the celebrations on the auspicious occasion of his majesty the King's 80th birthday anniversary [2]. Initially, in May 2007, the project provided only the content of the secondary school; now the eDLTV has expanded its operations through a network of 35 Rajabhat universities, with more than 30,000 instruction content including videos, slides, sheets and tests [3].

1.2 Cloud Storage technology: an efficient way for data sharing over the Internet. People are able to access the storage anytime and anywhere [4]. Many large companies have begun to deploy their own cloud computing platform, such as IBM, YAHOO, Amazon, Google and Facebook [5]. Two popular methods used to create Cloud Storage are Hadoop Distributed File System and Gluster File System.

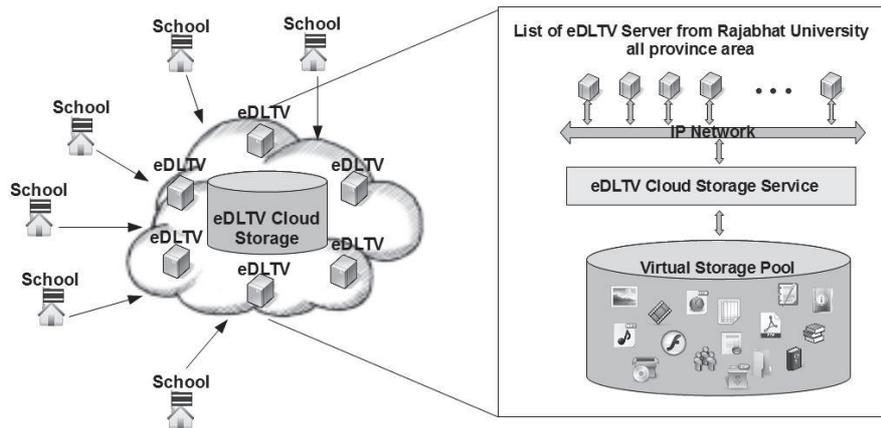
1.2.1 Hadoop Distributed File System (HDFS) is a distributed file system, which is one of the two component of Apache Hadoop [6]. The HDFS is composed of two modules called Namenode and Datanode [7]. The Namenode stores three major types of metadata of the entire file system, i.e. file and block namespaces, the mapping of files and blocks, and the locations of each block's replicas, whereas the Datanode stores the actual data [5].

1.2.2 Gluster File System (GlusterFS) is a network-attached storage file system developed by Gluster. The idea is to aggregate various storage servers over the Internet and interconnect them into one large parallel network file system [8]. Two component of GlusterFs are GlusterFS client and GlusterFS server. The GlusterFS servers are typically deployed as storage bricks, with each server running a glusterfsd daemon to export a local file system as a volume; the GlusterFS client composes these composite virtual storage volumes from multiple remote servers [9].

The paper will focus on GlusterFS because it is easier to be implemented with the eDLTV, since it doesn't affect the original data [9].

## 2. System Process

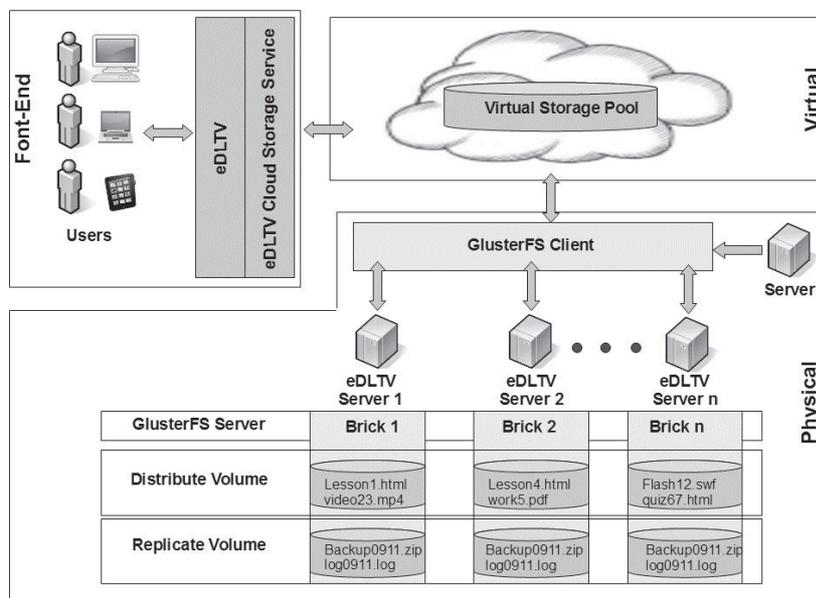
In this section, the overall structure and the functionality of the eDLTV Cloud Storage System is explained.



**Figure 1.** eDLTV Cloud Storage System Overview

*2.1 eDLTV Cloud Storage System Overview*

In Fig. 1, the eDLTV Cloud Storage System is the central storage for the eDLTV System. All eDLTV servers are connected to the eDLTV Cloud Storage Service which is then connected to the central Virtual Storage Pool that is responsible for storing data such as courses, texts, quizzes, SCORM, log files and so on. Every school has the same access to the same resource on the eDLTV server through the same URL, and will be able to use authoring tools, e-learning software and utilities from the eDLTV Cloud Storage Service without having to install them on their machines.



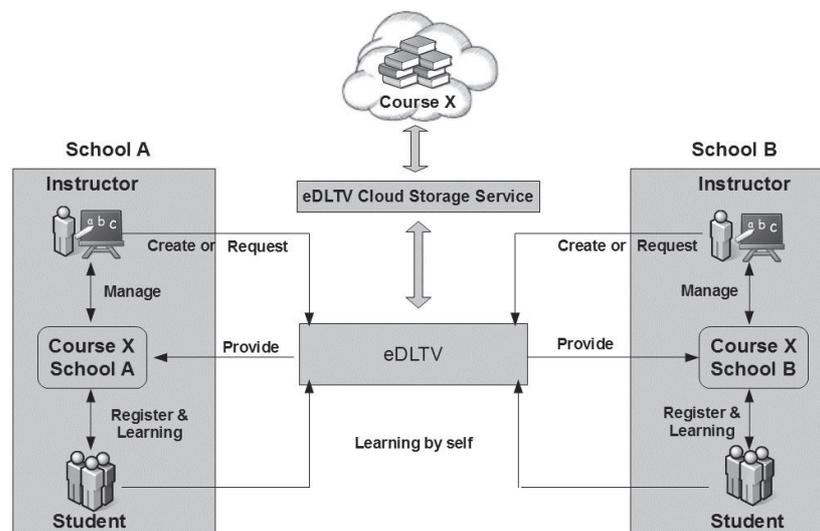
**Figure 2.** eDLTV Cloud Storage System Structure

*2.2 eDLTV Cloud Storage System Structure*

Fig. 2 is the process flow of the eDLTV Cloud Storage System: the flow starts when a user connects to the eDLTV server through various clients, such as computers or mobile devices

as shown in the Front-End block. Each eDLTV server then tries to retrieve the requested content via eDLTV Cloud Storage Service, which is connected the Virtual Storage Pool. Virtual block represents Virtual Storage Pool on the Internet. Virtual Storage Pool is created by GlusterFS which includes GlusterFS client and GlusterFS server.

In Physical block, the server that installs GlusterFS Client is responsible for managing GlusterFS Server from network, connect Brick from GlusterFS Server and defining data cluster type in Brick to create a virtual storage pool. Section of eDLTV server which installed GlusterFS Server will create Brick from free space in eDLTV server. Format of data cluster type of eDLTV cloud storage system includes two volume: Distribute and Replicate. Distribute Volume is distribute data storage of data cluster type which distribute files such as html, pdf, video, sound and flash store at each Brick. Example: Courses includes lesson1.html is stored in Brick 1, work5.pdf is stored in Brick 2 and flash12.swf is stored in Brick n. Replicate Volume is replicate data storage of data cluster type which replicated same files in all Brick. It backups file about content and log file.



**Figure 3.** LMS via eDLTV Cloud Storage System process

### 2.3 LMS via eDLTV Cloud Storage System Process

Fig. 4 illustrates the work process flow of the LMS in eDLTV cloud storage system. As you can see, School A is connected to eDLTV servers. If the students want an access to Course X, they can do so using the eDLTV server through the Internet. The eDLTV server fulfills the request by connecting to the eDLTV cloud storage system, retrieving the Course X, and passing it to the students. The same process also applies if the instructors want to create their own course; they can upload their courses to the eDLTV cloud storage system using the eDLTV Cloud Storage Service as well. School B also has the same access to the eDLTV system; however, the instructor and the student of School B will not have the access to the custom course created by School A.

### 3. Conclusion and Future work

The purpose of this work is to solve two major problems in implementing e-learning in schools in Thailand, which are the creation of digital content and the readiness of the infrastructure. We proposed a model of an e-learning system that can be used in schools without the requirement to have their own server or to create the content themselves. By using cloud storage technology, we expect that the digital content will be thoroughly distributed to schools in every part of the country, the issues concerning human and financial resource will be reduced, and the quality of the education system will improve.

In the future, we plan to connect the eDLTV to the Repository system to provide a larger knowledge base.

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# An Article/Presentation Revising Support System for Transferring Laboratory Knowledge

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**Abstract:** The main topic addressed in this paper is to develop an article/presentation revising support system for transferring experiential knowledge to be shared by a research laboratory in university. Graduate and undergraduate students in the laboratory usually deal with not only formal information such as research articles and presentation documents but also informal information which represents a process of research activities. However, it is difficult for them, especially new students belonging to the laboratory, to acquire such informal information from researchers and other students in the laboratory. In order to resolve this issue, we focus on the concept of laboratory knowledge. The laboratory knowledge is information such as research know-how, which facilitates the research activities for the laboratory members. We then demonstrate the article/presentation revising support system called CommentManager using the Office Open XML format. The system extracts the laboratory knowledge from the informal information accumulated from the laboratory members using.

**Keywords:** Article/Presentation Revising, Laboratory Knowledge, Informal Information Research Activity, Office Open XML

## Introduction

In our daily research life, researchers and students, who belong to a research laboratory in university, have to handle various research activities with a lot of information. They usually deal with not only formal information such as research articles and presentation documents but also informal information which represents a distinctive process of the activities in a laboratory manner. On the other hand, such laboratory periodically experiences a students' turn-over by their admission and graduation. Although management policy of the laboratory often remains the same for long period of time, it causes a decrease in number of students who have good experiments for performing the distinctive research activities. Therefore, it is difficult for the students, especially new students belonging to the laboratory, to acquire useful informal information accumulated from the laboratory members.

In order to resolve this issue, we adopt the concept of laboratory knowledge [1]. The laboratory knowledge is useful information such as research know-how for revising the articles or presentation and for making research schedule, which facilitates the research activities for the laboratories. For instance, actual process of trial and error for making a presentation document is one of the informal information. On the other hand, how to make a presentation in the laboratory manner is one of the laboratory knowledge extracted from the informal information or past experiences. Of course, it is important for the students to accumulate the informal information and to refine the laboratory knowledge so that they can

improve productivity of the research activities. However, informal information has the problem of disappearing with the time passage. It is also important for the laboratory members to transfer such knowledge to the novice students of the laboratory.

We have consequently developed an article/presentation revising support system called CommentManager that can extract the laboratory knowledge from the informal information accumulated in the process of revising the research articles by the laboratory members. One of the features of CommentManager manages all the comments distributed by several versions of the research article or presentation based on the Office Open XML[2]. This makes it easier for the students not only to comprehend the comments for their own articles or presentations but also to find high-frequent or useful comments by the other members.

In this paper, we first describe a model of the article/presentation revising and demonstrate the functions of CommentManager. We then report preliminary case studies by using CommentManager with the comment data described by the researcher in the articles that our laboratory students had written as master theses. The results of the case studies showed a potentiality for extracting the laboratory knowledge and some future tasks to improve CommentManager.

## **1. Article/Presentation Revising Model**

### *1.1 Process of Article/Presentation Writing*

In this paper, the target of the research activity is “article/presentation writing” that is frequently performed by the graduate or undergraduate students in their student life. Such activity enables them to promote understanding of not only specific research findings but also widespread reasoning skill [3]. The process of the article/presentation writing usually involves a series of revising documents with comments and corrections by the researcher. From this way of communication, they may be able to learn how to write the article/presentation practically. However, it is not so easy for them to accomplish the article/presentation according to the laboratory writing style. One of the reasons why they do not learn sufficient writing skill is that the researcher does not always take a systematic approach for training of the article/presentation writing skill. Of course, the students often read some articles or see some presentations related to their research. But, it is difficult to learn the writing skill since the ways of writing are different in the ones written by the laboratory. They also learn how to write the research article/presentation by taking the courses or reading the books. But, these courses and books do not necessarily cover the specific writing style in their research field. For these reasons, the students do not have enough chance to learn the writing skill apart from corrections of the articles/presentations by the researcher. Therefore, the article/presentation revising is one of the important roles from laboratory education point of view.

### *1.2 Model of Article/Presentation Revising*

Figure 1 shows a model of the typical failure process of the article/presentation writing. The student first writes a draft version of the article or presentation. The researcher then makes comments for the draft version. The student next seeks to correct the article/presentation, but he/she gets stuck on such revising. Some of the reasons why the student has troubles in the article/presentation revising are as follows.

- (a) The student, especially novice student in the laboratory, cannot reflect the provided comment to the new version of the article/presentation because it is difficult to understand the researcher's intentions of the comments.
- (b) The student is often interrupted by revising not contents but style of the article/presentation because he/she is not always aware of what he/she should consider in the article/presentation writing.
- (c) Most of the student cannot estimate the time to revise the article/presentation in advance because he/she does not have enough experience for the article/presentation writing.

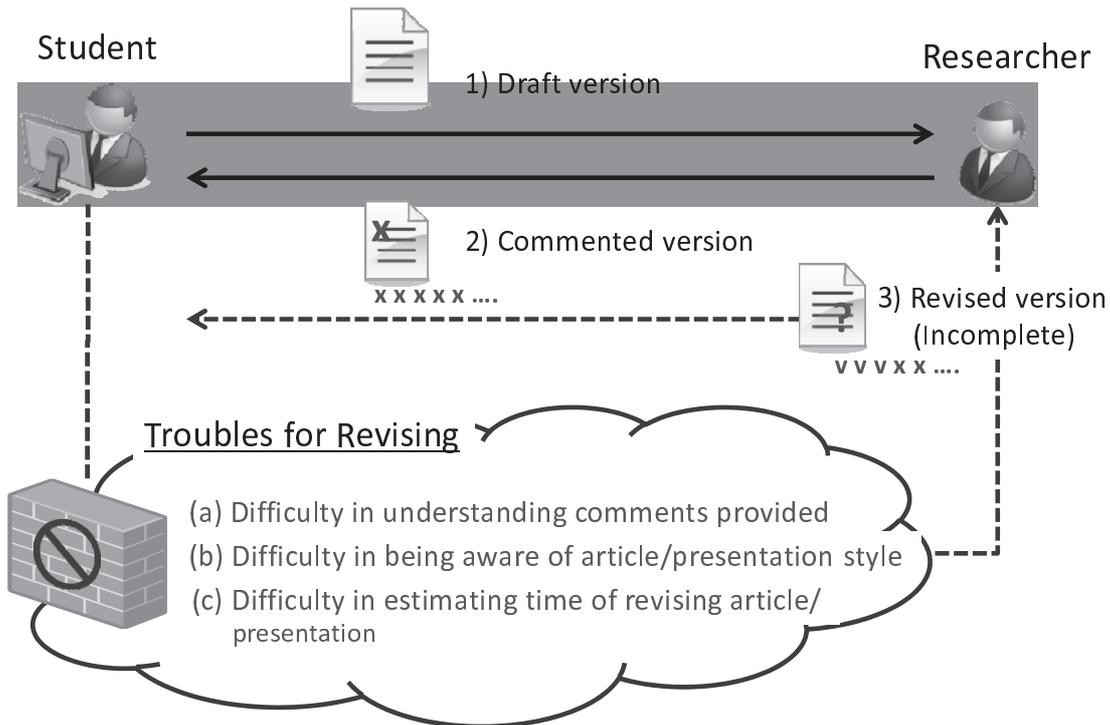


Figure 1. Model of Article/Presentation Revising

### 1.3 Approach

In the process of the revising, the researcher and the student exchange informal information. Such information has a central function for the article/presentation revising in a quick and efficient manner. From laboratory management point of view, it also makes the laboratory members communicate with each other effectively. However, it is difficult to figure out actual informal communication because it is implicit and disappears rapidly.

In order to resolve this issue, we need to provide the laboratory members with the laboratory knowledge for the article/presentation revising. Our approach is to extract the laboratory knowledge by gathering informal information existing in the process of the article/presentation revising from the laboratory members. In this research, the informal information means a set of researcher's comments and corresponding process for the article/presentation revising by the student. For this reason, such information often exists in more than one version of the article/presentation as the history of the corrections of the comment as shown in Figure 2. Therefore, we first design a comment management system which stores the researcher's comment to be revised and the student's answer. This system would facilitate the revising process by means of a comment list function which manages

status of the comments. At the same instant, the system gathers the comments and the answer as the informal information and extracts reference comments as the laboratory knowledge. The reference comments are frequent comments from the researcher or complex comments for the student. This makes the laboratory members trace other's corrections of the comment and the answer, if he/she had a trouble in the revising process.

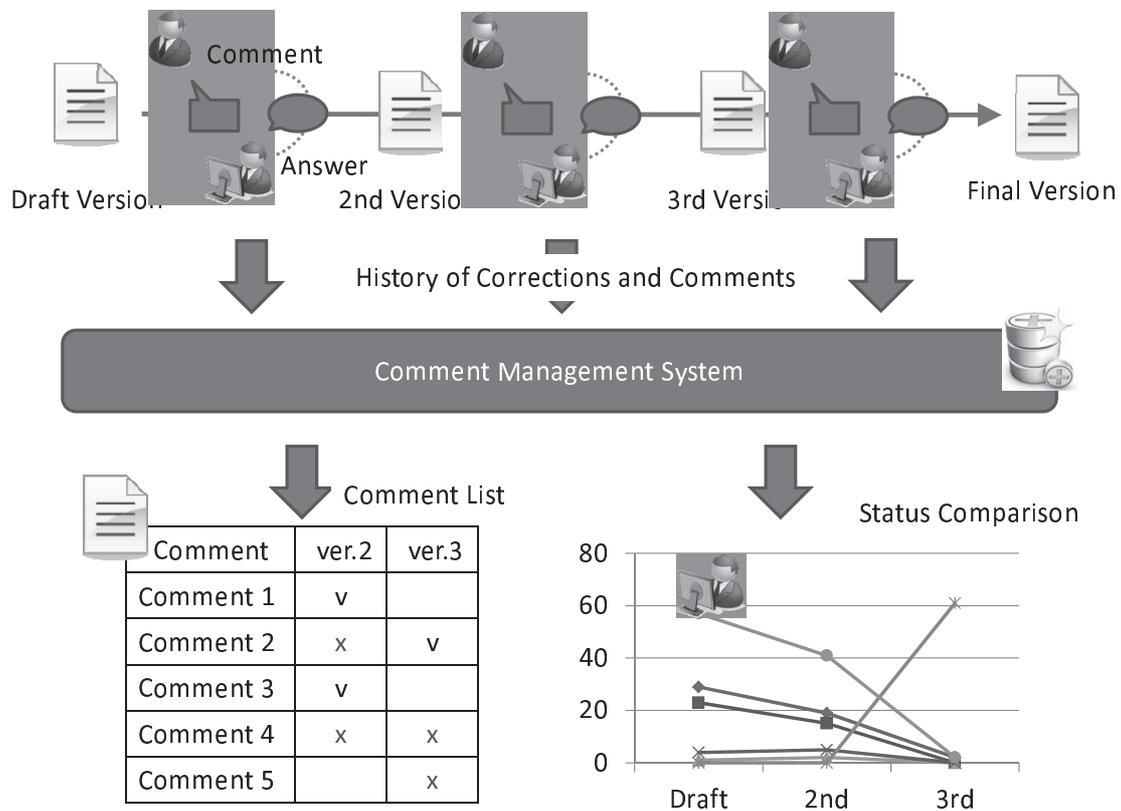


Figure 2. Concept of Comment Management System

## 2. CommentManager

We have developed an article/presentation revising support Web service called CommentManager. In the article/presentation revising process, many comments are exchanged between the researcher and the student. However, these comments are usually distributed by several versions of the article/presentation so far. CommentManager manages such comments as the informal information through the revising process. In addition, CommentManager provides the students with a knowledge transferring function which navigates related comments and high-frequent comments as the laboratory knowledge.

### 2.1 Extended Comment

CommentManager has a version control function for not only the articles/presentations but also the comments as extended comments. The extended comment means a set of comment, original and revised sentence, and the answer with the serial number among versions of the article/presentation as shown in Figure 3. This makes the researcher and the student share the informal intention for the revising. When the student uploads a Microsoft Word document (.docx) or a Microsoft PowerPoint file (.pptx), CommentManager makes a

comment list from the comment metadata by using the Office Open XML automatically. After that, all communication for the comments and the answers takes place in CommentManager. In addition, the researcher and the student are able to set a status flag such as “try again” and “close it” to the extended comments.

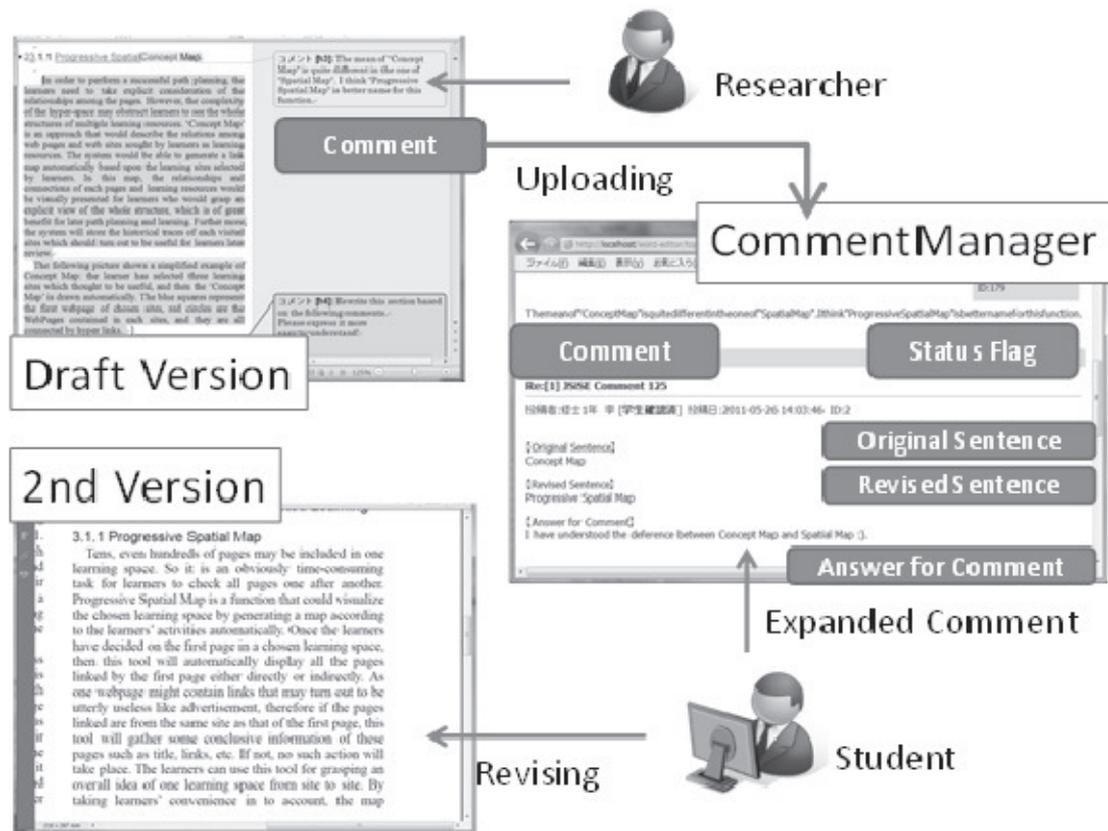


Figure 3. Sample of Extended Comment

## 2.2 Extracting Laboratory Knowledge

The extended comment implies a process of trial and error for the revising. CommentManager extracts the laboratory knowledge by gathering such comments from the laboratory members. CommentManager first lists the comments that the researcher made frequently or typically as a check list. This would make the student notice important points for the researcher’s check in advance. CommentManager also extracts the reference comments that the student could not correct suitably by a single revising. Such process would be available for learning how to revise in the laboratory manner.

We have divided 200 over comments that the researcher of our laboratory makes in the article revising process of the laboratory old boys and girls into five categories as shown in Table 1. Weight in Table 1 means average time taken to respond to the comment in the category. These values were decided by actual time of the revising process. Therefore, Commentmanager calculates the estimate time needed to submit next version of the article/presentation if the student selects the category of the comments. It also compares writing schedule of the old boys and girls. These functions make the student plan the writing schedule of the article.

Table 1. Categories of Comment

Category	Weight	Description
Comment for Section	60 min.	Revising a section including course of story.
Comment for Sentence	20 min.	Revising a sentence including word definition.
Comment for Format	1 min.	Revising a format error.
Comment for Figure	30 min.	Revising a figure and associated sentence.
Direct Correction	1 min.	Revised by the researcher.

### 2.3 Flow of Revising by CommentManager

Figure 4 shows a basic flow of revising by CommentManager. It has been implemented with PHP based on OpenTask [4] which is an open source bug tracking system. First, the student writes the draft version of the article using the check list so that he/she avoids basic indications. And then the researcher makes comments for the draft version. Next, the student looks up the expanded comment, especially the ones revised more than once as the reference comment, if he/she faces the comments that he/she is unsure how to deal with. The students write down his/her expanded comment such as original/revised sentence or slide and the answer for the comment to CommentManager. If needed, he/she is able to link the expanded comment to other comment that he/she use as a cue. Finally, the researcher checks the status of each expanded comment and changes the flag of the comment. If the flag is “try again”, the researcher adds advice so that the student can revise it effectively.

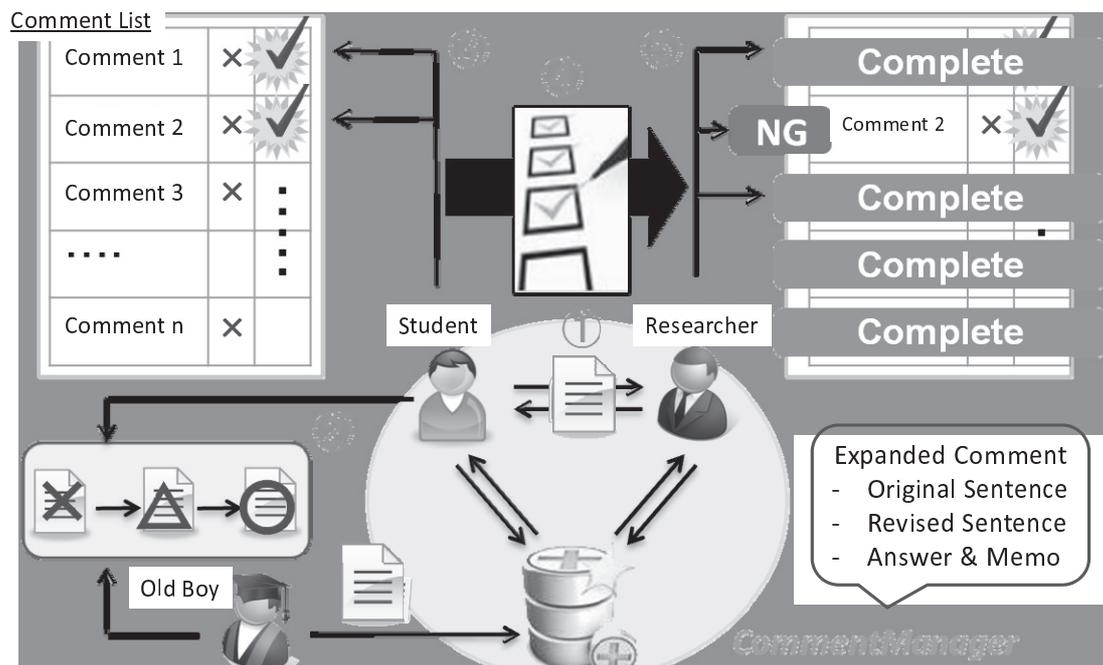


Figure 4. Basic Flow of Revising by CommentManager.

## 3. Preliminary Case Studies

### 3.1 Observation of Comments

In order to analyse tendency of the comments, we observed logs for a student who used CommentManager in the process of writing his master thesis. Figure 5 shows a number of

the comments classified by the categories in each version of the article. From the results, the comments for Comment for Sentence and Comment for Figure tended to be closed in the early versions. On the other hand, the comments for Direct Correction were received in the last half version. Such tendency would depend on the strategy of the article revising of the researcher. The reason why the comments were increasing from draft version to 2nd version because draft version was just 7 pages abstract and 2nd version was over 60 pages detail version. Compared with Microsoft Word, CommentManagere gave the researcher the student's intention to the comment that he could not revise adequately. However, the student had a load for managing a lot of unimportant comments.

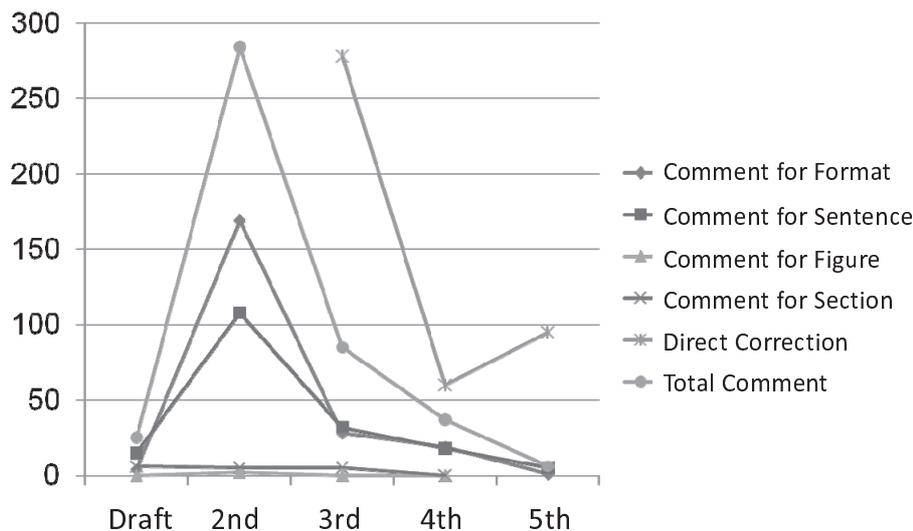


Figure 5. Variation with Number of Comment by Categories in Each Version

### 3.2 Observation of Laboratory Knowledge

In order to decide criteria for extracting the laboratory knowledge, we manually listed the comments made to 2 out of 3 students who wrote master thesis at January 2011 in our laboratory. Table 2 shows the candidates of the check list items. More than half of the candidates were matched with what the researcher usually coached. Therefore, we need to extract such candidates automatically.

We then compared subjective reference comments judged by the laboratory members to estimated reference comments determined by whether the one was revised by a single revising. From 284 comments, the number of the subject reference comments was 18 and the number of the estimated reference comments was 17. 11 comments were contained within both of them (precision ratio = 61.1%, recall ratio = 64.7%). The result indicated CommentManager extracted a certain number of the reference comments as the laboratory knowledge by managing the comment over the version of the article. We would like to improve the accuracy by implementing an evaluation function by each student.

## 4. Conclusion

This paper has described the article/presentation revising support system called CommentManager. The fundamental functions of the system are to manage the expanded comments over the versions of the article and to provide the students with the laboratory knowledge by the form of the check list and the reference comments. These functions would

enable the laboratory members to transfer the laboratory knowledge to be shared such as research know-how, which would facilitate learning research skill.

In addition, this paper has discussed the preliminary case studies for confirming effectiveness of CommentManager by using the comment data described in the articles that our laboratory members had written. We first inputted the informal information such as "memo of the trial and error" by using CommentManager, and then analyzed what the laboratory knowledge was extracted from the system. The results of the case study showed potentiality for extracting the laboratory knowledge, which would support the article revising process of the new students.

In the near future, it will be necessary to improve the extraction accuracy and to facilitate skill development for writing the research article. Finally, we need to evaluate effectiveness of the functions by new students belonging to our laboratory in a more detail.

Table 2. Candidates of Check List

Candidates by Multiple Comments	Number of Commented Students	Evaluation by Researcher
Specify the definition of new technical term.	3	Important
Standardize technical term in the article.	3	Important
Describe why the support needs.	3	Important
Use concrete examples.	3	Important
Match figure and sentences.	3	Normal
Rewrite complex sentence to short sentence.	3	Important
Study and list reference work.	3	Important
Correct typographical and grammatical errors.	3	Normal
Divide paragraph adequately.	2	Normal
Check font style and size.	2	Normal
Avoid being redundant in sentences	2	Normal

## Acknowledgements

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# Applying an Extensible Learning Support System to Collaborative Learning Environments

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**Abstract:** This paper describes an investigation of the application of an extensible learner-adaptive system, Extensible Learning Environment with Courseware Object Architecture (ELECOA), to a collaborative learning environment. The design goal of ELECOA is to provide a flexible learning environment that ensures both function extensibility and content reusability. The concept of a “courseware object,” which is a program module that is used to incrementally implement various educational functionalities, has been introduced to achieve this goal. Based on this concept, a self-learning environment has been implemented that is fully compliant with the SCORM 2004 specification. This report provides the investigation results of implementation on a collaborative learning environment based on the Learning Design specification within the ELECOA framework.

**Keywords:** Learner Adaptation, Courseware Object, Learning Design, Extensible Learning Support System

## Introduction

In order to provide high-quality e-learning services that offer rich educational experiences, the interoperability and reusability of learning content is vital. There have been various efforts made to develop and disseminate e-learning content specifications [4]. Many learner-adaptive systems, capable of presenting learning content and resources that match the learner’s comprehension level, have also been considered as an effective means to provide an improved learning experience [2, 7, 9]. However, there has been little consideration of the interoperability and reusability of content in the field of learner-adaptive systems. Generally speaking, learner-adaptive systems have been designed on the basis of a certain single learner-adaptive strategy without any extensibility to support multiple learner-adaptive strategies or even to modify a single implemented strategy. Due to this lack of flexibility, it is difficult and sometimes impossible to add new functions that could improve the effectiveness of learning because the newly added functions may interfere with the current content, thus impairing its reliable behavior.

In response to this problem, we developed a learning-system architecture called Extensible Learning Environment with Courseware Object Architecture (ELECOA) that can both extend learner-adaptive functions and make the learning content interoperable [10]. This architecture was designed around the concept of a “courseware object,” which is a program module that implements various educational functionalities and is usually embedded as an inseparable fragment of program code in the learning platform. It is possible to incrementally extend functions by adding new courseware objects. We have previously shown that several learner-adaptive functionalities for self-learning, including

the SCORM 2004 standard specification [1] and its extensions, can be successfully implemented on ELECOA [10].

Educational Modeling Language (EML) has attracted the attention of developers of learning environments. EML was designed to formally describe formations and sequences of various types of educational activities, including not only self-learning materials but also lectures and collaborations in which groups of learners and instructors are involved. The intent was to share and reuse pedagogical strategies to achieve effective learning. In particular, the IMS Learning Design (LD) specification [6, 9], which was derived from EML and developed by the Open University in the Netherlands, has been widely used in several research projects. These projects include the development of LD authoring tools, LD execution systems [3, 8], and a system to generate pedagogy described in LD from higher level design requirements that take into account instructional design theories [5].

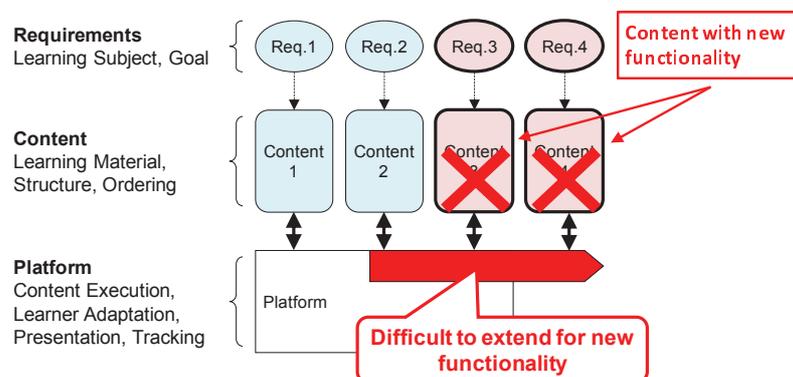
In this paper, we discuss our investigation of how to implement an LD execution system based on ELECOA, which has primarily been used only in the self-learning environment. The results of our investigation indicate that ELECOA is capable of seamlessly integrating self-learning learner-adaptive environments (such as that of SCORM 2004) with an LD-based collaborative learning environment. We also found a few issues related to this implementation that will need to be addressed.

## 1. Extensible Learner-Adaptive System Architecture

### 1.1 Issues with Conventional Learner-Adaptive Systems

Conventional learner-adaptive systems typically have the system architecture shown in Fig. 1, in which the content is separated from the platform [10]. In this type of architecture, the content consists of learning materials specific to a particular learning subject, and the platform devises common learner-adaptive functionalities independent of the specific learning subject. By separating the content from the platform, this configuration makes it possible to design learner-adaptive content with less effort because the designer can concentrate on creating content to fulfill the specific learning goals and not worry about the specifics of implementing learner-adaptive functionalities.

The drawback to this architecture is its lack of function extensibility. After implementation, extending the platform to add new functionalities is difficult because it is not possible to ensure that the existing learning content designed for the original platform will work correctly on the extended platform. A representative standard with learner-adaptive capabilities, SCORM 2004, uses the same configuration, resulting in the same lack of function extensibility.

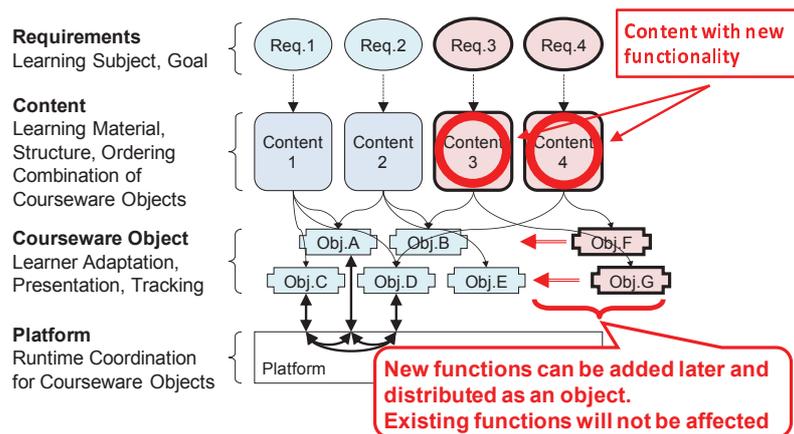


**Fig. 1. Architecture of conventional learner-adaptive systems.**

### 1.2 Approach of Proposed Learner-adaptive Architecture

To overcome the drawbacks of conventional learner-adaptive systems, we recently proposed a learner-adaptive system architecture called ELECOA with the aim of achieving both function extensibility and system interoperability [10]. Our key to accomplishing this goal is the concept of a “courseware object” to modularize the learner-adaptive system architecture. The courseware object is a program module that implements various educational functionalities that are embedded in the platform of the conventional architecture. The courseware objects implement functions, including learner adaptation, to select the most suitable learning material for the learner, material presentation to tailor the way the learning material is presented, and learner tracking to record the status of the learner’s progress. For example, there might be multiple courseware objects, each of which implements simple linear, conditional branching, complicated remedial, or much more sophisticated strategies such as scenario-based sequencing using a state-transition machine.

Fig. 2 shows the proposed ELECOA architecture in which the courseware object is clearly separated from the platform. With this configuration, incremental extension of functions is possible by adding new courseware objects. Since this extension does not affect the previously implemented functions, the existing content will continue to work correctly. In addition, courseware objects can be distributed along with content, thus enabling existing platforms to be immediately updated for newly developed functionalities.



**Fig. 2. Proposed ELECOA architecture.**

### 1.3 Application of ELECOA to Self-learning Environment

For the ELECOA architecture to be of any value, it must be possible to assemble any courseware objects developed by various designers at various times and have them work together. To make this feasible, it is necessary to design some criteria or standards to which every courseware object designer must conform. These criteria may include the communication scheme between courseware objects, the information maintained by courseware objects, and the responsibility of courseware objects.

To investigate these issues, the system was designed in accordance with the following principles and assumptions. First, it was assumed that the content is structured hierarchically, or like a tree. This is because content with a hierarchical structure is widely adopted in learning materials by various standards, including AICC CMI, ADL SCORM, and IMS CC [4], as well as various proprietary LMSs. Second, it was assumed that the courseware objects are assigned for each hierarchical node of content, as outlined in Fig. 3.

It is the responsibility of the courseware object assigned to a content node to manage the learner-adaptation behavior of the sub-tree under its node. The courseware object sequences its child nodes by taking into account their learner progress information according to the pedagogical strategy implemented in it. This makes it possible to implement different pedagogical strategies in different sub-trees. It is also assumed that the communication between courseware objects is only limited between parents and children. On the basis of this assumption, definitions are designed for the required communication patterns between courseware objects and the interface that courseware objects should provide for other courseware objects.

The SCORM 2004 specification, which is a standard for learner-adaptive content, has been implemented based on these principles and assumptions [10]. The implementation was demonstrated to be conformant to SCORM 2004 3rd edition by checking against the test suite of the specification consisting of 100 test cases.

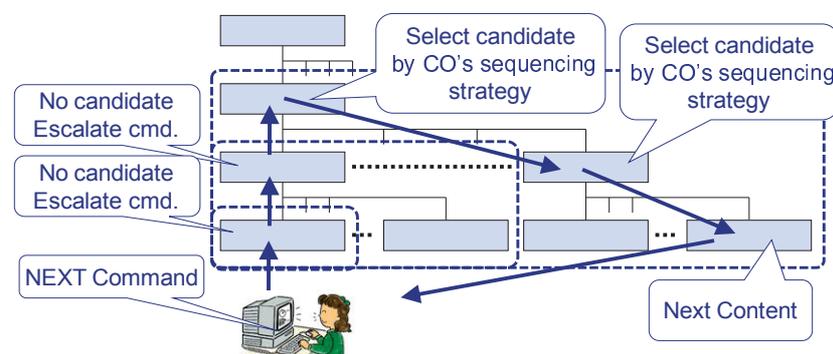


Fig. 3. Communication between courseware objects in hierarchical configuration.

## 2. Application of ELECOA to Learning Design Specification

### 2.1 Learning Design Specification

The LD specification is designed to promote the sharing and reuse of pedagogical strategy to achieve effective learning results by formally describing formations and sequences of educational activities. It is a pedagogy-neutral technical specification capable of describing various types of educational activities, including self-learning materials, lectures, and group learning. However, the LD specification's most notable feature is its capability to describe collaborative learning activities, which follows the recent trend of e-learning toward a learner-centered approach.

The LD specification defines a data model to describe learning activities. In the LD specification, the primary elements to describe learning activities are "activity," "role," and "environments." An activity uses several environments, including "learning objects" and "services." It also involves people with several roles, such as "learner" or "staff." The activity has an "activity structure," which is a hierarchical one so that the aggregation of activities becomes an upper-level activity. The above-mentioned description of learning activity can be represented using level A of the LD specification. With level B, the properties of a person or group and conditions for the sequence of activities can be described to control the learning sequence. In addition, events resulting from certain activities, such as the notification of a question from a learner, can be described with level C.

LAMS [3], which is the most commonly disseminated open source learning tool compliant to the LD specification, has two types of communities: one for a system developer to update the system itself and the other for instructional designers to share and

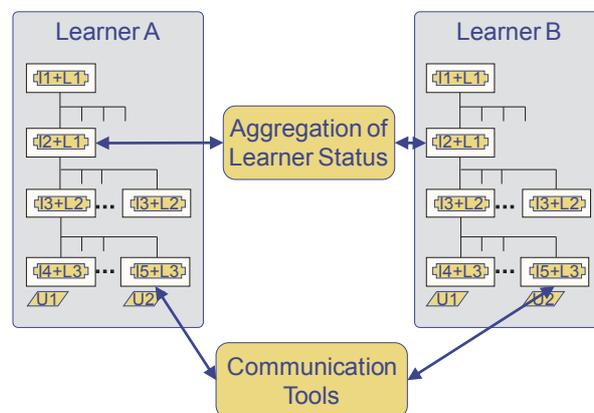
reuse descriptions of designed educational activities. LAMS deals with sequences of learning activities, e.g., each learning activity can be assigned to one of a variety of environments, such as document, survey, chat, or forum. It can also deal with a hierarchical activity that has an internal structure with conditional branches. Synchronization of multiple learners can be implemented by a waiting point where all the learners have to stop until every other learner finishes the previous activities. For example, before entering a synchronous forum, all the participants must finish a pre-assigned series of activities.

## 2.2 Basic Framework to Implement LD Specification with ELECOA

The basic implementation framework of the LD specification using ELECOA has previously been investigated [11]. ELECOA was originally designed for self-learning; it was not intended to support group learners. However, both ELECOA and the LD specification deal with hierarchical structures. In addition, ELECOA has the capability to control learning activity sequences by means of courseware objects.

The investigation took into account these characteristics. With the LD specification, learners follow a predefined learning path in which they communicate with other learners and instructors using communication tools such as chat or forum. The learning path varies according to the learner's own learning status as well as those of other learners. Thus, the following issues should be considered for implementing the LD specification using ELECOA:

- (1) implementation of a learning path for each individual learner,
- (2) integration with communication tools, and
- (3) control of the learning path based on the status of multiple learners.



**Fig. 4. Implementation of LD specification with ELECOA.**

The implementation is outlined in Fig. 4. First, the learning path of each learner is controlled by the courseware objects in a similar manner to the original ELECOA behavior for self-learning in a hierarchical structure. The courseware object selects the next node to be presented to the learner according to the learner's status. This makes it possible to implement learning path control that takes into account each individual's status. Second, communication tools are integrated as learning resources to be associated with the leaf node of the hierarchical content. In the LD specification, communication tools and learning services are environments that also include learning resources such as static HTML documents or quizzes associated with the leaf node of hierarchical learning activity. Thus, in the ELECOA-based implementation, they are associated with the leaf nodes in the same way that the original ELECOA has learning resources assigned to leaf nodes. Finally, to

reflect multiple learners' statuses in each individual learning path, a courseware object is equipped with the capability to exchange information with other courseware objects controlling the learning path of other learners. In this way, the courseware object can determine the learning resources to be presented by taking account of multiple learners' statuses. This means that each learner's learning sequences can be controlled on the basis of their own learning status as well as those of other learners.

It is important to note that the basic framework of ELECOA is not modified to implement the LD specification. The framework defines the process of information exchange between courseware objects assigned to a hierarchical structure to determine the next learning resources presented to the learner. Since this framework is independent of the learning resources to be presented, it does not need to be modified if communication tools or learning services are assigned as learning resources. In addition, this framework simply defines the communication schema between courseware objects in the hierarchical structure, which is independent of the internal behavior of each courseware object, to control the learning path. Thus, the framework does not need to be modified if the courseware object, as its "internal behavior," exchanges information with other learners' courseware objects to control the learning path. It is therefore possible to implement the LD specification using ELECOA without modifying its basic framework by simply adding learning resources and courseware objects for collaborative learning.

### *2.3 Issues to be Considered regarding Implementation of LD Specification with ELECOA*

The following issues should be considered with regard to the implementation of a group learning environment defined by the LD specification within the ELECOA framework:

- (1) assignment of activities and environments according to roles,
- (2) dynamic generation and assignment of activities and environments, and
- (3) function to aggregate and control this information.

These issues are discussed in the following sections.

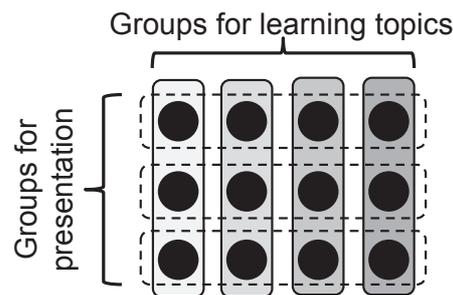
#### *2.3.1 Assignment of Activities and Environments according to Roles*

The biggest difference between a collaborative learning environment and a self-learning environment is the necessity of multiple-user control in the former environment. In the collaborative learning environment, every user can be a learner, or some users can be another role type such as an instructor. The LD specification defines learner and staff as two major roles. Designers can also define new roles that are derived from the major roles. Roles can be defined in a hierarchical manner, and this functionality makes it possible to assign users to hierarchically divided groups. The designer may assign activities and environments to roles. It is thus possible to create assignments in which each learner group uses different discussion rooms and instructors can join any discussion in any room. From the system implementation point of view, these assignments can be created either before runtime, when the activity structure is generated, or during runtime, while the learning sequence is executed.

#### *2.3.2 Dynamic Generation and Assignment of Activities and Environments*

Flexible formation of learner groups is necessary in any collaborative learning activity. For example, the jigsaw method requires separate groups to learn certain topics and then give

presentations on these topics, as shown in Fig 5. In this method, first, different learning topics related to one learning subject are assigned to each group. These groups discuss the assigned topic, and then groups are formed for presentations in such a way that each group gives a presentation to learners from different groups on their particular learning topic. In this way, learners with knowledge about different topics collaborate in their respective groups to discuss their topic and prepare their presentation. There is the option of assigning learners to multiple groups during collaborative learning activities, and there are also various options about the number of groups and the criteria for assigning individuals to groups (such as fixed, random, learners' preference, learners' performance, etc.). These assignments are made either statically in advance or dynamically during the learning activity itself.



**Fig. 5. Group Formation for Jigsaw Method.**

Another example is the Versailles role play, shown as an use case in the Learning Design specification [6]. In this case,  $n$  groups of learners corresponding to  $n$  countries perform bilateral negotiation. All combinations of countries require  $C(n, 2)$  negotiation meetings. For example, as  $n$  is set to 6 in this use case, it is required to prepare  $C(n, 2) = 15$  online meeting rooms statically defined in the LD manifest file.

As seen in this example, the original LD specification requires environments to be statically defined before execution, which can possibly lead to a lack of flexibility and extensibility. LAMS, on the other hand, provides a group assignment strategy based on the number of groups and the number of learners per group. To carry out this assignment strategy, it is necessary to implement a function to dynamically generate the proper number of groups with required environments according to the number of learners and to assign learners to these groups.

### 2.3.3 Function to Aggregate and Control Information for Collaborative Learning

In order to deal with the issues discussed in the previous two sections, it is necessary to implement functionality for learner status aggregation and learning sequence management (as shown in Fig. 4). Various physical implementation schemata for this functionality can be considered, including a schema with a central server aggregating all information, a schema with functions and information completely distributed to the courseware objects of each learner, and an intermediate schema in which both a central server and courseware objects are responsible for managing learner status and learning sequence. In fact, the original LD specification has been implemented in several ways, including on a single state transition machine that takes care of the management of all learners and on a P2P network in which the distributed engine assigned to each learner exchanges information for the learning sequence [8].

Because of these differences, if used, the implementation schemata would impact the scalability of the system and the effectiveness of implementing management functionality. In addition, since the implementation schemata would affect the extensibility and reusability of courseware objects for collaborative learning in ELECOA, careful consideration is required as to the responsibility and interface between individual learners' modules and common modules taking care of learner status and learning sequence management.

### 3. Conclusion

In this paper, we discussed our investigation of the implementation of the LD specification using ELECOA, an extensible learner-adaptive environment enabling both functional extensibility and content interoperability. Although the original intention of ELECOA was to support self-learning, its extensibility may make it possible to implement the LD specification to include group learning. With this capability to implement self-learning and group learning in the same framework, it would be possible to provide an integrated learning environment in which materials and learner history could be seamlessly exchanged between self-learning and group learning. Further study is needed to clarify a few issues that remain in applying ELECOA to the implementation of collaborative learning environments that include the LD specification.

### Acknowledgments

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# Expanding the Scope of Metadata and the Issue of Quality

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## **Abstract:**

This paper summarises the current context of metadata standards development relevant to Information Technology for Learning, Education, and Training (ITLET). A number of issues are identified that need further discussion in order to harness the potential of ICT in LET. In particular, issues related to assessing quality of standards; how to scope ITLET standards; and how to specify metadata for explanatory content are highlighted.

**Keywords:** metadata, ICT standards, IEEE LOM, ISO MLR, learning resource description, learning technologies, ITLET

## **1. Introduction**

Metadata is a term that can convey diverse meanings, probably because the root ‘meta’ has rich semantics and can mean: ‘beyond’, or ‘above’ as in metaphysics or metacognition; ‘behind’ or ‘after’ as in metaphase; ‘change’ as in metamorphosis; and, ‘together with’ as in metabolism. It is a term that has been adopted in recent decades by standards development organizations such as the Institute of Electronics and Electrical Engineers (IEEE) and the International Organization for Standardization (ISO). It also describes the core focus of the Dublin Core Metadata Initiative (DCMI) and is basic to the specifications developed by the IMS Global Learning Consortium (IMS GLC).

While both the IEEE and ISO choose not to define it within their standards that are used by IMS GLC and many other stakeholders worldwide [1, 2], the DCMI uses a very short and commonly accepted definition of metadata as “data about data”. The US-based National Information Standards Organization (NISO) provides a longer version as: “structured information that describes, explains, locates, or otherwise makes it easier to retrieve, use, or manage an information resource” [3]. While it is also noteworthy that Wikipedia declares it to be “an ambiguous term” [4], evidence suggests a common and evolving understanding of this term within the standards development community is that metadata is data that not only describes or identifies other data, but also information resources (digital and non-digital), events, people, and services [5, 6]. Following on from this the discourse on metadata standards for learning is far from over and indications are that the scope of what metadata does within ICT infrastructure is expanding.

It is commonly stated, however, that “the nice thing about standards is that there are so many of them to choose from.” This quote, attributed to Andrew Tanenbaum [7] highlights the dilemma of many implementers of metadata standards. Due diligence, particularly in the ISO context, requires that any new standardization project must identify and situate its scope of work in the context of having navigated a complicated standards

landscape of the past, relevant current initiatives. For implementers, the challenge is discerning those standards that are best fit for purpose.

IEEE LOM was the first e-learning metadata standard, published in 2002 [1]. Other *de facto* standards at the time, such as the Dublin Core (DC) Metadata Element Set [8], also provided a means of describing learning resources, although without the same degree of specificity. However, this situation unfortunately led to significant confusion by stakeholders in the education community. While both these standards had similarities they were not interoperable, and implementers of systems were left to solve the interoperability issues with workarounds. It was in this context, following the formation within ISO/IEC of SC36 (subcommittee 36, IT for Learning, Education and Training – ITLET), that a project on Metadata for Learning Resources (MLR) was initiated. While there were perceived deficiencies with IEEE LOM, however, national bodies participating in SC36 wanted to produce “a harmonized standard” with LOM and DC. Also, because of industry adoption of LOM as a result of the market success of SCORM [9] they also wanted to “maintain compatibility with the implementation of IEEE 1484.12.1:2002 where practicable”. Apart from these initial requirements the consensus about direction of development was not clear and the early years of drafting a framework for specification went through much iteration. This was further complicated as a consequence of significant and evolving work taking place within the Dublin Core Metadata Initiative (DCMI) [8]. As a consequence, SC36 used the rest of the decennium before finalizing their first MLR standard, the framework part, published in 2011 [2].

It might be easy to criticize SC36 on the time span involved in delivering MLR to the ITLET community without understanding the full context – a context which is characterized by unprecedented innovation in information and communications technology (ICT) development and strained relations between a number of the specifications and standardization bodies. Standards development does not happen in isolation, however, and ensuring optimum process and quality outcomes is dependent upon a number of factors. Probably of most importance for the next steps in metadata standards is consideration of the broader context of ICT innovation on the Web and the consequences this has for the specification and use of metadata.

### *1.1. The Evolving Web*

From the very beginnings of the Web metadata has played a key role shaping its ongoing architecture. Whether in the form of HTML META tags (to assist search engines of the time), as hypertext enabling the foundational utility of the Web, or as indexes produced by the sophisticated algorithms developed by Google, metadata has existed in various forms. Hypertext itself represents a powerful instance of executable metadata; Extensible Markup Language (XML) is a key technology that facilitates the interoperability of structured content and provides capacity for very rich encoding of metadata; Web 2.0 tags used in social software applications (such as del.icio.us, Twitter, and Flickr) provide a collective, informal means of classifying and sharing resources [10]; and metadata standards such as the IEEE LOM [1] and the Dublin Core Metadata Element Set [12] have provided standard mechanisms for the description of resources on the Web for many years [5,6]. The recent publication of the ISO standard, *Metadata for Learning Resources – Part 1: Framework*, builds on both these standards and provides an extensible and modular framework for specifying new metadata data elements [2].

While much of the development of e-learning standards started after it became clear that the web would have a huge impact on learning technologies the relational database paradigm continued to influence metadata development. The IMS Content Package

specification [13] was developed in tandem with the IEEE LOM and has played a dominant role in moving resources between applications, despite this specification having been modeled on the pre-web CD-ROM media. This legacy contributed to controversy in the development of ISO MLR with regards to “web enabling” the standard, leaving the database area to embrace the web architecture view on metadata.

An environmental scan of related metadata innovations reveals a number of other uses of metadata, particularly in relation to e-learning. For example, the European standards committee CEN has recently standardized Metadata for Learning Opportunities [14], based on the Dublin Core Abstract Model (RDF). This is the first in a series of smaller standards that address “European learner mobility”. We also see that syndication technologies such as RSS and ATOM, which play an important role in Web 2.0 technologies, are commonly used in educational settings and are dependent upon metadata (RDF or XML) to function. For the ITLET standards community, however, it is essential to adopt or adapt the work of other communities, e.g., the digital library community. This is because the scope of ITLET embraces *both* standards that need to be specifically developed for ITLET purposes (such as e-learning) as well standards that are useful for it (such as digital library protocols like METS) and promote interoperability with an ever expanding domain of Web technologies [15]. This breadth of scope, however, has also brought alternative specifications and development philosophies to the standardization committee tables. This has often created tensions regarding due process and often politicized or tribalised the consensus-building process required. So, the questions arise: *where to go from here with the application of metadata to ITLET systems and services and how might issues of quality be addressed within the broadening scope of development?*

## **2. Implementation and the issue of Quality – the top-down perspective**

In addressing the quality of a metadata standard a number of guidelines and frameworks aim to improve both the product quality (i.e. the quality of the information models, profiles, bindings etc.), and the process quality (i.e. the modeling technique) [16].

A metadata standard is typically developed once conceptual modeling of a particular domain, e.g., the field of educational technology, is clearly established. Some commentators claim that all metadata schemas have an inherent model, whether this has been made explicit or not [17]. Such a model is also known as an “abstract model”, as it describes the abstract overarching information structure the standard relies on for implementation, e.g., the information model or a binding [17]. In the case of DC metadata [8] an abstract model was produced many years after the element set was standardized. The fact that over time it became perceived as necessary to specify is significant, and vindicates the view that was already inherent. Interestingly, the history of the DCMI can be seen as a bottom-up development that responded quickly to the immediate needs of the rapidly evolving Web.

The product quality raises issues of how well the developed models are fit for purpose or give a good description of the domain. This discourse on quality is often based on top-down frameworks [18] which define quality dimensions inspired by e.g. accounting principles, as the Guidelines of Modeling of Schuette and Rothowe [19]. The guidelines include six principles to improve quality of information models: correctness, clarity, relevance, comparability, economic efficiency, and systematic design – the first three being a more necessary precondition for quality than the other dimensions [16]. Correctness and relevance are principles also found in the semiotic framework (SEQUEL) developed by Lindland *et al.* in 1994 [20], in which the Perceived Semantic Quality dimension is measured by indicators of correctness, relevance, completeness and

authenticity. Quality goals of completeness (expressiveness) and validity are not easy to validate empirically. Krogstie *et al.* [21] have revised their SEQUEL framework, taking into consideration the problems participants had making reliable evaluations by means of it. They also supported the criticism of the first version SEQUEL taking a too static view of the domain, leaning towards the “knowledge-as-object” view talking about the model as “externalized knowledge” [21]. Krogstie *et al.* has come up with a concept of “active models” [21], leaving behind the descriptive conceptual modeling (‘as-is’ modeling) in favour of more prescriptive process models. “The notion of quality for a model is extended by looking at its ability to facilitate learning and action, more than just being a representation of the domain” [21]. This extended quality notion establishes also a new context for assessing metadata standards. The following short case study illustrates why this is much needed.

### *2.1 Measuring quality by counting elements in different metadata standards*

In the July 2011 issue of IEEE Learning Technology newsletter Pons *et al.* give an update on “e-learning metadata standards” and a comparison between “the most commonly used standard for learning object metadata” IEEE LOM and the new ISO/IEC MLR [22]. They note that the new standard is “based on two basic principles”, modularity (since it is a multipart standard) and compatibility (since it “opts for compatibility with LOM and Dublin Core”). Pons *et al.* state that the “usefulness of an educational resource metadata corresponds to data stored about pedagogical features of the educational resource”. This leads to a quantitative assessment of which of the two standards that have the highest number of data elements covering the different dimensions of the standard. Pons *et al.* find that MLR “overall incorporates 45% more” of educational information, and “offers much more capacity to include information about intellectual property” (finding 25 such elements in MLR and only 3 in LOM) [22].

This is not the place to discuss what the authors of this IEEE LT newsletter story might have misunderstood about ISO MLR, considering that the parts on educational elements and IPR elements are not yet published. They are not alone in assessing quality of standards in this way. When a European best practice project recently reported on strengths and weaknesses of current specifications and standards it concluded: “ICOPER chose to use LOM instead of DC-Ed as the base standard for Teaching Method/Unit of Learning application profiles because fewer description fields could be mapped to DC-Ed.” [23]

The authors of this paper observe that it is a widespread approach to appraise the quality of metadata standards by putting a quantitative metric on expressiveness, assessed by the number of data elements defined in the standard. Our claim is that this implies a static and ontological idealistic view on knowledge, which does not align with an active concept of knowledge and Learning, Education and Training needed in the 21st Century.

### **3. Quality of standards – the bottom-up perspective**

Mendling *et al.* [18] reports on several works on bottom-up metrics related to quality aspects of process models. In summary, this research concluded that “larger models tend to be negatively connected with quality” [18]. Model size is important for understandability of the model. Therefore, a large number of metadata elements will at some level inhibit the quality of a standard, at least when it comes to implementation by diverse communities of stakeholders.

However, expressiveness is not necessarily linked to size of a model, measured by number of data elements. When the CEN WS-LT discussed design principles of the CEN MLO standard the group came up with a declaration stating

*“Harmonization efforts should focus on small, simple models based upon existing commonalities that can be expanded upon at national or regional level, rather than all-inclusive monolithic standards.” [24]*

The key phrase here is “expanded upon”. Building on the Dublin Core Abstract Model principles the European experts agreed that *extensibility* was a more important quality criterion than *completeness* (i.e., that the standard covered all aspects of the domain). This lifted the quality discussion to a meta level, from the coverage of the metadata model to the ability of the model language to cope with future need for constructs.

## 4. Emerging requirements

### 4.1 Due Process towards a good Product

The LET domain is described as complicated, complex, emergent and adaptive [25, 26] and this highly dynamic context is putting great strain on both the process of standardization and the resulting products. The legitimacy of the activity is under threat [27], and therefore, it is an urgent need to deliver on promises. However, it is impossible to change the process without changing the outcomes. A more agile design process will give a different kind of standards. At the moment, the authors do not observe a strong debate on design principles for ITLET standards. Without an informed discussion on both process and product the tensions in the LET standards community will be disguised as a conflict between organizations and strong personalities rather than between different design approaches.

### 4.2 Expanding the scope of metadata

No e-learning standard is “pedagogically neutral”, as the US Department of Defense (ADL) put it when they first published SCORM [9]. Underlying every standard is an idea of rewarded activity taking part in learning, education or training. Delivery of content has been a primary concern till now. The ubiquitousness of means of *communication* with the evolving web opens up new possibilities for a wider range of pedagogical ideas to be supported by technology. Exchanging units of meaning rather than units of content expands the scope of metadata. We therefore see that recent terminology like “learner-ownable information”, “competencies”, “learning opportunities”, etc. enter the scope statements of ITLET standards. This development has just begun and calls for leadership.

### 4.3. Beyond Metadata about Learning Content

Conceptions of “learning content” and “learning resources” are in most practical cases semantically equivalent. However, the short history (15-18 years) of metadata standards development relevant to ITLET demonstrates a bias toward “object oriented” conceptions of content. IEEE LOM has been the most successful metadata standard to date that has been specifically developed to support e-learning. Its name gives clear emphasis to the notion of a “learning object”. Likewise, in the ISO context, the publication of MLR builds on this approach, although it also implicitly embraces the entity-relationship model of the Semantic Web and the Dublin Core Abstract Model. But in neither of these cases is

there any (current) specific support for the discovery of content that is specifically explanatory in nature. Both schemas ultimately privilege content or learning resources that can be described or referenced by factual *information* (derived from the primitives: *who*, *what*, *where*, and *when*). However, *explanation* is more than information; it is often a key to comprehension, understanding, and learning. Clearly, if a metadata specification (such as MLR) purports to support learning in any holistic sense then a means for specifying the varieties of explanatory content and the metadata elements required to do so represents work that could be undertaken.

Mason [28, 29] presents a sense-making model that indicates potential new scope for the application of DC-based metadata in relation to accommodating *explanative* metadata – that is, metadata that can effectively reference *explanatory* as opposed to just *descriptive* content. Mason argues that among the many questions a learner might ask while learning or discovering content *why*-questioning is important as it is closely linked to reasoning and critical thinking. Despite advances in natural language search engines, such as TrueKnowledge [30] and DeepQA [31] there is still a lack of Web-based tools that can support learners asking *why*-questions. This is partly due to the fact that *why*-questioning is often heavily dependent upon context and the variety of *why*-questions possible spans causal, motivational, conditional, and teleological dimensions [32]. Thus, this adds complexity to any information that needs to be rendered into suitable metadata elements.

## 5. Issues

The following represents a preliminary list of issues that relate to metadata specification and implementation in the field of ITLET. They are listed as a means of stimulating discussion in the context of a workshop:

- Issue #1 Quality assessment of specification and standards – are the principles articulated by Schuette and Rotthowe (correctness, clarity, relevance, comparability, economic efficiency, and systematic design) adequate?
- Issue #2 Standards development and the tension between innovation and standardization – choosing a good process for a good product and the demands for agility
- Issue #3 The expanding scope of opportunities for learning with ICT requires a broadening understanding of stakeholder requirements with regards to standards
- Issue #4 How to specify metadata for *explanatory* content, and how to develop an information model of explanatory content?

## 6. Conclusions

It is not clear if a little more than two decades of development history of ITLET standards should be characterized as a success or a failure. A great number of standards are published, many of those metadata standards. The evolving Web and pedagogical, economical, demographical and other challenges have changed the context for ITLET standards development expecting the standards community to engage in a discourse covering both the quality and design principles of the current work, and the scoping of new and innovative metadata schemes.

This paper has argued that issues of quality, both of process and product, should be addressed. Furthermore, there is scope for an expanded view on metadata in

ITLETmoving beyond content objects into the domain of learning opportunities and competencies. It would appear to be timely for the standards community to address metadata for explanatory content in order to assist in stimulating ICT support for the sense-making activities so important for learning. The paper is a contribution to a workshop on Strategic Approaches for e-Learning Standards and as such more concerned to find a strategic entry point to the discussion. However, this aim has limited the authors' possibilities to discuss in depth where to go with metadata development.

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# The Effect of Ontological Modeling of Lesson Design: A Case Study in a Community of Teachers

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**Abstract:** This paper discusses computer support for sharing empirical instructional design knowledge among active teachers in schools. The authors have developed an ontology called OMNIBUS and a theory-aware authoring system called SMARTIES. This study prompts their adoption by a community of social studies schoolteachers in Tokyo. This paper presents the advantages of OMNIBUS and SMARTIES and considers problems faced in widening their adoption in schools.

**Keywords:** ontological engineering, authoring system, lesson plan

## Introduction

In the field of education, people have accumulated knowledge theoretically as well as practically. A representative theoretical approach is to build theories of learning or instructional. A typical practical approach involves a “lesson study” [5], in which schoolteachers observe and review each other. This interactive approach does not always work as well as in other areas. Schoolteachers tend to educate students using their own experiences [7].

A big goal of this study is to build an information system that support both for putting theoretical knowledge to practical use and for sharing the empirical knowledge of schoolteachers. In other words, this study aims at promoting exchanges of knowledge between researchers and schoolteachers. Hayashi et al. propose an ontology and an authoring system for utilizing theoretical knowledge of teaching; OMNIBUS ontology is a basis for organizing learning and instructional theories and SMARTEIS is a theory-aware and standards-compliant authoring system [1]. As the first step to achieve the latter goal, support for sharing the empirical knowledge of schoolteachers, this paper reports attempts to deploy them in practice with a lesson study group of teachers.

Deploying them in practice requires analyzing the needs of actual schoolteachers and developing support functions to meet these needs. The authors conducted a needs analysis with a lesson study group of teachers in Tokyo. This group is consisted of active teachers and former teachers. The active teachers are highly interested in lesson study and have experience of it. The former teachers are working in school committees to coach active teachers. In this study, we examined the practical aspects of OMNIBUS and SMARTIES with this group and considered improvements that can be made to the technology based on insights gained in its practical use.

	Items to be learned	Point of instruction	Evaluation (■), Methods (○)
Introduction (a)	<p>“ Check the location of Fuchu City in the Kanto region ”<sup>(b)</sup></p> <ul style="list-style-type: none"> <li>• Students <u>look</u><sup>(b)</sup> for Fuchu city in the Kanto region and <u>express</u><sup>(c)</sup> it in their exercise books.</li> </ul>	<ul style="list-style-type: none"> <li>• The teacher <u>calls students attention</u> to the positional relation of Fuchu City in Kanto region with comparative expression.</li> </ul>	<ul style="list-style-type: none"> <li>■ Students can look for Fuchu city in Kanto region with atlas</li> <li>○ statements, exercise book</li> </ul>

Fig. 1Part of a lesson plan modeled in this study.

This paper discusses the effect of modeling of design of lessons based on OMNIBUS. Schoolteachers describe a design of lesson in a document called lesson plan. The authors were given lesson plans that the group had prepared for their lesson study and modeled them based on OMNIBUS. The authors discussed the models with the active teachers in the group. What is discussed are the analysis results, proposals for alternative instructional strategies, and the usefulness of OMNIBUS and SMARTIES. The authors received six lesson plans from the group and modeled four of them. This paper reports the findings of the practical efforts in using the models.

The rest of this paper is structured as follows. The next section explains a proposed modeling framework and how a lesson plan is described in the framework. Section 3 reports the results of the practical efforts and considers the effectiveness of the framework, based on comments received from active teachers. Finally, the last section concludes this paper and presents some future plans for this study.

## 1. Modeling Lesson Design based on OMNIBUS

### 1.1 Learning and Instructional Scenario Model

OMNIBUS proposes a framework for modeling the learning and instructional process, called the *learning and instructional scenario model (I\_L scenario model)*. This will not be taken up in detail here. This section concentrate on the basic features of it. Further details are given in [1].

The I\_L scenario model is composed of the concepts *I\_L event* and *WAY* that are defined in OMNIBUS. The definitions of them are explained later with examples. The basic features in the definition of the I\_L scenario model are the following [6]:

- learning is modeled as a state change of a learner<sup>1</sup>;
- learning and instructional process are organized separately as “what to achieve” and “how to achieve”; and
- the principles of learning and instruction are organized in relation to “how to achieve” as the design rationale.

Based on these features, OMNIBUS allows us to describe the design rationale of the learning and instructional process as a hierarchical part–whole structure of learning goals. Although OMNIBUS is firstly proposed as a basis for organizing theoretical knowledge in a cross-paradigm manner [1], this paper discusses another use of it. It is to extract and organize empirical knowledge from the practical efforts of active teachers.

<sup>1</sup> This includes change of cognitive, physical and affective state.

### 1.2 Modeling Lesson Designs as I\_L scenario models

The aim of this study was to allow us to make computer-understandable *lesson design*. By lesson design, we mean a plan of a lesson in a teacher's mind. This study proposes describing lesson design as an I\_L scenario model.

As mentioned above, a lesson design is often described in a document called a lesson plan. A lesson plan is composed of a plan of lessons for a course unit. A teacher describes the overall plan of the lessons and the detailed plan of one of them with learning goals, points of instruction and so on. Figure 1 shows an example of part of a detailed plan. The average length of a lesson plan is four A4 pages. Broadly speaking, half of them are for the overall plan, and the others are for the detailed one. This document functions as a medium for sharing lesson design among teachers. However, it is difficult for teachers to represent lesson design in a document of lesson plan because of the length limitation mentioned above and the difficulty in externalization of thoughts in one's mind. The I\_L scenario model is expected to work as a means for bridging the gap between a lesson design and a lesson plan.

Figure 2 shows an example of an I\_L scenario model made from the lesson plan shown in Fig. 1. This tree structure represents not the *is-a* structure of I\_L event but the *part-whole* structure of it. Each node represents I\_L event. This is composed of instructional action, learning action and state change of learner. The state change is the core of the I\_L event as mentioned above. Each line linking nodes above and below it represents WAY. It means that the upper I\_L event can be decomposed into the lower ones. On the contrary, this also means that the lower I\_L events can achieve the upper one.

This model represents the design rationale behind the lesson plan. The part of the lesson plan shown in Fig. 1 describes the introduction part of the lesson. This description is shown as the nodes surrounded by a dotted line in Fig. 2. The authors inferred the rest from the description in the lesson plan and observations made in a lesson given by the teacher who created the lesson plan. In the lesson plan, the teacher asks students a question (Fig. 1(b, b')) and then lets them write down the answer (Fig. 1(c)) in the introduction part (Fig. 1(a)). Two nodes surrounded by a dotted line (Fig. 2(b) and (c)) represent the intention of these concrete actions. These nodes are I\_L events representing that students recognize a topic (Fig. 2(b)) and externalize the cognition (Fig. 2(c)). The links between these events and the event representing the whole of the introduction part (Fig. 2(a)) composes the design rationale of this lesson plan.

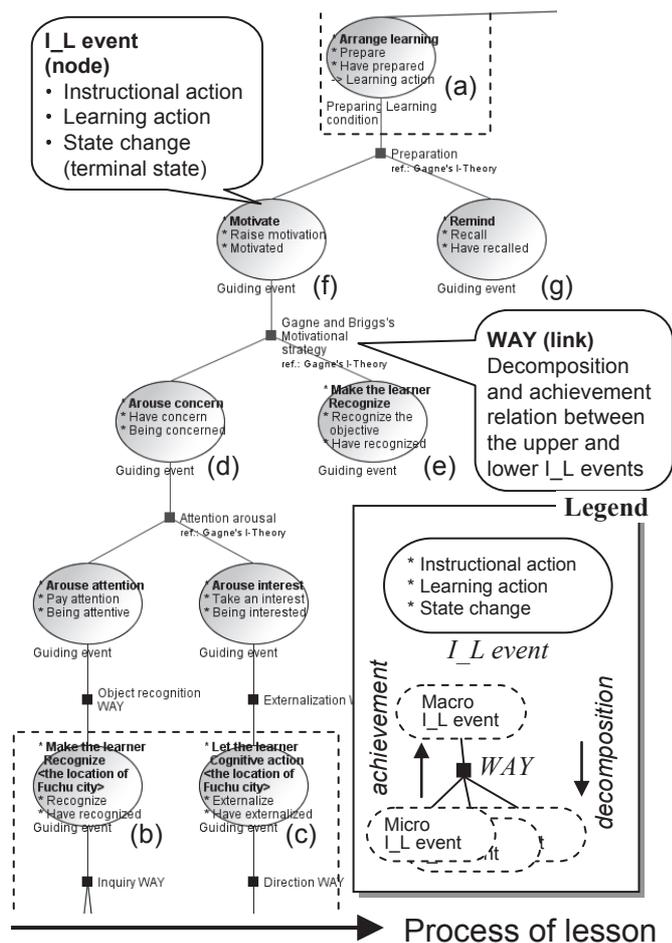


Fig. 2 Part of an I\_L scenario model.

The events in Fig. 2(b) and (c) are for achieving the goal to get motivated to learn, which is represented in the event shown in Fig. 2(d). The event is paired with the event shown in Fig. 2(e) for making the learner recognize the goal of learning. This pair of events is for motivating the learner (Fig. 2(f)). Finally, this event for motivation is paired with the event for recalling prior learning (Fig. 2(g)), together composing the introduction of this lesson (Fig. 2(a)). Like this, an I\_L scenario model allows us to describe the design rationale included the lesson design as a hierarchical structure of I\_L events.

The lesson plans the authors examined are simple, like the one shown in Fig. 1, and do not have a detailed description of the design rationale. Of course, due to the length limitation, it is difficult for schoolteachers to write a lesson design in detail. However, reflection of the lesson design by the creator and sharing of it with others requires such an implicit design rationale included the lesson design. This study positions making I\_L scenario model based on OMNIBUS as a tool to extract an implicit design rationale from a lesson design.

Note that the authors do not insist that the I\_L scenario model should replace a lesson plan. The I\_L scenario model complements a lesson plan, making the relation between the lesson design in the teachers mind and lesson plan as the resulting document clear by externalization of the implicit design rationale that is not described in the lesson plan clearly. Furthermore, making lesson design computer-understandable, the authors also aim to facilitate sharing of lesson designs and empirical knowledge among teachers. One of the causes of difficulty in sharing lesson designs is the differences in backgrounds among teachers or communities of teachers. OMNIBUS and the I\_L scenario model help to expose such diverse backgrounds, allowing us to describe the lesson design behind the lesson plan. They also enable us to analyze lesson design, such as the characteristics of each lesson design, comparisons between them, and the tendencies of teachers and teacher communities.

## **2. An Analysis of Lesson Design with I\_L Scenario Models**

In this section, we discuss analysis of lesson design with an I\_L scenario model and teachers' responses to it. The origins of the models illustrated in this section are lesson plans made by the group of teachers cooperating with the authors. The authors modeled the lesson plans with a presumption of the design rationale and then analyzed them and alternatives to some part of the design. We showed the teachers the models, analysis results, and alternatives in order to discuss their validity and the usefulness of the I\_L scenario model for them. The authors made only four models and this section discusses the extraction and management of empirical knowledge of active teachers via these models.

In the practical efforts, the authors made the I\_L scenario models on SMARTIES and the teachers did not operate it. This is because the purpose of this work was to assess not the utility of SMARTIES as an authoring tool but the usefulness of making I\_L scenario models based on OMNIBUS. Although the preliminary study [3] suggests the usefulness of OMNIBUS, it also suggests some difficulty in the use of SMARTIES by active teachers. Therefore, in order to focus on assessing the usefulness of the model, active teachers were not assigned the task of making the I\_L scenario models on SMARTIES in the current study.

### *2.1 A Structural Analysis of Lesson Design*

An advantage of making an I\_L scenario model is that we can compare lesson designs on a common foundation. OMNIBUS works as the common foundation that converges varying terms and represents the design rationales behind lesson plans.

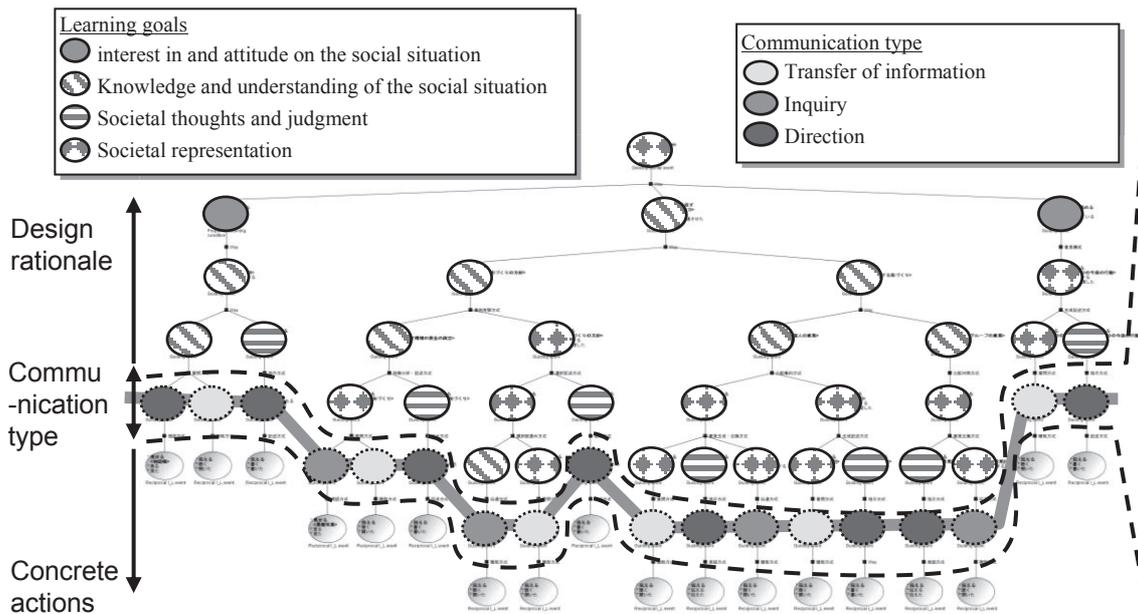


Fig. 3 An overview of an I\_L scenario model.

Figure 3 illustrates an overview of the I\_L scenario model made from a lesson plan provided by an active teacher and the structural analysis result obtained from it. This figure represents the model of the whole of a lesson. The nodes and links in the figure represent I\_L events and WAYS, respectively. The flow of the lesson is represented from left to right in the figure. The bottom nodes represent the time-line of concrete actions to be performed teachers and students from left to right. For example, concrete actions include teachers talking or showing materials to students, and students verbalizing their opinions, so on. The hierarchical structure represents the design rationale behind the process of such concrete actions at multiple levels. For example, the second level from the root coarsely represents the lesson process, composed of “introduction”, “development” and “summary”.

Analysis shown here can be carried out from two standpoints according to the types of layers of the I\_L scenario model [2]. One is the standpoint of interaction between teachers and learners, and the other is the standpoint of learners’ internal states that express learning goals. In particular, in the latter, the states defined by OMNIBUS are related to the goals defined in the curriculum guidelines set by the Ministry of Education in Japan, which are familiar to active teachers.

Fig. 3 also shows the I\_L scenario model with state types. Nodes are overlaid with patterns correspond to types of learning goals and communication. This distribution of types represents tendency of this lesson. Fig. 4 shows quantitative analysis that is the proportion of types of communication between teachers and students in the model. These results tell that us this scenario is well-balanced in terms of both learning goals and communication styles with students because the types of them are not weighted in a type.

The teachers gave positive comments in the practical analysis of lesson design with OMNIBUS. Their comments showed that this analysis is useful to bring to light the problems involved in lesson design, such as inconsistency in lesson design and the gap between lesson design and the lesson plan.

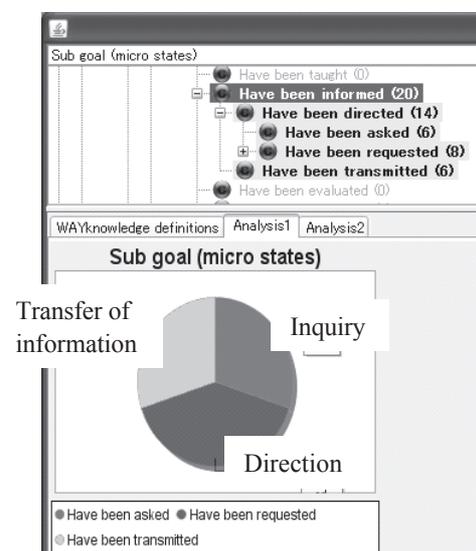


Fig. 4 Lesson design analysis result.

This will allow them to get an overview of a lesson design and then to refine it.

## 2.2 A Comparative Analysis of Instructional Strategies in Lesson Design

Another advantage of making an I\_L scenario model is to record the design rationale included a lesson design. As stated above, an I\_L scenario model can separately deal with a learning goal and ways to achieve it because of the separation of the concepts of I\_L event and WAY. For example, in order to make a learner recognize his/her error, a teacher can directly inform him/her or can make him/her aware of it indirectly. The former is a kind of cognitivist way to achieve the goal. The latter is a kind of constructivist way. There are pros and cons to both: whereas the former is effective in achieving the goal itself, the latter is effective in generating self-reflection. In this manner, there are alternative ways to achieve a learning goal, depending on the educational policy. Organizing learning goals and ways to achieve them separately and combining them for a lesson allows us to record not only the final decision but also alternatives. This helps to clarify the reason for the decision making.

Figure 5 shows an example of such a record that includes a teacher's final decision and the alternatives. The combination of WAYs (a) and (b) is the final decision described in the source lesson plan. WAYs (a') and (b') are alternatives to (a) and (b), respectively. The final decision, the combination of WAYs (a) and (b), means that a teacher presents multiple choices of typical thoughts on the topic in order to help learners make their own thoughts and then let the learners choose one as their own thought. Modeling the process as multistage decomposition by WAYs (a) and (b) is helpful in considering alternatives. In this case, the main focus of decomposition is multiple choices to be presented to students. The difference between WAYs (a) and (a') is whether or not a teacher lets the students consider multiple choices. The difference between WAYs (b) and (b') is whether or not the teacher gives choices to the students when the teacher lets the students consider multiple choices.

It is noteworthy that, in this study, the WAY describes these differences in the abstraction level. Making each instructional or learning strategy reusable in the other lesson designs requires abstraction and modularization of the strategy instead of embedding it in a lesson design. Furthermore, its background is valuable information for principled reuse of strategies. For example, WAY (b') is closer to a constructivist approach than WAY (b) is and requires a heavy cognitive load of learners. Therefore, we could consider that WAY (b) is suitable for the primary stage of learning and WAY (b') is suitable for the advanced stage.

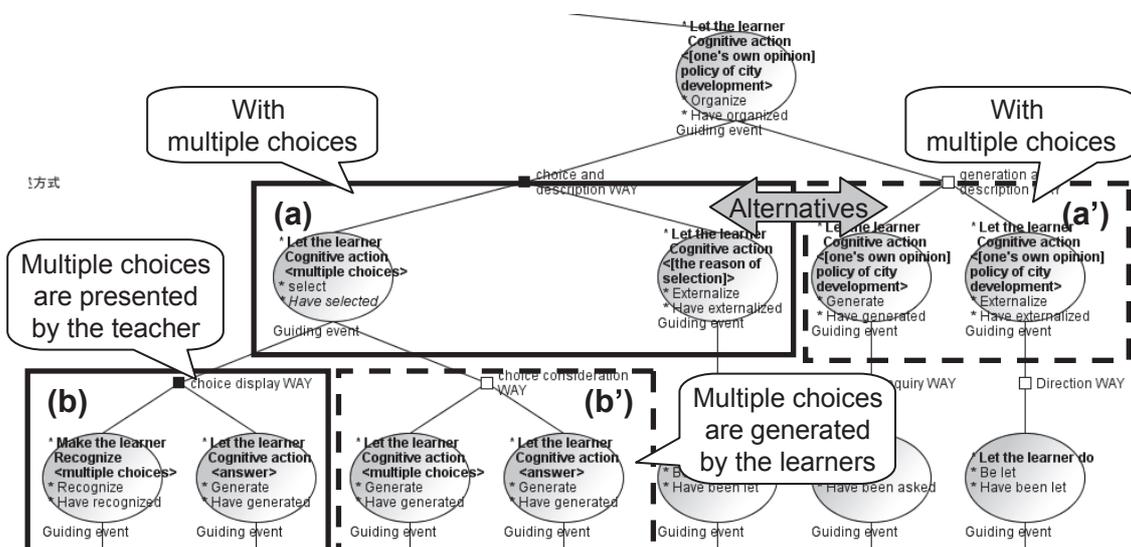


Fig. 5 Alternatives in an I\_L scenario model.

Abstraction of strategies and information about them will allow us to reuse lesson designs and strategies included in them effectively.

In fact, when the authors showed an I\_L scenario model with alternative strategies to an active teacher, he explained the difference between his own educational policy and that of the teacher who made the source lesson plan. He noted that the teacher who made the lesson plan often used the strategies of WAYs (a) and (b), whereas he often used the strategies of WAYs (a) and (b') not like this lesson design. He also said that, although he had been aware of the difference between him and other teacher, he had never fully verbalized the difference. Based on these impressions, he commented that describing a lesson design as an I\_L scenario model helps to understand the difference between not only lessons but also teaching styles. He also suggested that this method may be helpful for disseminating instructional strategies in a community of teachers. He expected that such dissemination facilitates awareness of the differences between teachers' own strategies and those of others.

### 3. Conclusion

This paper reports the findings of practical efforts for the development of a technology for extracting and organizing empirical knowledge of active teachers. Although we do not insist on the generality of the results because of the paucity of available data, the teachers who joined in the practical efforts gave positive comments on the effectiveness of OMNIBUS in describing lesson design. Their comments suggested that modeling strategies in a lesson design as WAYs allows us to organize empirical knowledge in a reusable manner.

Our practical efforts revealed that what active teachers require is a system for organizing the instructional strategies of excellent teachers or strategies that have been refined in a community, rather than mere theoretical knowledge that the authors have accumulated so far by themselves. In response to these findings, we also aim to make OMNIBUS a common foundation for sharing the empirical knowledge that active teachers have accumulated. This foundation may be a circular system of theory and practice in which we can put theories into practice effectively and build theories from findings gained in practice.

Of course, it is difficult for active teachers to describe lesson design and extract empirical knowledge to be shared in a community of teachers with their current forms of OMNIBUS and SMARTIES. In the earlier preliminary study and the practical efforts reported in this paper, it took time for teachers to understand OMNIBUS and SMARTIES. It is difficult for them to describe the lesson designs behind lesson plans because they tend to make lesson designs with habitual ways of thinking. They are usually not aware of the design rationale. Therefore, the authors are planning to improve OMNIBUS and SMARTIES in terms of usability. This includes not only refining the user interface of SMARTIES but also developing a way of managing OMNIBUS and SMARTIES in a community of teachers. In addition to that, the authors also planning to add functions for reducing the cognitive load on teachers in terms of meta-cognition [4]. It is necessary to consider support functions for helping externalization and self-reflection of the lesson designs in their mind.

An even broader goal of this study is to strengthen the solidarity of communities of teachers in terms of knowledge sharing. Currently communities of teachers are mainly organized by subject. For example, the community that we have collaborated with is social studies. In social studies, there are the three areas of civics, geography, and history, and each area tends to develop its own instructional methods. Of course, each area needs its own methods that depend on the subject. However, through our practical efforts, we consider that

there are two types of instructional method that can be shared beyond subject boundaries. We are planning to conduct a survey of pilot schools with regard to such cross-subject instructional methods. In pilot schools, teachers conduct cross-curricular discussions with each other, and this appears to be a suitable scenario for considering the generality of instructional methods.

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